

Jacques de Vaucanson
High School
37 Tours - France

2011-2012

How to shorten the flight
of a solar balloon safely ?
or

The « Objectif Tourne-Sol » Project

Alix
CAYLA

Clément
FOULLON

Julian
GUINARD

Synopsys

Synopsys	2
Thanks	3
Introduction - Summary	4
Bibliography	4
A. How to cause the descent of the flight chain?	5
1) Reversal technique or rotation of the balloon	5
2) Electric cutting of the rope	6
a) Pressure sensor or how to choose the altitude at which the reversal will take place?	6
b) Operational amplifier or how to use the evolution of the voltage supplied by the pressure sensor?	7
c) Field effect transistor or how to use the change of state of the operational amplifier ?	8
d) Resistive wire or how to cut the string?	8
e) Final circuit	9
B. Mechanical study of the balloon	11
a) Characteristics of the flight chain components	11
b) Assessment of forces acting on the system S	12
c) Air density	12
C. How to secure and plan the descent?	13
1) Estimates and follow-up of the balloon flight path	13
a) Tracking with a G.P.S./A.P.R.S. device	13
b) Estimates	14
2) Securing the descent with a parachute	15
a) Attaching the parachute	16
b) Parachute dimensions	16
3) “Anti-rotating” device	18
Conclusions and outlooks	20
Appendix : press releases	22

Thanks

A big THANK to Laurent Besset, amateur of solar balloons from who we were inspired by the idea of reversal of the balloon.

We thank Etienne Lalique and Axel Talon for the outstanding work they have completed in our High School from 2007 to 2009 on the construction of balloons, the principle of their flight and their follow through their project named "Phaeton". Do not forget the students in our class and parents who assisted us in the construction of balloons and logistics for tests.

We thank also all institutional and association partners who have provided financial, material or technical assistance to realise our project:

Sciences à l'École



Financial assistance



Financial assistance



Financial assistance



Financial assistance



Technical assistance and equipment for the follow of the balloon with GPS / APRS and radio reception



Financial assistance



Gift of polyethylene to construct balloons



Technical assistance to provide and analyse local weather forecasts of the day



Financial and technical assistance



For the excellent media coverage of our project

Finally a big thank to all our high school's staff who has provided assistance or support, particularly Mr Grimaud and Mr Baroni, electronics teachers.

And of course, we greatly thank our physics and chemistry professor, Emmanuel THIBAULT who allowed us to live this wonderful experience and who supports and suffers us every day!

Introduction

A solar balloon is made of a black plastic envelop, which absorbs almost all solar radiation and thus allows it to go up naturally. However it goes down at sunset, making research after school hours and at night impossible, and severely limits its utilization to high school. Moreover, it can travel hundreds of kilometers away it is essential to retrieve it because of all the components which are on board the basket to study the atmosphere or surrounding. Therefore, we looked for a way to cause its descent in the day time at an altitude that was determined in advance. However, these raises security issues which we also worked.

Problem: How to shorten the flight of a solar balloon safely?

The project name: "Objectif Tourne-Sol" at first in reference to the ingenuity of Professor Calculus of Tintin, because we actually had to be ingenious to solve each new problem. But also for the pun: First, the solar balloon is facing the sun allowing it to rise up, but secondly because we have decided to reverse it in order to go back to the ground.

Bibliography

« Phaéton, the solar balloon of Vaucanson High School»

<http://www.vaucanson.org/actions/solaire/>

The solar balloon, a lightweight balloon, Laurent Besset's website

<http://ballonsolaire.pagesperso-orange.fr/>

Planète Sciences, « Parachutes of experimental rockets»

<http://www.planete-sciences.org/espace/publications/techniques/parachutes.pdf>

Our website

<http://www.vaucanson.org/tournesol/>

A. How to cause the descent of the flight Chain?

1) Reversal technique or rotation of the balloon

To cause the descent of the flight chain (see its constitution p10), we thought of several solutions. The only way to make it back down before nightfall is to deflate the balloon. We thought first of an explosion inside the balloon to create a hole in the envelope. We quickly give up this approach because we would have had to rebuild a balloon after each release.

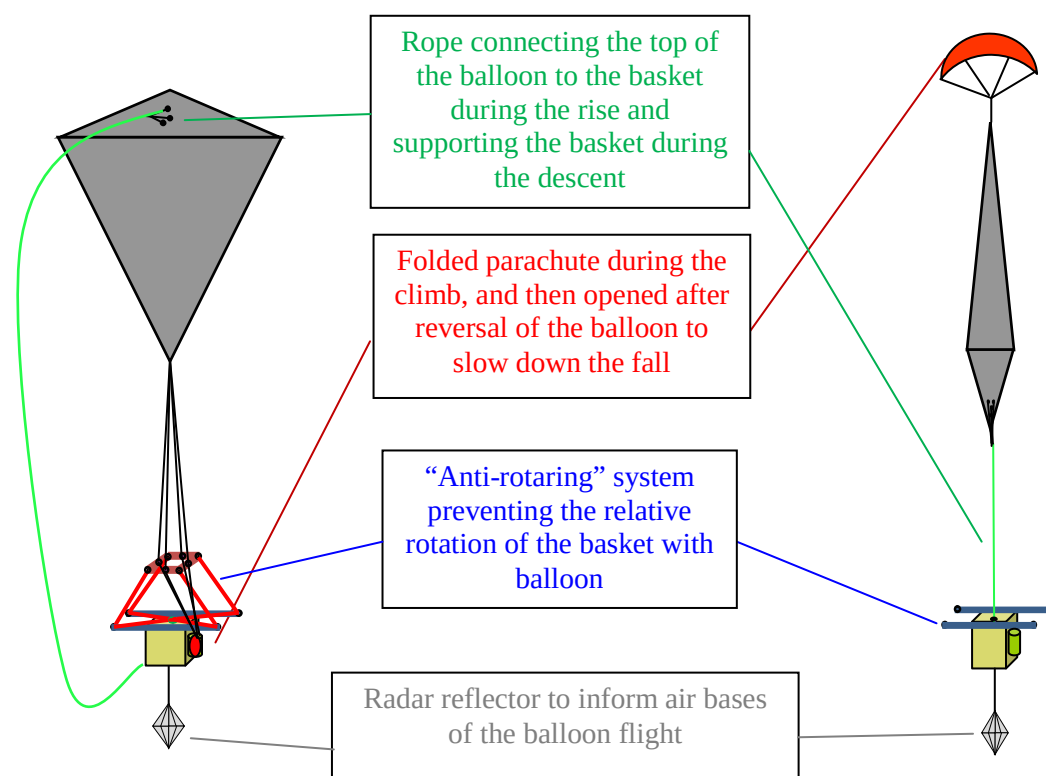
The possibility of installing a valve was also considered, but mechanically it seemed too complex to design and it would certainly make it considerably heavier overall.

So we came up with an alternative and we opted for the solution of the reversal suggested by Laurent Besset, an expert in solar balloon.

With this technique, the basket is fastened to the balloon to two points (Doc.2a): The first one connects the mouth of the balloon to the basket as with any balloon with a short rope. However, the second one connects the basket with the top of the balloon (Doc.1) using a much longer rope. To turn the balloon over, the cord that connects the mouth to the basket is cut through an electronic system. Cutting the rope causes the basket to drop as a result of its weight. It pulls on the longer rope which causes the reversal of the balloon. Once the reversal completed, the mouth is now up and the hot air inside the balloon, can come out (Doc.2b).



Doc1b: Connexion of the rope to hold the basket after the reversal



Doc.2a : Flight chain before reversal

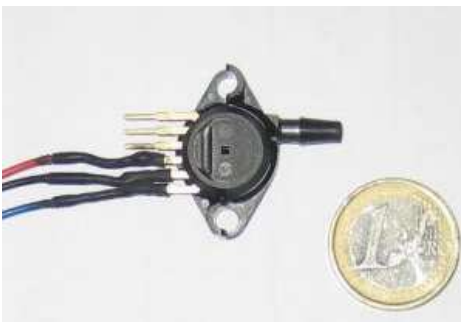
Doc.2b : Flight chain after reversal

2) Electric cutting of the rope

We initially thought of an explosion at a chosen altitude, or of a thread that would melt the balloon and then of a wire that would melt the rope connecting the nacelle to the balloon. In all these situations, we had to consider a circuit controlled by the increasing altitude of the balloon.

Therefore to design the circuit, we relied on the fact that with increasing altitude, the outside pressure decreases.

a) Pressure sensor or how to chose the altitude where the reversal will take place?



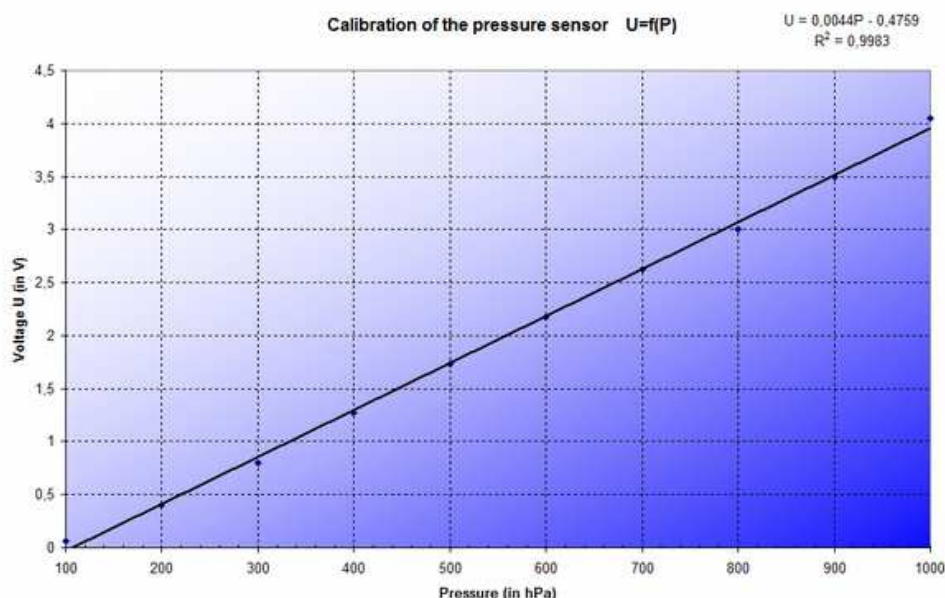
Doc. 3a : Pressure sensor MPX500A

We first studying the operation of a pressure sensor whose output voltage decreases as pressure decreases with altitude. We opted for the sensor MPX500a Motorola sensor (Doc 3a) which seems to be the most advisable in this kind of experiment because it is reliable, accurate, even at low temperatures. Moreover, it required a supply voltage of 5V : the radio transmitter (named KIWI) on board, paid for by the CNES, delivers this voltage. . The output voltage is between 0 and 5 V.

Therefore the calibration of the sensor was carried out. We matched the voltage to external pressure. For this, we used a vacuum chamber to simulate the pressure drop associated with the chosen altitude (FIG. 3b). We obtained the curve below (Doc.4a).

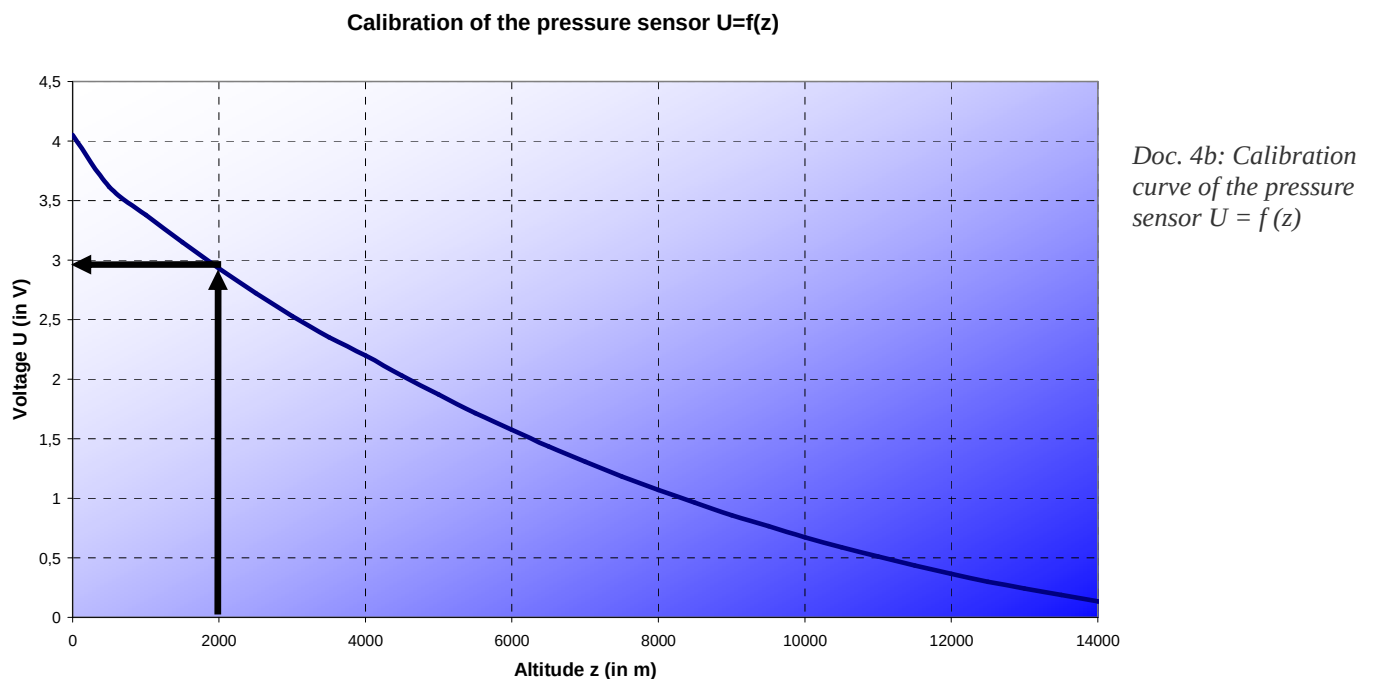


Doc. 3b: Pressure sensor calibration vacuum pump



Doc. 4a:
Calibration curve
of the pressure
sensor $U = f(P)$

Then, with models of pressure evolution depending on altitude, found on the “Planète Sciences” website, we matched pressure and altitude, and output voltage and altitude (Doc.4b), in order to choose the altitude we would like the balloon to descend.

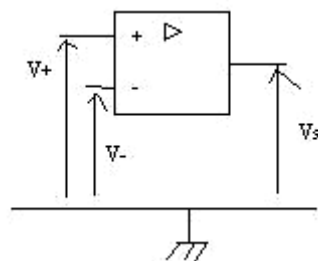


Reading example: to cause the reversal at 2000m, we must identify the passage of the voltage delivered by the sensor below 2.8 V. But how?

b) Operational amplifier or how to use the evolution of the voltage supplied by the pressure sensor?



Doc. 5a: Photography of the operational amplifier



Doc. 5b: Electric diagram of the operational amplifier

By using a component called "operational amplifier" (AOJR37AD), used as a comparator, it is possible to compare the voltage supplied by the pressure sensor to the terminals of a potentiometer (variable resistor).

In the graph above, if the input voltage $V +$ is higher than the input voltage $V -$, the output voltage, V_s , is 9V which is the supply voltage of the AO. If not, it is 0V. The amplifier is then used in the mode known as "saturated."

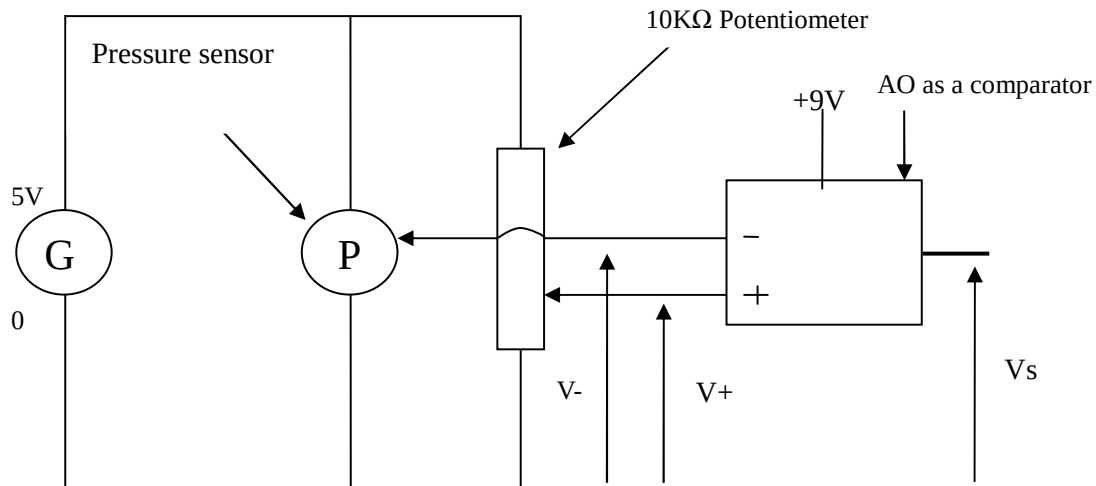
And sending the voltage supplied by the pressure sensor to the inverting input (-) and the voltage supplied by a potentiometer on the non-inverting input



Doc. 6 : 10 kΩ Potentiometer

(+) (Doc.7), when the voltage delivered by the sensor pressure falls below the one delivered by the potentiometer, the "comparator" delivers a voltage that goes from 0V to 9 V.

The potentiometer must be supplied like the pressure sensor, ie with a 5V voltage. And between its B and C terminals, we can adjust the tension of "tipping", so the altitude at which it will happen. We chose a 10 k Ω potentiometer to limit its electric consumption, according to Ohm's law, $I = U/R = 5,0 / 10.10^3 = 5,0.10^{-4}$ A.

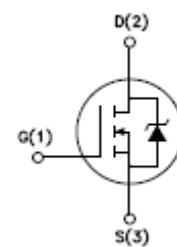


Doc. 7 : Circuit diagram of an operational amplifier-mode comparator

But how can we use this change of state of the operational amplifier used as a comparator?

c) Field effect transistor or how to use the change of state of the operational amplifier?

Initially, we thought of putting a solenoid (relay) at the output of the comparator with a diode. So we thought that when the voltage increases to 9 V, the intensity passed by the left diode is sufficient to operate the relay. However, we found that it did not work. The current delivered by the A. O. used was too low (only a few tens of mA). So on the electronic teacher's advices, we used a type N field effect transistor: it works as a variable resistor. This is roughly a switch controlled by the voltage while a usual transistor or relay can be likened to switches controlled by current.



Doc. 7b : Circuit graph of a field effect transistor

When the voltage between the gate G and source S, U_{GS} , equal zero, the resistance between the drain D and source S R_{DS} is very high and the current cannot flow in the battery circuit.

Conversely, when $U_{GS} = 9V$, Resistance R_{DS} is very low ($< 0.4 \Omega$) and $U_{DS} = 0 V$ and the current can flow.

d) Resistive wire or how to cut the string?

This component will therefore transform the current in a circuit powered by a battery of 4.5 V (Doc.9) with a resistive wire (resistivity $\rho = 60 \Omega.m^{-1}$). A 3 cm long wire has a resistance of $60 \times 0,03 = 1.8 \Omega$ or about 2Ω .

To solidify the wire after several failures, we had to twist several strands. With 5 strands, resistance is

divided by 5, or 0.4Ω . The resistance between the drain and source is constant and equal to 0.4Ω . The equivalent resistance for two resistors in series is $R_e = 0.4 + 0.4 = 0.8\Omega$

The current flowing is to $I = U/R_e = 4,5 / 0,8 = 5.5\text{ A}$, according to Ohm's law.



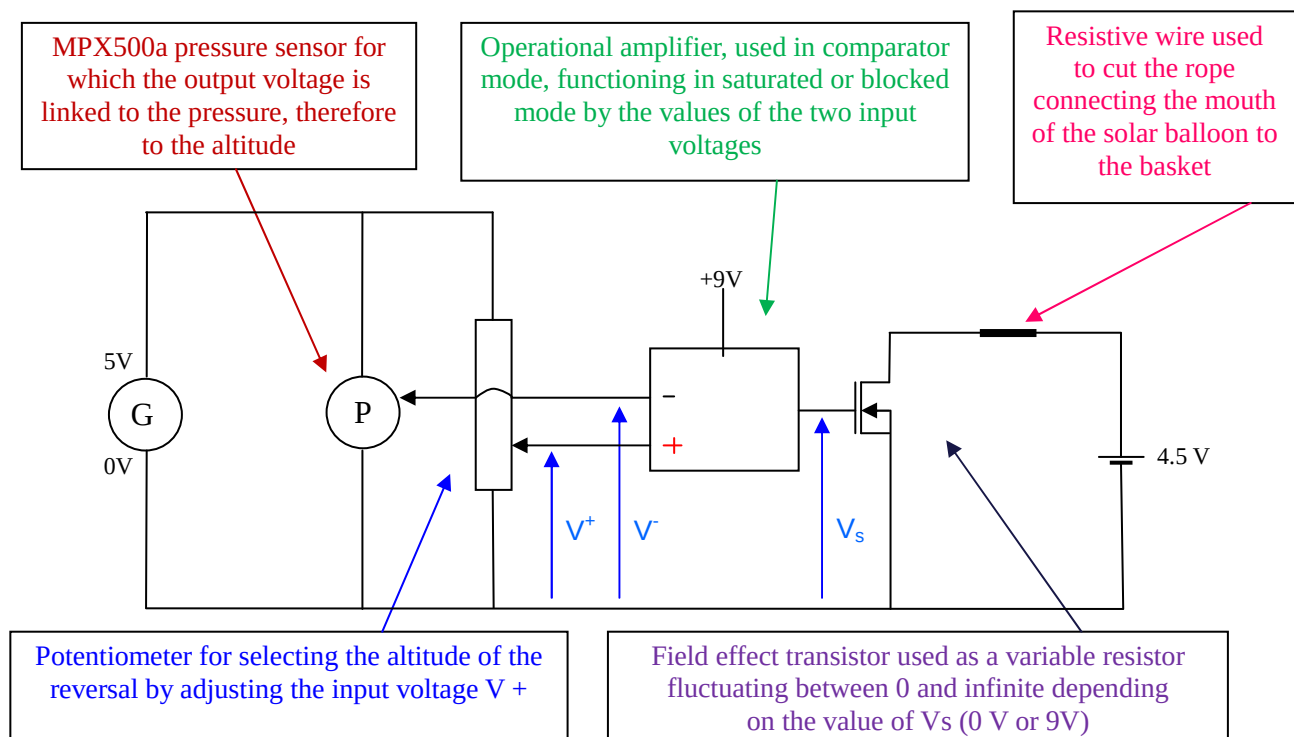
Doc. 8a : First installation of the resistive wire



Doc. 8b : Current installation of the resistive wire

After a problem with cutting the string during a release, we decided to change the spot we position the rope on the domino. Previously, before rope was simply sat on the domino, so it was likely be to break the wire because the forces applied only at one point or left the domino. Now we wind the rope around the heating wire, which helps balance the forces acting at several points and the rope may not leave the domino as it is wrapped around the heating wire.

e) Final circuit

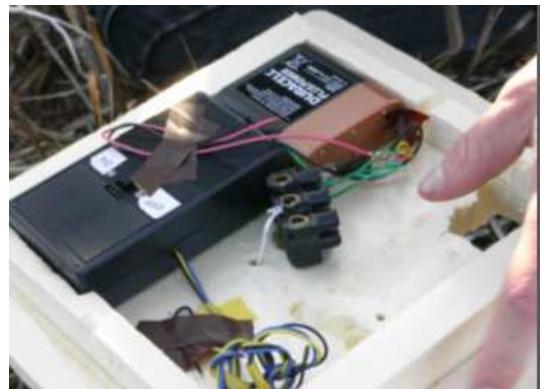


We found several problems with this circuit:

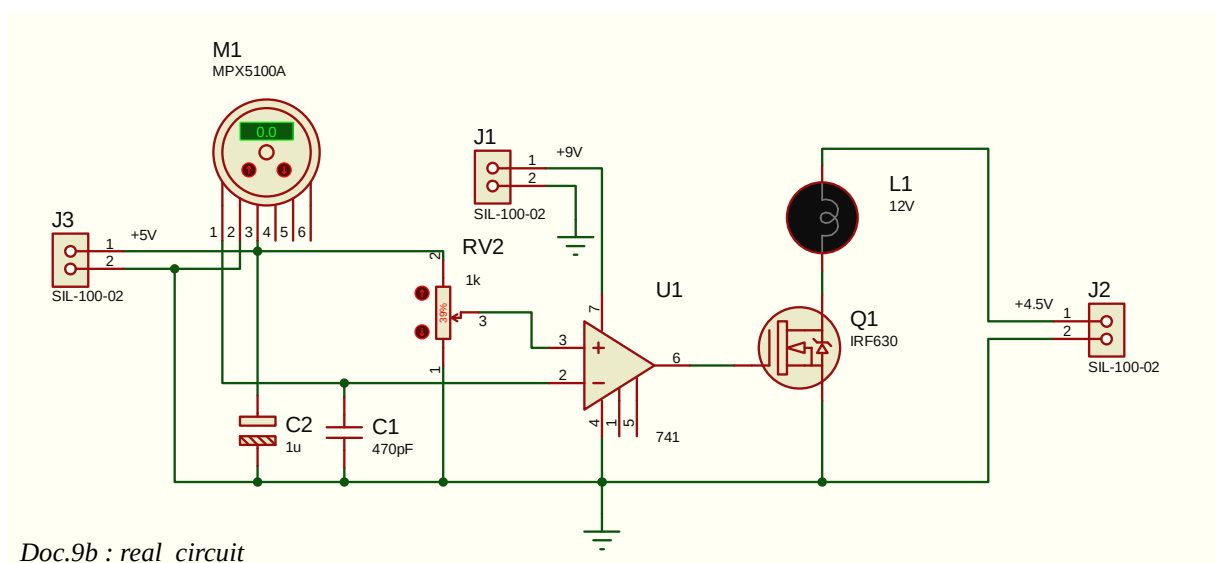
- First, whenever we fed the potentiometer and the pressure sensor with 5V voltage delivered by the radio transmitter, the wire began to heat up unintentionally that was not the case in our tests with a conventional battery. We detected the malfunction, only during the first successful trial. The balloon descent took place earlier than expected, at 2000m while we had planned 3000 m. Could the battery transmitter suffer cuts? This is an issues that we did not really found an answer, but to avoid it, we decided to use a controller to the 9v battery output to create an independent power supply 5 V;
- Still, we wanted to leave connections linked to the radio transmitter in order to follow the potentiometer and the pressure sensor output voltage. While we were preparing to make a second attempt, again the thread began to heat for no reason, so we decided to cut all ties with the radio transmitter!
- Our original circuit was not packaged in a box. On several occasions we had to weld the wire again. We ended up deciding to put it in a box.



Doc.10a : Photography of final circuit



Doc.10b : Installation of the device in the lid of the basket



Doc.9b : real circuit

B. Mechanical study of the balloon

In order to build a balloon, we studied how it works, but also the law not to build a balloon and a basket that would be illegal.

So we had to build a balloon that respects French law. We also read that the balloon should not be more than 60 m³ on the website of Laurent Besset, a solar balloons amateur.

a) Characteristics of the flight chain components

The balloon: To save time and for practical reasons, we choose to build a tetrahedral balloon (regular tetrahedron) that is cut out in one single piece. Considering the line of the tetrahedron, we can compute its volume as follows:

$$V = \frac{\sqrt{2}}{12} a^3 .$$

Taking into account the plastic we use, the line of our tetrahedron is 7.22 m long, so its volume V is 44 m³.

This volume allows respecting the legislation on light flying objects. The balloon has a volume less than 60 m³ and its mass doesn't exceed 2 kg, it weights only 1.2 kg, tape and rope included.

The basket: a cube with a 20 cm line of extruded polystyrene. Hardware included (camera, radio transmitter, GPS / APRS, turning device and batteries), it weights 1.5 kg. Thus the surface density is $S / a^2 = 1500/400 = 3.75 \text{ g.cm}^{-2}$ which is significantly below the law with a 13 g.cm⁻² limit.

In addition to the flight train, there is a parachute which weighs 50 g, a radar reflector which weights 150 g.

The total system weighs 2.9 kg, so it is well below 4.0 kg required by law, not to mention the indoor air.

We will study the movement within the terrestrial frame of reference.

The chute: 50g ; Radar reflector: 150g ; The basket: a cube with a 30 cm line and a mass of 1.80 kg made of extruded polystyrene.

b) Assessment of forces acting on the system S

We will study the whole system made of the above-mentioned components; its **total mass is 2.9 kg** including the mass of the inside air. The whole system movement will be studied in the terrestrial frame of reference (cf. Gallileo).

Assessment of forces acting on the system S (Doc.11) :

The weight W: The weight of the whole system can be divided into three parts:

Weight of the envelop (twine, adhesive tape, ropes), weight of the inside air, and weight of the payload added to the balloon. So we can write:

$$W = W_{\text{payload}} + W_{\text{inside air}} + W_{\text{envelop}} = (m_{\text{payload}} + m_{\text{inside air}} + m_{\text{envelop}}) \times g.$$

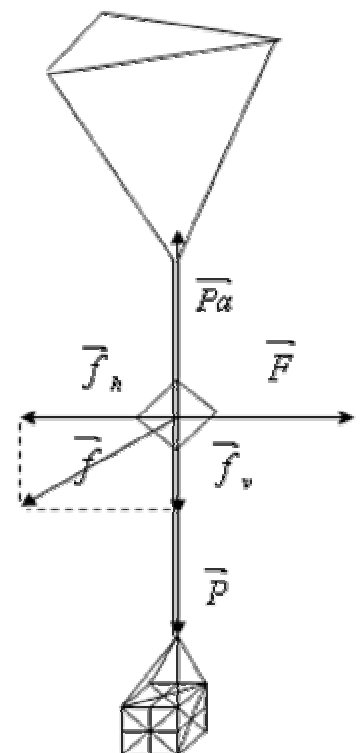
- $\vec{W}$: Weight in Newton (N).

- m_{load} : mass of the payload in kg ; $m_{\text{inside air}}$: mass of the inside air in kg ;

m_{envelop} : mass of the envelop in kg.

- g : strength of the gravitational field in N.kg⁻¹. ($g = 9.81 \text{ N.kg}^{-1}$ at ground level, in Tours).

We need to know the density of inside air ρ and the volume V of the



Doc. 11 : Assessment of forces acting on the S system

balloon to compute the weight of the inside air:

$$\rho = m/V \text{ so } m = \rho V.$$

- Buoyancy $\vec{P}_a$: According to Archimedes' principle, an upward and vertical force is exerted on any object immersed in a fluid (liquid or gas). This force is equal to the weight of the volume of the displaced fluid. In the case which we are studying, the fluid is the surrounding air. So, the standard is: $P_a = m_{\text{ambient air}} g = \rho_{\text{ambient air}} V g$.

P_a : buoyancy in Newton (N) ; g : strength of the gravitational field in N.kg^{-1} ; V : volume of the balloon in m^3 .

Consequently, we need to know the volume of the balloon, the density of the inside air and of the ambient air to evaluate it

- The drag or friction force $\vec{f}$ which is co-linear to the movement can be broken into a vertical component $\vec{f}_v$ and a horizontal one $\vec{f}_h$

The force $\vec{F}$ due to the wind is supposed to be horizontal only beyond 3000m high. We came to this conclusion after the discussion we had with Meteo France Tours engineers.

→ **Rise of the system:** Once our system is rising, it is then subjected to friction forces ($f = kv^2$). Thus these forces are proportional to the square of its speed and also depend on its shape and $\rho_{\text{ambient air}}$, through the constant k . We have not gone any further yet in this study get due to lack of time and knowledge. Maybe, this will be a new goal for next year...

→ **Horizontal movement:** As we studied it previously, this system moves at the same speed as the surrounding air.

c) Air density

It is assumed that air is an ideal gas, that is to say that the average distance between air molecules is big enough so that the intermolecular forces are negligible.

According to the ideal gas law: $pV = nRT$, knowing that: $\rho = \frac{m}{V}$ and $n = \frac{m}{M}$ therefore,

$$pV = \frac{m}{M} RT.$$

$$\text{So : } \left[\rho = \frac{m}{V} = \frac{pM}{RT} \right]$$

p : atmospheric pressure in Pascal (Pa) ; M : molar mass of the surrounding air in kg.mol^{-1} .

R : ideal gas constant in $\text{Pa.m}^3.\text{mol}^{-1}.\text{K}^{-1}$ ($R = 8.314 \text{ J.K}^{-1}.\text{mol}^{-1}$); T : air temperature in Kelvin (K).

ρ : density of air in kg.m^{-3} .

Using this formula, we were able to compute the air density, knowing its temperature, its pressure and its molar mass.

Example: $p = 1,013.10^5 \text{ Pa}$; $R = 8,314 \text{ Pa.m}^3.\text{mol}^{-1}.\text{K}^{-1}$; $T \text{ (in K)} = \theta \text{ (in } ^\circ\text{C)} + 273.15$;

$M_{\text{air}} = (80/100) \times M_{\text{N}_2} + (20/100) \times M_{\text{O}_2}$ (it is assumed that air is simply composed of 80% of nitrogen gas N_2 and 20% of dioxygen O_2): $M_{\text{air}} = 0,80 \times 28,8 + 0,20 \times 32 = 28,8 \text{ g.mol}^{-1} = 28,8.10^{-3} \text{ kg.mol}^{-1}$.

At a temperature of 30°C : $\rho = 1,013.10^5 \times 28,8.10^{-3} / (8,314 \times 303) = \underline{1,16 \text{ kg.m}^{-3}}$; at 0°C : $\rho = \underline{1,29 \text{ kg.m}^{-3}}$.

C- How to secure and plan the descent?

There is a number of landing areas that we wanted to avoid in our tests at the risk to stay away from damage or having difficulty to retrieving our material: city, wetlands, highways, military zones, ... Thus, we used a software application to estimate the landing site.

Moreover, even if the deflated balloon still has a large surface slowing the descent, for safety reasons we decided to install a parachute because, once deflated, the flight train makes an almost free fall drop with only a slight frictional force exerted on the balloon.

1) Estimates and follow-up of the balloon flight path

a) Tracking with a GPS/APRS device

→ **The G.P.S. (Global Positioning System)** : We used a GPS navigator attached in the basket. The GPS uses Medium Earth Orbit Satellites that are precisely located. To find out a location on Earth, the GPS uses the triateration principle: the location of the object is on the flight path of three satellites that orbit in outer space around the object. Using four satellites allows the receiver to measure time, altitude, latitude/ longitude and speed. After having defined the parameters of our system, the ham radio operators in Tours sent us these four data. Each satellite broadcasts its identification number, its precise orbit and the exact time when the message was sent. Thanks to this information and the integrated clock synchronized with satellite's clock, the receiver computes the signal travelling at the speed of light through outer space and measures the distance to each satellite from which it determines the position of the receiver.

→ **Running of the APRS (Automatic Position Reporting System)** :

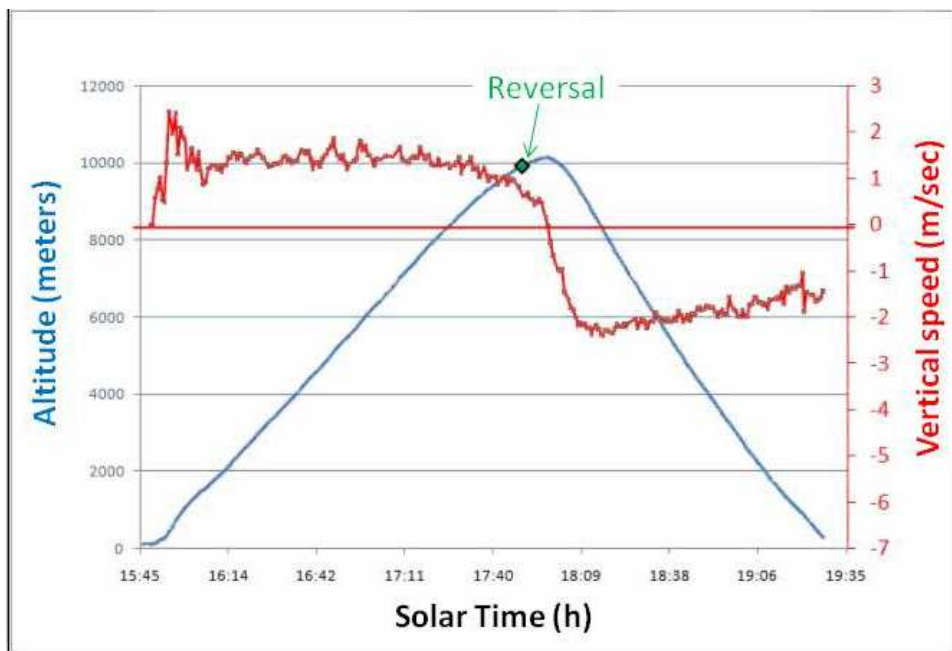
In order to follow-up our balloon live, we connected the GPS receiver to the APRS which does three things:

- The AX 25 network transfers data encapsulated in packets and proceeds to fast packet forwarding. Tinitrack, a modem, encrypts these data coming from the GPS receiver.
- a VHF radio transmitter that broadcasts encrypted data on the 144,800 MHz frequency dedicated to the APRS network. The ham radio relay stations receive these data in real-time. They are transmitted anew through radio waves and the Internet (VPN system, Virtual Private Network), through the web site <http://aprs.fi/>. Our system was identified under: F6KCI-11. It is possible to have a look at the data concerning our tries on this web site as data remain available for 6 months. Direct transmission of data or relay station-to-relay station transmission allows a real time follow up of the balloon. In fact a receiver is connected to a lap-top which contains, for example, the UI-View programme created by ham Roger Barker G4IDE.

b) Estimates

The **Balloon Track** software created by another ham gives an estimate of where the balloon could land. It uses the following data:

- Average ascending and descending speeds,
- *Time of descent*,
- Estimates of direction, strength and wind direction in high altitude, collected by the NOAA (National Oceanic and Atmospheric Administration).



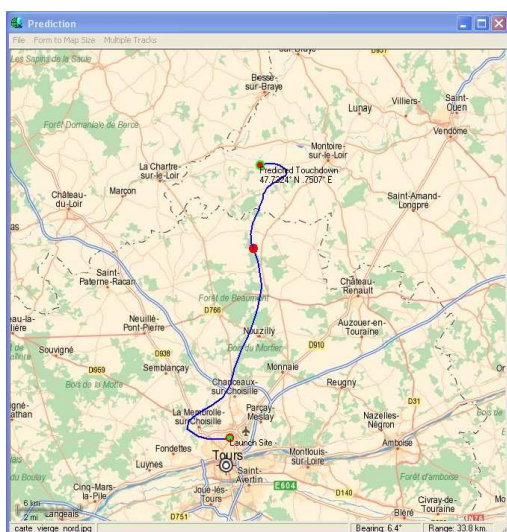
Doc. 12 : Curve giving the altitude and the vertical component of the flight chain speed in terms of time during a flight without reversal (09/23/2011) .

The first release of our balloon which took place on May, 13th, 2011 at 6.00 PM loc. allowed us to:

→ **Estimate** the ascending and descending speeds of the balloon at the end of the day with in a cloudless sky, i.e. $1,2 \text{ m.s}^{-1}$ when ascending and $2,0 \text{ m.s}^{-1}$ when descending without rollover. These values may slightly vary depending on sunlight (position of the Sun in the sky and presence/absence of clouds).

→ State that the balloon descent coincides more or less with sun set. Consequently, we were able to estimate the maximal altitude of the balloon without rollover. The speed of the whole system decreases before sunset as the gradient of the temperature between the air inside and outside the balloon *becomes insufficient*.

So, we were able to compare the estimation supplied by the software (Doc.13a) and the *effective track of the balloon* (Doc13b): the balloon landed 2 km only far from the estimated landing area, with a track of 50 km. So we were able to go very fast on the landing area. We found the balloon only 10 minutes after its landing thanks to the GPS/APRS that had sent a last piece of information as on the ground. This would have been impossible if we had not been next to it because of its low transmission power (110mW).



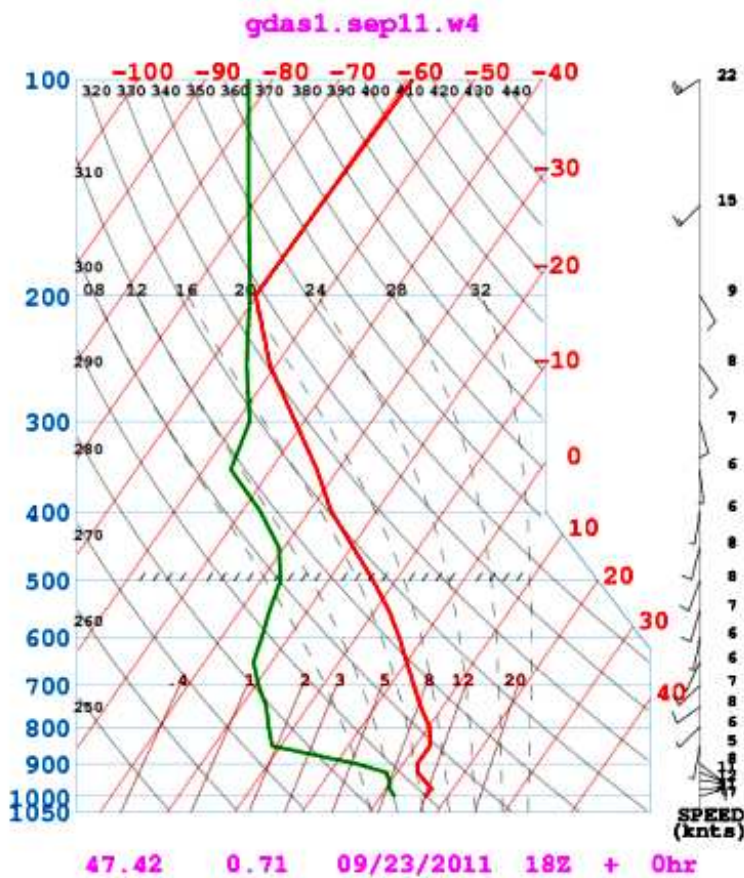
Doc. 13 a : Forecasting of the track of the balloon (23/09/2011) using the software Balloon Track



Doc. 13 b : Real track of the balloon (23/09/2011) provided by the website <http://aprs.fi>.

We are able to compare the forecast horizontal winds provided by website <http://ready.arl.noaa.gov> with the real track of the balloon (direction and speed). For example, we noted that the balloon, 5000m high, flew

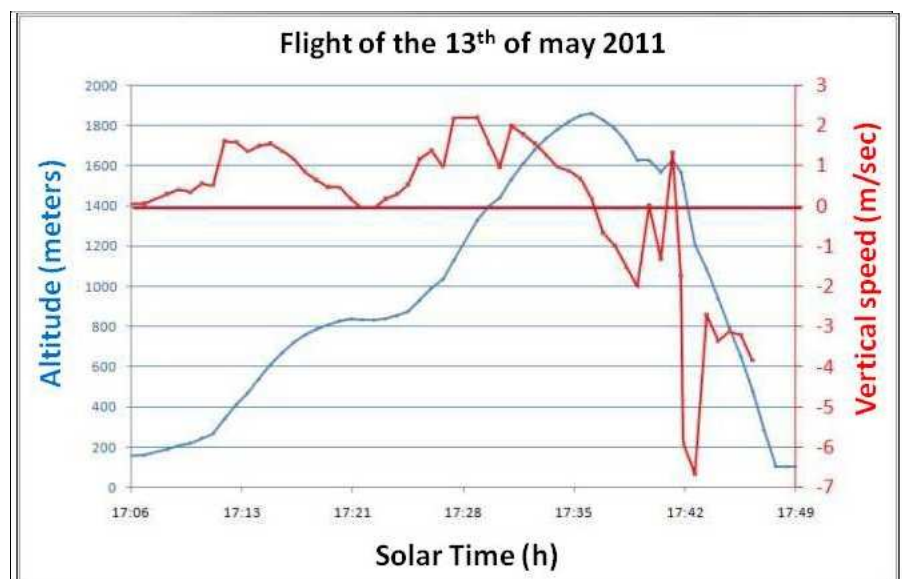
at around 13 km.h^{-1} at 0° North-South after 60 minutes of flight. It totally corresponds to the estimations about direction and strength of winds (8 knots, i.e. 15 km.h^{-1}).



Doc.13c : Map of upper winds retrieved from the site <http://ready.arl.noaa.gov>

2) Securing the descent with a parachute

In a first satisfactory attempt, we found that during its descent, the flight train reached a peak of 7 m/s to touch the ground about 4 m/s as we can see from the graph (Doc.14). While these are typical speeds reached by weather balloons, we decided to equip the flight train of a parachute.



Doc. 14 : Curve giving the altitude and the vertical component of the speed of the flight train in time during a flight without reversal (13/05/2011)

a) Attaching the parachute

The parachute is located between the nacelle and the mouth of the balloon. The upper part is connected to the nacelle while the lower section (the section of the parachute) it is connected to the mouth of the balloon. Thus to the rise, the parachute is upside down. It is therefore found at the location at the time of reversal to be above the balloon and opened to slow the descent.

During one of our tests, we could see from the ground, the different lines were more or less entangled, limiting the opening of the parachute and then the surface of contact with air, so the parachute is now placed in a container hanging on one side of the nacelle, and when the nacelle falls off following the cut of the string, the parachute is released and opens.



Doc. 15 : Parachute déployé

b) Parachute dimensions

To be effective, the parachute must be a certain size to slow the descent of the balloon correctly.

Along the vertical, the forces acting during the descent are:

- Total weight: [+ nacelle + Balloon + rope + parachute + radar reflector] of mass m
- The frictional force exerted when the parachute is deployed can be modelled by the relation:

$$f = \frac{\rho \cdot S \cdot C_x \cdot V^2}{2}$$

with ρ : density of air

S : surface of the parachute m^2

C_x : aerodynamic coefficient

V : speed of parachute

In the reasoning which follows, we do not take into account the strength of friction of the air on the deflated balloon. It's far from being unimportant account held by the large surface of the balloon thus the speed waited with used parachute will be maximum.

- We neglect the push of Archimedes because of the low volume of the balloon when it is deflated.

When the parachute plays its role, the train of flight gets down again in constant speed according to the vertical line, thus according to the principle of slowness, the vertical strengths counterbalance which means that:

$$\vec{P} + \vec{f} = \vec{0}$$

We throw according to the vertical line: $f - P = 0$ thus $f = P$ whether $m \cdot g = \frac{\rho \cdot S \cdot C_x \cdot V^2}{2}$

Where from the formula to calculate the surface of the parachute for a speed of descent V_d deliberate:

$$S = \frac{2 \cdot M \cdot g}{\rho \cdot C_x \cdot V_d^2}$$

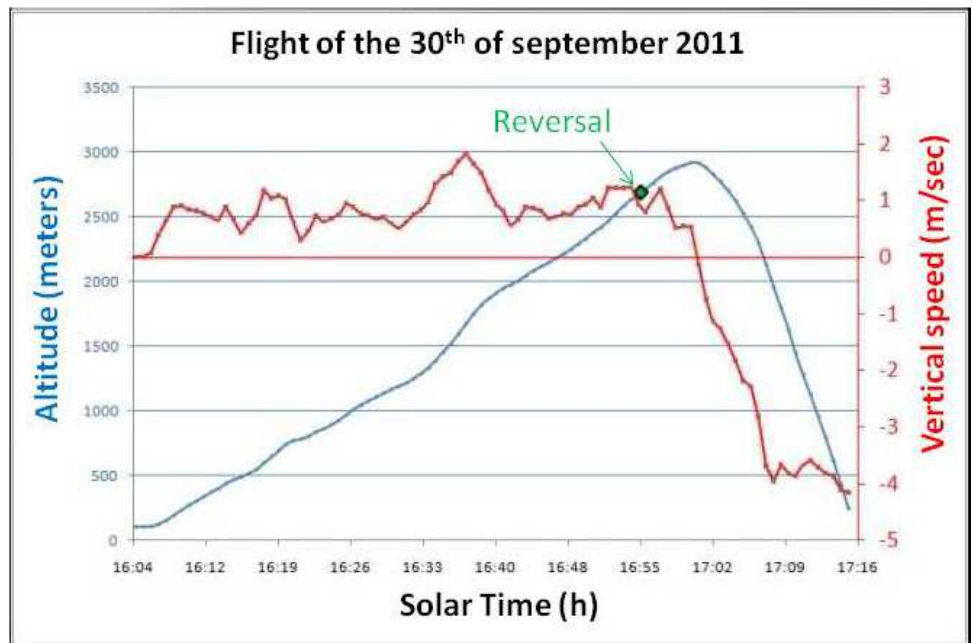
Example: for a descent to $V = 5.0 \text{ ms}^{-1}$ on the ground, a coefficient $C = 1.4$ by Planète Sciences, a density of air $\rho = 1.20 \text{ kg.m}^{-3}$ for a temperature of 20°C and atmospheric pressure of 1013 hPa. :

$$S = \frac{2 \times 3,0 \times 9,81}{1,20 \times 1,4 \times 5,0^2} = 1,4 \text{ m}^2 \quad \text{This corresponds to a radius } R = \sqrt{\frac{S}{\Pi}} = \sqrt{\frac{1,4}{\Pi}} = 0,67 \text{ m.}$$

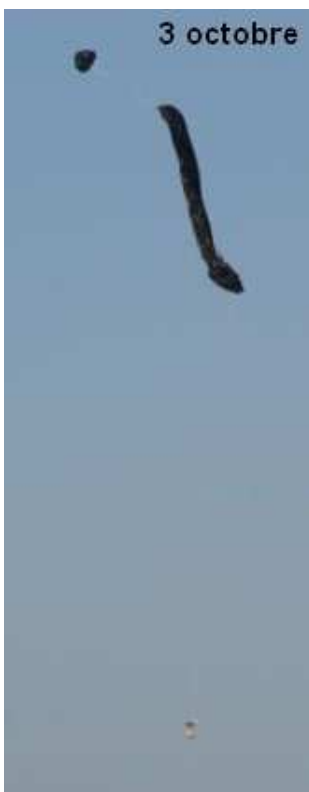
In our last two tests (Doc15, 16), it was found that everything came down at a speed of 4m / s. Indeed, the large surface of the balloon causes a force of air friction on the ball, which further reduces the speed of the flight train as we have already clarified.



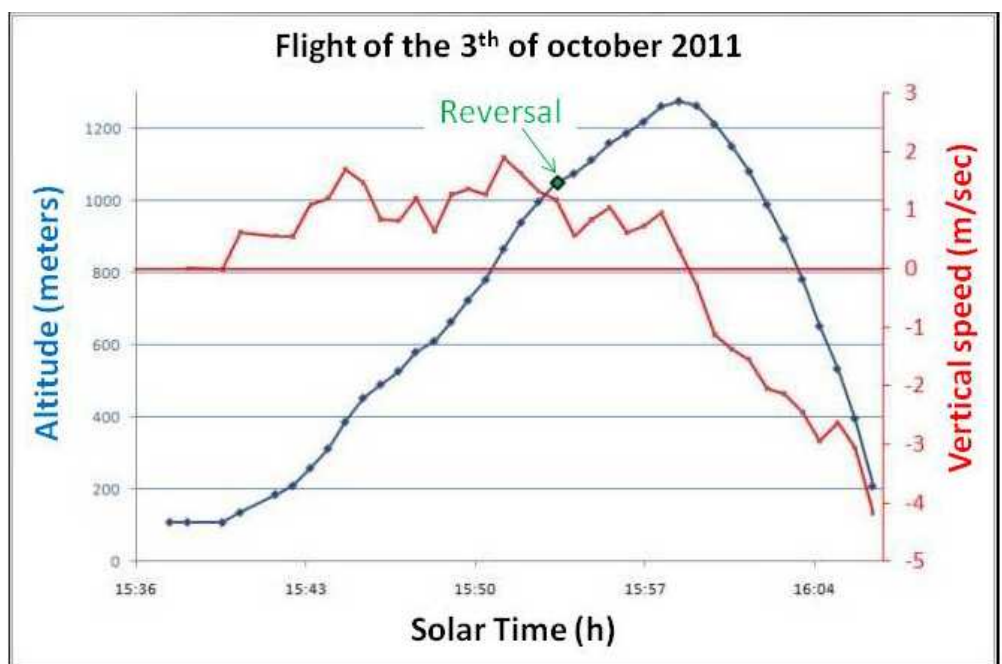
Doc. 15a : Chain of flight with parachute deployed during the descent of 30/09/11.



Doc. 15 b : Altitude and vertical component of the speed of



Doc. 16a : Channel flight with parachute deployed during the descent of 03/10/11



Doc. 16a : Altitude and vertical component of the speed of 03/10/2011

3) “Anti-rotating” device

At the end of several releases, we found, as can be seen in these photos (doc. 17a and 17b), that the lines of the balloon, the parachute, the reflector and the cord that connects the top of the balloon nacelle tangled. These tangles can cause several problems:

- The bad reversal of the balloon
- The obstruction of the opening which prevents the balloon from emptying and from getting down again;
- Or still the breakage of the rope holding the nacelle to the balloon provoking a premature reversal.



Doc. 17a et 17b : Entanglement of lines



Doc. 18a : Flight train to climb

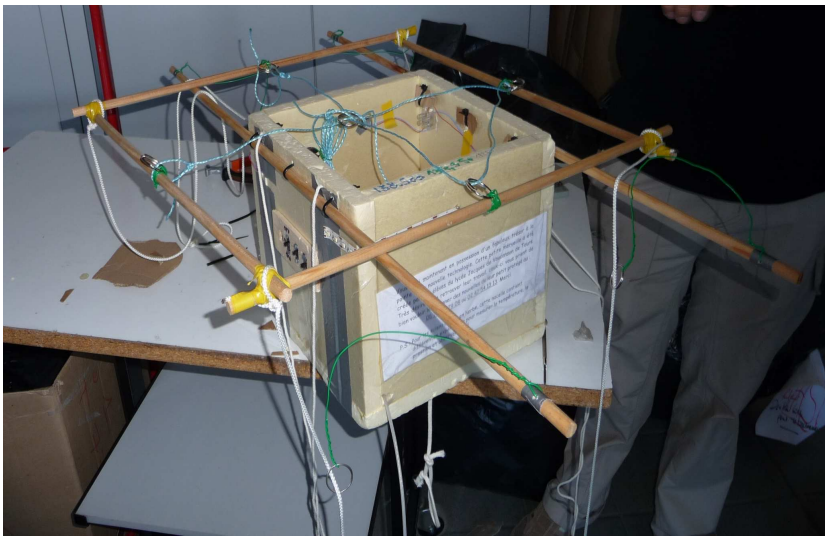


Doc. 18b : Bad reversal of the balloon

To avoid this problem, we decided to create a system which allows preventing the rotation of the nacelle from the balloon and therefore all tangles of ropes. We called it « Anti-rotating device ».

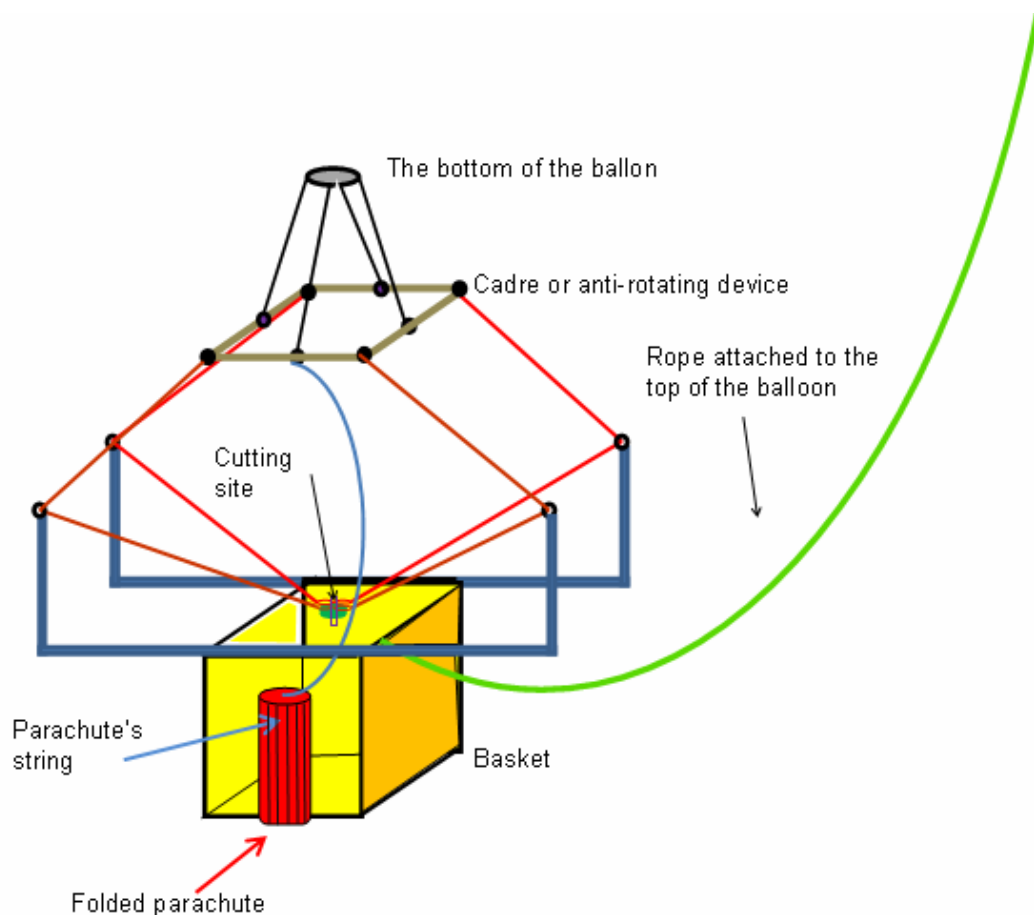
For it we were inspired by hot-air balloons on whom the nacelle is hung on in 4 points on the ball. So, When the one turns, the other one follows it, which prevents the possible mess with a single mooring. Our device is more complex because, at a given height, the nacelle must be separated from the balloon and this by cutting just one thread.

Between the nacelle and the balloon, we added a frame (Doc.19a et 19b) which is attached in 4 points so the rotation of one of the elements pulls the rotation of the set. Not being able to cut 4 ropes simultaneously they are connected with the nacelle by a buckle which is cut by the heating thread. Once cut, they are released. For the manufacturing of the system, we used stalks of carbon. To make the 2 bars stuck on the nacelle and the frame holding the suspending ropes, we used a total of in all 3 bars of 20g each.



Doc. 19a : Photography of the « anti-rotating device »

Doc. 19b : Plan of the anti-rotating device



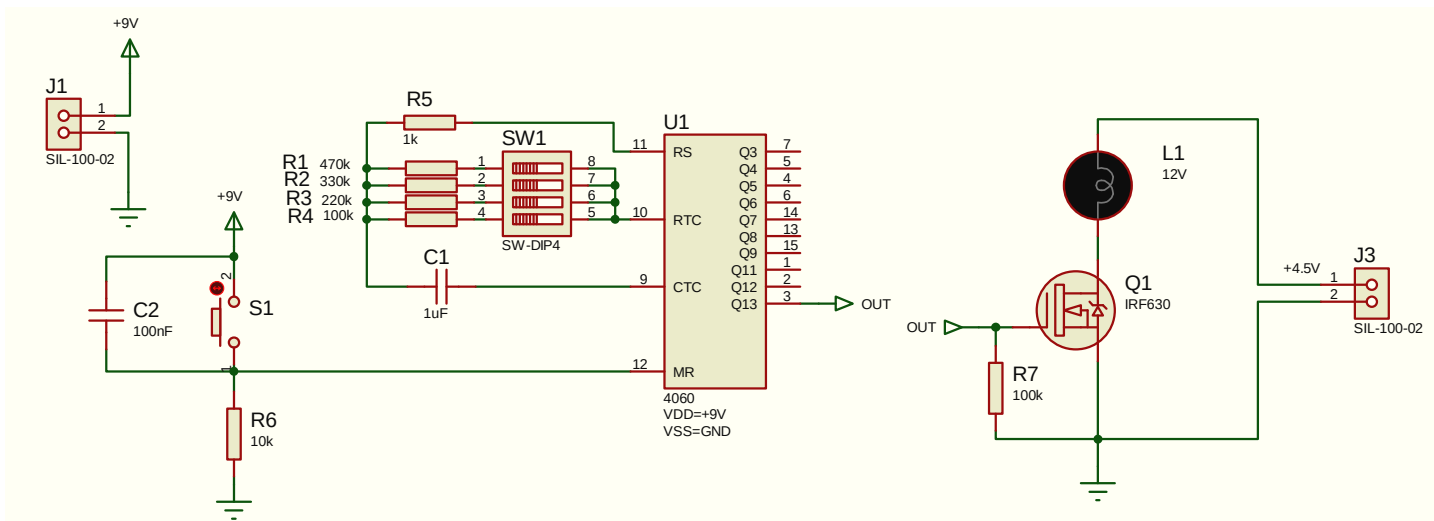
Conclusions and outlooks

At the moment, we made eight attempts of releases. In every released, we met various problems and, in every new problem, we found a solution which allowed our project to improve to get to our last release which is the most accomplished release! The solar balloon can be used thus now for studies of the atmosphere or the ground in Middle school and in College during the day!

	Planned altitude (m)	Altitude of the reversal	Reached altitude (m)	Problems	Solutions
1st Release 12/05/2011	3000	/	5	Collision in a tree (too much wind) Disorganization	Revision of the organization (distribution of the roles)
2nd Release 13/05/2011	3500	2000	2000	Malfunction of the circuit, tangle of ropes, + too fast descent	Creation of one 3 rd circuit + parachutes
3rdRelease 25/05/2011	3000	/	0	Problem of inflating of the (balloon) + inconvenient break of the thread	Replacement Battery + drop Kiwi connection
4th Release 14/09/2011	3000	/	5	Collision in a tree because too heavy nacelle for the portance of the balloon	Stop of the double cone
5th Release 23/09/2011	2500	/	10 130 (Balloon still found).	Problem of heating thread	Improvement of the heating thread
6th Release 30/09/2011	2500	2676	2921	Tangling cords	Anti-rotating device
7thRelease 03/10/2011	1100	1051	1277	No problem	/

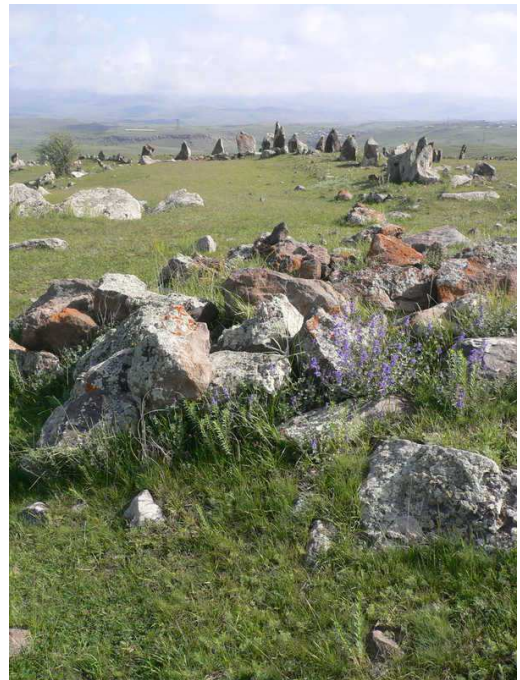
Doc. 20: Summary of different tests outlining the problems and developments of the project

However, it is always possible to bring improvements. That is why we still work on new projects. To improve the reliability of our system, we thought of adding a time switch to our circuit which would allow another circuit to cut the rope after a while if our main circuit has a problem and does not work. We also thought of adding a micro-controller which would allow us to adjust the height of release of the circuit and the time of flight from a computer.



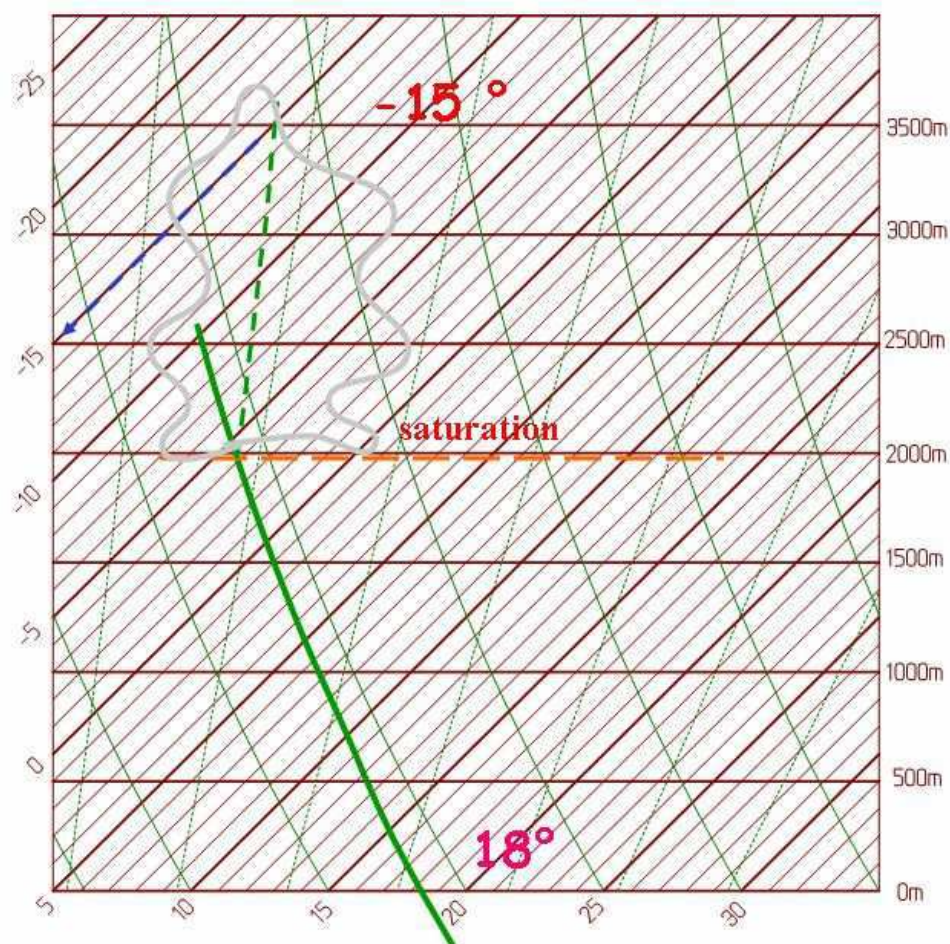
Doc.21: Emergency "timmer" circuit

For applications, the "Archéoarménie" association will organise in May next, a scientific expedition to study the Karahunj site, one of the more archaic lines stones in world. Located nearly 1500 meters above sea level, this extraordinary site requires a precise analysis by air with camera and camcorder. To do, "Archéoarménie" association appealed to Jacques Vaucansson high school to launch a testing program using a solar balloon fitted with a "anti-rotating" device to limit rotation of the basket during filming. Three 20 m3 balloons, two baskets and a "anti-rotating" device must be sent before May 11, 2012 to Eric Gonthier, researcher and lecturer at the National Museum of Natural History.



Doc.22 : Karahunj megalithic complex

Students of preparatory classes of our high school wish to use our balloon to measure temperature and humidity in the morning up to a height of 3500m in order to forecast the altitude of clouds formation by identifying the temperature inversion in the late morning. Our device will thus be absolutely necessary to provoke the descent of the balloon and avoid having to look for it abroad at best, or to lose it in the sea after more than 12 hours of flight!

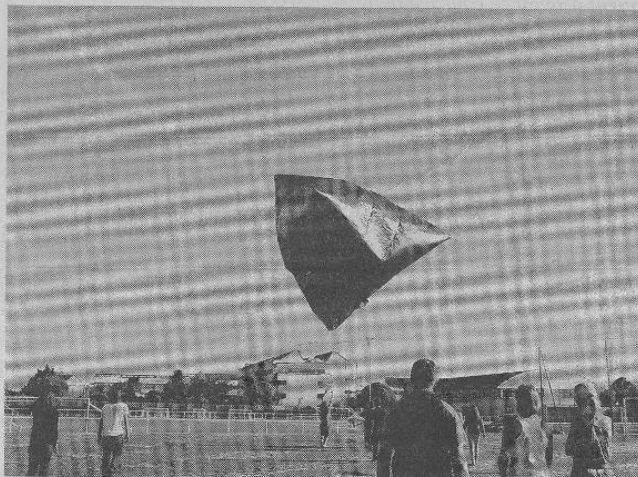


Doc.23 : Atmospheric data allowing to forecast clouds formation

Appendix : press releases

« Nouvelle République » newspaper, release of May 19, 2011

Attention, lâcher de ballon solaire !



Chaque vol apporte une réponse aux questions que se posent les élèves.

En fin de semaine dernière, un drôle d'objet a survolé Tours-Nord pendant 40 minutes, puis est redescendu à toute vitesse, 4 mètres par seconde exactement ! Il s'agissait du ballon solaire, deuxième génération, piloté par une classe de seconde du Lycée Vaucanson. Reprenant le travail de leurs aînés, ces lycéens se posent de multiples questions qui ne peuvent être résolues que par des essais successifs. Un vol sur la neige, lors du séjour aux Orres, a permis d'éclaircir certains points ; le vol de cette semaine a permis de répondre en partie à la question : est-il possible de faire redescendre le ballon avant la nuit ?

Le ballon a bien touché terre, un peu vite, mais enveloppe et nacelle ont été retrouvés en bon état.

La qualité du projet a déjà séduit Frédéric Thomas, Conseiller général et Guy Charlot, inspecteur d'Académie, qui suivent de près son évolution et souhaitent le voir s'étoffer dès la rentrée de septembre. Il reste encore beaucoup de questions à résoudre... et le mystérieux objet noir va certainement réapparaître dans le ciel tourangeau avant l'été !

Correspondante NR :
Agnès Riffonneau

« Nouvelle République » newspaper, release of Thursday, October 6, 2011

16 - 37T
16

tours

La Nouvelle République
Jeudi 6 octobre 2011

la chambrerie

Le ballon solaire des lycéens vole toujours

Au fil des essais effectués par les lycéens, les voisins de Vaucanson ont appris à reconnaître cette silhouette ronde et noire qui s'élève dans le ciel et s'éloigne doucement en fonction des vents. Deux vols ont eu lieu cette semaine avec un objectif précis : décider de l'altitude à laquelle le ballon doit redescendre et assurer sa redescende en toute sécurité. Pour l'instant, les précédents élèves avaient toujours attendu la tombée de la nuit pour voir redescendre leur ballon, car le ballon monte ou se maintient en l'air tant que le soleil réchauffe son air intérieur. Cette contrainte rendait difficile l'utilisation en milieu scolaire et la recherche du ballon de nuit avec seulement les émetteurs GPS ou radio embarqués prenait beau-



Au moment de l'envol, c'est à chaque fois l'effervescence !

coup de temps (2heures de recherche en moyenne !). Un groupe de quatre élèves a donc travaillé sur un système provoquant le retournement du ballon à une altitude donnée.

La bouche se trouvant en haut, le ballon va se dégonfler. Le premier essai de vendredi a été un véritable succès, avec une précision inattendue : les élèves avaient prévu une redescende vers 2.900 m, elle s'est produite à 2.930 m ! Le deuxième essai de lundi prévoyait une redescende vers 1.500 m pour pouvoir prendre des images du retournement depuis le sol mais aussi constater ou non la reproductibilité de l'expérience : « C'est cela aussi la démarche expérimentale, souligne Emmanuel Thibault, le professeur qui suit le projet. Ce sont les petits aléas de chaque essai qui nous font avancer ! Observer le problème, comprendre ou du moins faire des hypothèses sur son origine, et enfin agir pour améliorer ou corriger... Je crois que nos élèves se sont bien appropriés cette démarche scientifique et les pseudo-échecs qu'ils ont rencontrés leur ont appris beaucoup plus que si tout avait fonctionné du premier coup ! »

beaujardin-raspail

> Loto à la salle Raspail samedi après-midi.
L'association Partage espoir organise un loto pour aider la recherche médicale sur les spondylarthropathies samedi 8 octobre dans la grande salle de l'école Raspail, rue Édouard-Vaillant à Tours. Ouverture des portes à 12 h 30, début des jeux à 13 h 30 (deux lots surprises et partie enfants gratuites). Loto interdit aux animaux. Limité à 140 places - pas de réservation. Restauration et buvette sur place. Lots : un four à pizza, un ensemble de couvertures, machine à pain, radiateur-souffleur. L'association se réserve le droit d'annuler le loto en cas de nombre insuffisant de participation et/ou refuser des participants en cas de surnombre. Prix : 1 carton 3 euros, 4 cartons 10 euros, 6 cartons : 13 euros, 7 cartons 15 euros, 8 cartons 16 euros.

indre-et-loire

l'essentiel

> p. 12
ASTRONOMIE. Ce soir, si le ciel s'y prête, vous pourrez assister à une pluie d'étoiles filantes. Un rendez-vous que, Serge Toussaint, ancien instituteur et astronome amateur passionné ne manquera pas.

> p. 15
TOURS. En prévision du lancement commercial de son réseau, sans doute début 2012, le nouvel opérateur de téléphonie Free Mobile cherche des lieux d'implantation pour ses antennes-relais. Dans un premier temps, cinq sites devraient recevoir ses équipements.

> p. 33 et 34 Avis d'obsèques

> p. 37 Sports
FOOTBALL. Le TFC pourra-t-il garder Prince Oniangue au moment du mercato d'hiver ? Rien n'est moins sûr, car le footballeur tourangeau intéresse pas mal de clubs de Ligue 1 (lire page 40).



Serge Toussaint, amoureux du ciel.



En vidéo, la mission scientifique des lycéens.

> p. 48 Courses

> p. 51 Bourse

> p. 52 Jeux

> p. 53 Télévision

> p. 54 Éditorial

> p. 62 Météo

[www.lanouvellerepublique.fr]

> **VIDÉO.** François Fillon, Premier ministre était hier à Richelieu pour l'inauguration de la Maison du Richelais, et pour parler réforme territoriale : il relâche la pression sur celle-ci.

A voir aussi, des élèves (option méthode et pratiques scientifiques) du lycée Vaucanson de Tours nord viennent de lâcher leur ballon solaire de 46 m³, à 1.500 m d'altitude, avec succès. Ils l'ont retrouvé en rase campagne dans le Vouvillon. Mission accomplie !

billet

Pas secondaire

Le PS d'Indre-et-Loire revendique un bon millier d'encartés. Demain, il espère rassembler 10.000 votants. Certes, ces Tourangeaux qui glisseront leur bulletin dans l'urne rose ne seront pas comptabilisés comme adhérents, mais devront signer la « charte des valeurs de gauche » et payer au moins 1 € symbolique. Le parti va enrichir son carnet de contacts et de soutiens, c'est sûr. Autre sujet de débat : au bureau, à l'atelier, dans les familles, on pourra se dire, lundi, que ceux qui n'ont pas voté la veille sont à droite, en tout cas pas au PS. Est-ce là l'objectif d'une telle consultation que de reconnaître les siens ou ses adversaires ? A ce titre, la primaire socialiste n'a rien de secondaire.

Olivier Pourreau

La Nouvelle République
Vendredi 16 décembre 2011

tours

la chambrerie

Les lycéens au sommet avec le ballon solaire

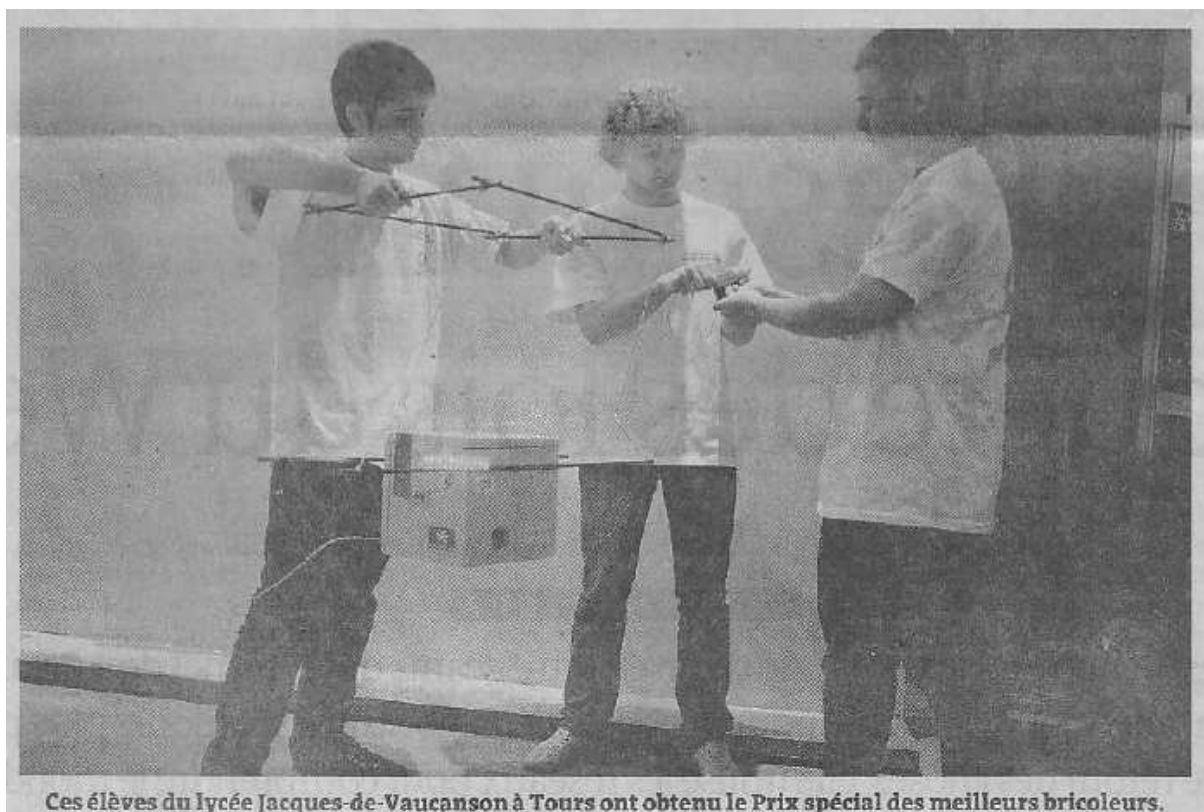
Voici quelques jours, le projet de ballon solaire a brillamment remporté la première place aux sélections régionales des Olympiades de physique du grand ouest, à l'école Polytech' d'Orléans. Il sera donc en finale nationale, au Palais de la découverte les 27 et 28 janvier 2012. Le jury a salué la richesse et la pertinence du projet qui englobe de nombreux domaines (électricité, mécanique, fluide et optique) et bien sûr le dynamisme des élèves. Mais les projets ne s'arrêtent pas là ! Alix Cayla, Clément Foullon et Julian Guinard viennent d'être retenus pour le concours C.Génial, première étape avant les résultats de la sélection générale, le projet est appuyé par la fondation C.Génial, les Sciences à l'école et les Olympiades de physique. Il a également trouvé deux fervents défenseurs en la personne de Pierre Encrenaz, académicien des sciences, et Thérèse Encrenaz, planétologue de renommée internationale : en visite à Vaucanson cet automne, le couple a salué cet excellent travail d'investigation et d'expérimentation, lui prédisant un avenir très prometteur !

Les derniers essais du ballon solaire datent d'octobre. On peut les consulter sur le site du lycée : www.vaucanson.org, rubrique « actions scientifiques ».



Alix, Julian et Clément accompagnés d'Emmanuel Thibault, leur professeur.

tion (mars 2012) et la finale qui aura lieu le 12 mai. Il faudra faire aussi bien que leurs aînés, qui ont gagné par deux fois cette finale, en mai 2008 avec le projet Phaéton et en mai dernier avec le Rubik's Cube. Ils pourront alors atteindre les concours internationaux, dont le prestigieux concours Eucys (European Union Contest for Young Scientists) pour lequel le lycée Vaucanson a décroché une récompense à deux reprises. Soutenu financièrement par la région Centre et le con-



Ces élèves du lycée Jacques-de-Vaucanson à Tours ont obtenu le Prix spécial des meilleurs bricoleurs.

La Nouvelle République
Jeudi 9 février 2012

tours

la chambrerie

Le ballon solaire aux USA ?

Quel début d'année animé pour les trois jeunes chercheurs de Vaucanson ! Le projet Tourne-sol (références à Tintin parfaitement assumées !) sur lequel ils travaillent depuis un an séduit tous les jurys, jusqu'en Amérique. Ils reviennent des Olympiades de physique à Paris, où ils ont remporté le 2^e prix (800 € et une visite scientifique à Toulouse) et surtout le Prix Philippe Lancel, prix spécial décerné pour les qualités d'inventivité du projet.

Qualifié pour le Texas
Clément Foullon, Julian Guinard et Alix Cayla ont savouré l'expérience : « Devant le jury, on n'était pas trop impressionné. Ce qu'on a aimé surtout, c'est la journée ouverte au public. Notre stand a eu du succès, on a pu parler à des dizaines de personnes très intéressées, qui comprenaient nos recherches. On a aussi



L'équipe au complet aux Olympiades de physique à Paris.

vu les projets des autres et partagé nos impressions ! Ça donne envie de continuer ! »

Tant mieux, parce que l'aventure ne s'arrête pas là : sélection pour le concours C' Génial le 30 mars, animation d'un atelier devant tous les professeurs de physique-chimie de l'académie le 11 avril, salon des jeunes inventeurs de Monts les 1^{er} et 2 juin... et surtout la qualification pour les Olympiades I-SWEEEP !

Comme son grand frère, le projet Phaéton en 2009, Tourne-sol est sélectionné pour ce prestigieux concours international qui aura lieu à Houston, du 2 au 7 mai prochains : « C'est plus de

400 projets venant de 70 pays différents et rassemblant plus de 1.000 jeunes scientifiques, souligne Emmanuel Thibault, leur professeur. Une expérience fabuleuse pour ces jeunes ! Mais il nous faut trouver l'argent nécessaire à ce voyage, notamment pour les billets d'avions qui restent à notre charge ! »

Tout le lycée se mobilise autour du projet : Pascal Baroni et Vincent Grimaud, professeurs en sciences de l'ingénieur, les professeurs d'anglais et ceux qui les entraînent pour leurs présentations et Stéphane Blardat, le proviseur du lycée, qui a entamé la recherche de financement... Un appel est lancé à tous ceux qui souhaitent soutenir l'aventure !

Pour tout savoir sur le ballon solaire et ses enjeux scientifiques, consulter le site : <http://www.vaucanson.org/tournesol>