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Education Programs using Small Aerospace Systems (Part 2)

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ABSTRACT

The authors have been working on small aerospace systems such as small experimental rockets, unmanned aerial vehicle (UAV) and some other mobile robots. These systems are quite useful to give a touch of system engineering to young college students and engineers in a short period. These systems are relatively easy to conceive and to build yearly basis. Yet they stimulate the mind of young people who are entering the world of aerospace systems and robots. In this paper, the authors would try to show some of these education tools and the implied future potentials. In particular, the review of UCK-06 & UCK-06A rocket designs, the recent development of small unmanned aerial vehicle and the future scope of small quasi-satellites will be discussed.

1. Introduction

The first small experiment rocket of Young Astronauts Club of Japan (YAC-J) came to France in 1992 to join the launching campaign, when it was ISY (International Space Year). Since then, the authors have realized that these small systems together with other small flying robots such as High-Tech Water Rockets and a small unmanned aerial vehicle (UAV) are suitable to educate young college students and engineers, especially system engineers (Ref.1). These programs followed (Ref.2 and Ref.3).

2. Some Examples of Small Systems

2. 1 Small Experiment Rockets

UCK-06 Rocket, which was launched in the summer of 2006, suffered the destruction soon after the lift-off. The reason for this break-up was suspected either by the interference with the launch facility or by the flutter because of the low rigidity of its fins. This year, almost the same rocket, UCK-06A, has been built and flew in La Courtine in France. The flight was almost perfect except the parachute deployment, namely it separated from the rocket (Figs.1, 2 & 3). However, the payloads, three quasi-satellites, were successfully deployed, and two of them recovered on the ground.

Fig.1 Launch of UCK-06A Rocket in La Courtine

Fig.2 Flight of UCK-06A Rocket

The designs of the rocket, which has the capability of deploying 3 quasi satellites, and the design of the quasi satellites itself are now almost completed. The Space Club Kansai is now moving toward the new stage of more advanced rocket design.

Fig.3 Separated Parachute & UCK-Sat

The major specifications of UCK-06 rocket are summarized in Table 1.

Items	Specifications
Size	150mmφ x 1,680mmL
Weight	13.7 Kg wet
Payload	3 Quasi Satellites
Sensors	Video, Digital Camera
	Acc., Speed Meter
Structure	Aluminum, GFRP

Table.1: Major Specifications of UCK-06A

2.2 Small Unmanned Aerial Vehicle

The second category of small systems is the unmanned aerial vehicle (UAV). In particular, the system was designed so that it can be operated in the mountain area without its runway. The system uses a catapult-like launching device and a recovery net (Figs. 4 and 5). This system has been developed with a GPS Navigation Device, and equipped with a digital camera or a video camera to observe the ground. Although the system has been conceived as an education tool, some provincial governments and private industries are interested in this system. It may become a practical tool for disaster monitoring or prevention.

Fig. 4 Launch Device of Small UAV

Fig. 5 Launch of Small UAV

Other applications are the survey of high voltage electrical transmission towers and the observation of the water reservoir for electrical power generating plants (Fig. 6)

Fig.6 **<u>High Voltage Electrical Power Facilities</u>**

Of course, this UAV system can be used to locate landed experiment rockets from above. The tentative specifications of this system are summarized in Table.2.

Items	Specifications
Size	2,000mmW x 1,600mmL
Weight	6.5 Kg
Control	GPS receiver + CPU
Launch	Catapult-like Device
Recovery	Net

Table.2: **<u>Major Specs for Souki-UAV</u>**

This system will be transformed into a new device of disaster prevention & monitoring, in which a small flying robot derived from the quasi satellites is used. The new design & experiment will soon start this year.

2.3 Small Quasi-Satellites

With UCK-06A rocket, three quasi satellites were deployed. All three satellites were successfully deployed. However, only two of them were recovered in the limited time. These were Reunion-Sat. (Fig.7) and TOIN-Sat. (Fig.8). All these satellites have one micro-computer (PIC16F877A) and one servo-motor for parachute deployment, and weighed approx. 500 grams.

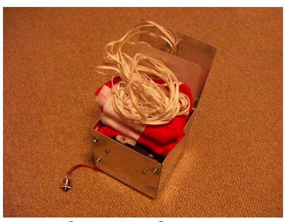

Fig. 7 **<u>Reunion-Sat in Preparation</u>**

These satellites were all deployed in sequence just before the maximum altitude was reached, where the speed of the rocket was expected minimum.

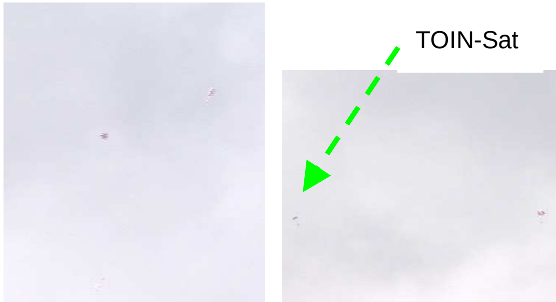

Fig.8 **<u>TOIN-Sat in its Dscent</u>**

The sensors on board each quasi satellite are summarized in Table 3.

Items	Sensors
TOIN-Sat	Digital Camera
Reunion-Sat	Acc., Temperature & Pressure
UCK-Sat	Ultra-Violet, Temperature & Pressure

Table.3: **<u>Sensors on Board Quasi Satellites</u>**

The data of Reunion-Sat are being analyzed. TOIN-Sat had a digital Camera on board. It took several pictures of the near-by ground of the launching site (Fig. 10). In these figures, the descending rocket parachute was also observed.

Fig.10 **<u>Ground Pictures taken by TOIN-Sat</u>**

Further analyses are being performed with these pictures. One of these will be the analysis of the satellite attitudes while it descending. Furthermore, the 3 dimensional geometry of the site will be tried. Thus, these figures have a great value as long as one has imagination.

4. The Future Scope of These Systems

Small aerospace systems are useful as the education tools in many ways;

1) They contains all the necessary sub-systems, which are required to construct small flying robots
2) They can be conceived easily and built in a short time, at least once a year.
3) They can be built with reasonably low cost.
4) They can attract all the students and engineers who are working in different fields.
5) They can test new ideas of flying robots, including experiment rockets and quasi satellites.
6) They are somewhere in the middle of education tools and something practical, and thus can be a bridge to the real world.
7) They can stimulate the mind of young people to make them challenge in this field of either 'Space' or 'Flying Robots'.

The systems introduced in this paper are only the beginning of this class. More or less the first designs of these systems have been successfully completed. In the second phase, the systems will be combined to show the synergy effects. One of these examples is the system in which a small UAV is combined with a quasi satellite type robot, to form a disaster monitoring system.
With the imagination, the future scope of these systems is unlimited. The authors are challenging with young members of Space Club Kansai to enter the more imaginative world of flying robots. The small systems described in this paper can be combined with on-orbit servicing technologies, to build and to maintain a larger system on orbit. For example, what kind of system will be needed to send a one kilogram of payload to Lagrange Point 5? Then to the moon, and to Mars (See Fig. 8)?

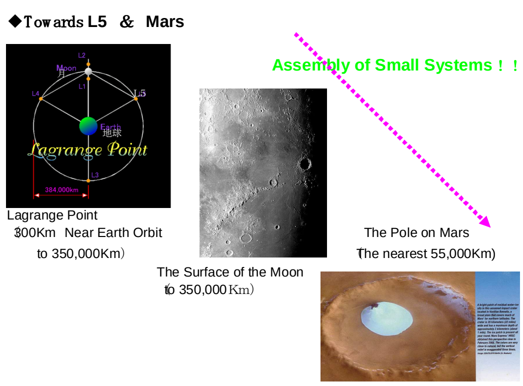

Fig.8 Imagination towards Moon & Mars

The orbit servicing technologies provides the means to build a meaningfully larger system from an assembly of small units such as quasi satellites. The next step for Space Club Kansai will be towards a small system with on-orbit servicing technologies in orbit. It will stimulate the mind of young people ever more before (See Fig. 9).

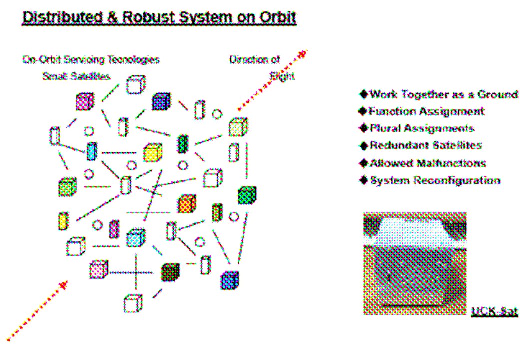

Fig.9 Distributed & Robust System on Orbit

However, these servicing technologies, including inspection, assembling, dis-assembling, self diagnosis, rendez-vous and docking, has to be demonstrated. To initiate this kind of demonstration, one should first describe a grand scenario of the evolution of small aerospace systems.

5. Conclusions

Space Club Kansai has been working on small aerospace systems, such as experiment rockets, UAVs and quasi satellites. They have been successfully launched, with some failures. However, these systems have already demonstrated their potentials as the tools for educating young students and system engineers through building hardware. Space Club Kansai will make their efforts to continue developing these small systems in various fields, and they may one day demonstrate the capability in orbit

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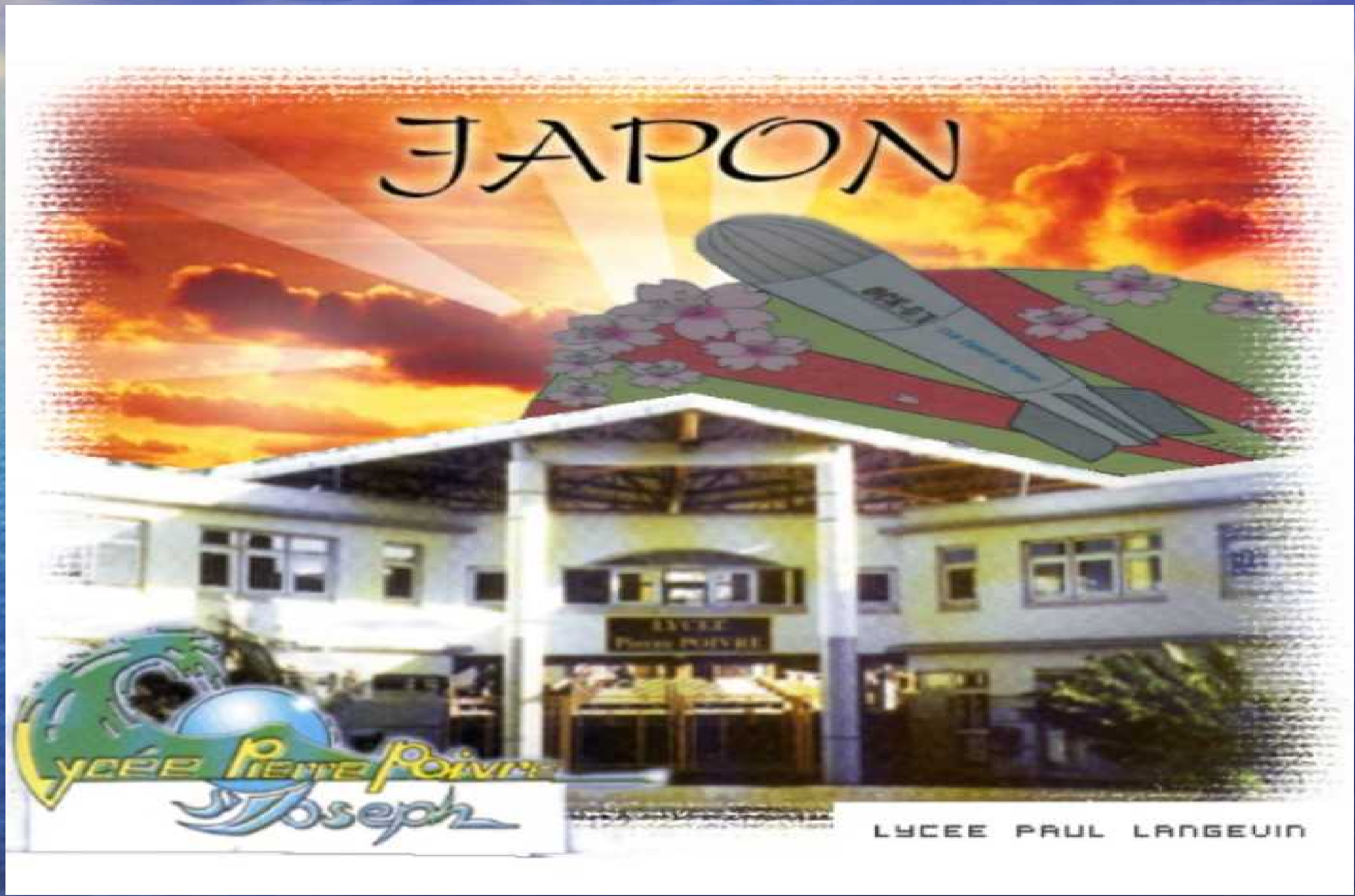
Reunion quasi-satellite 2007



TOIN High School Presentation – Higashiosaka – 20 March 2007

I/ MECHANICAL PARTS

- Opening system:
  - Door's fixation

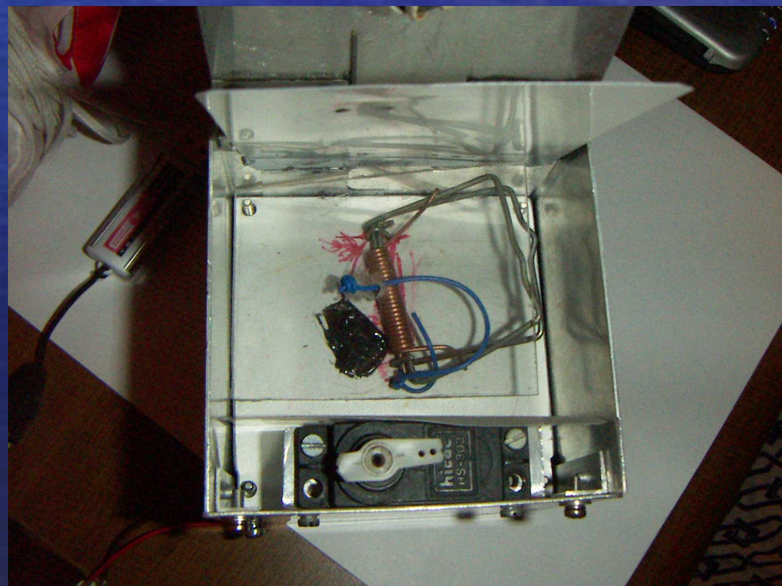
Two hinges

Spring

I/ MECHANICAL PARTS

- Opening system:
  - Opening of the door:

Servomotor



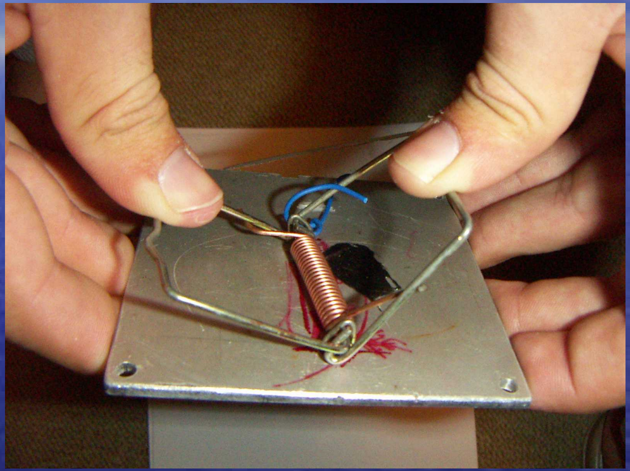
I/ MECHANICAL PARTS

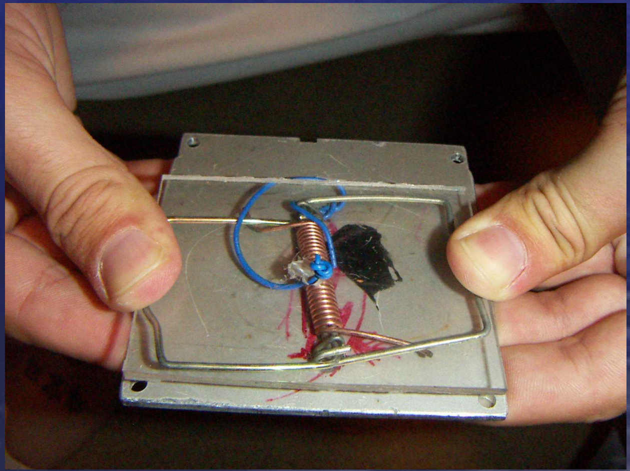
- Opening system:
  - Parachute attachment:

Ring

I/ MECHANICAL PARTS

- Opening system:
  - Parachute ejection system:



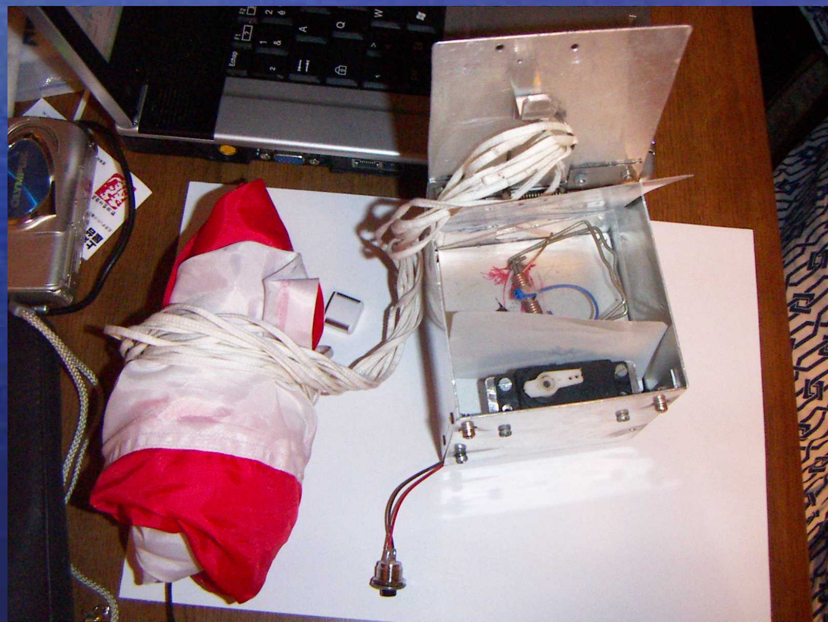


Mousetrap system

I/ MECHANICAL PARTS

- Switch:

Switch



I/ MECHANICAL PARTS

Electronics card’s fixation:

I/ MECHANICAL PARTS

Procedure:

nscrew the side of the quasi-sat.

et the two 9V DC batteries in place.

escrew.

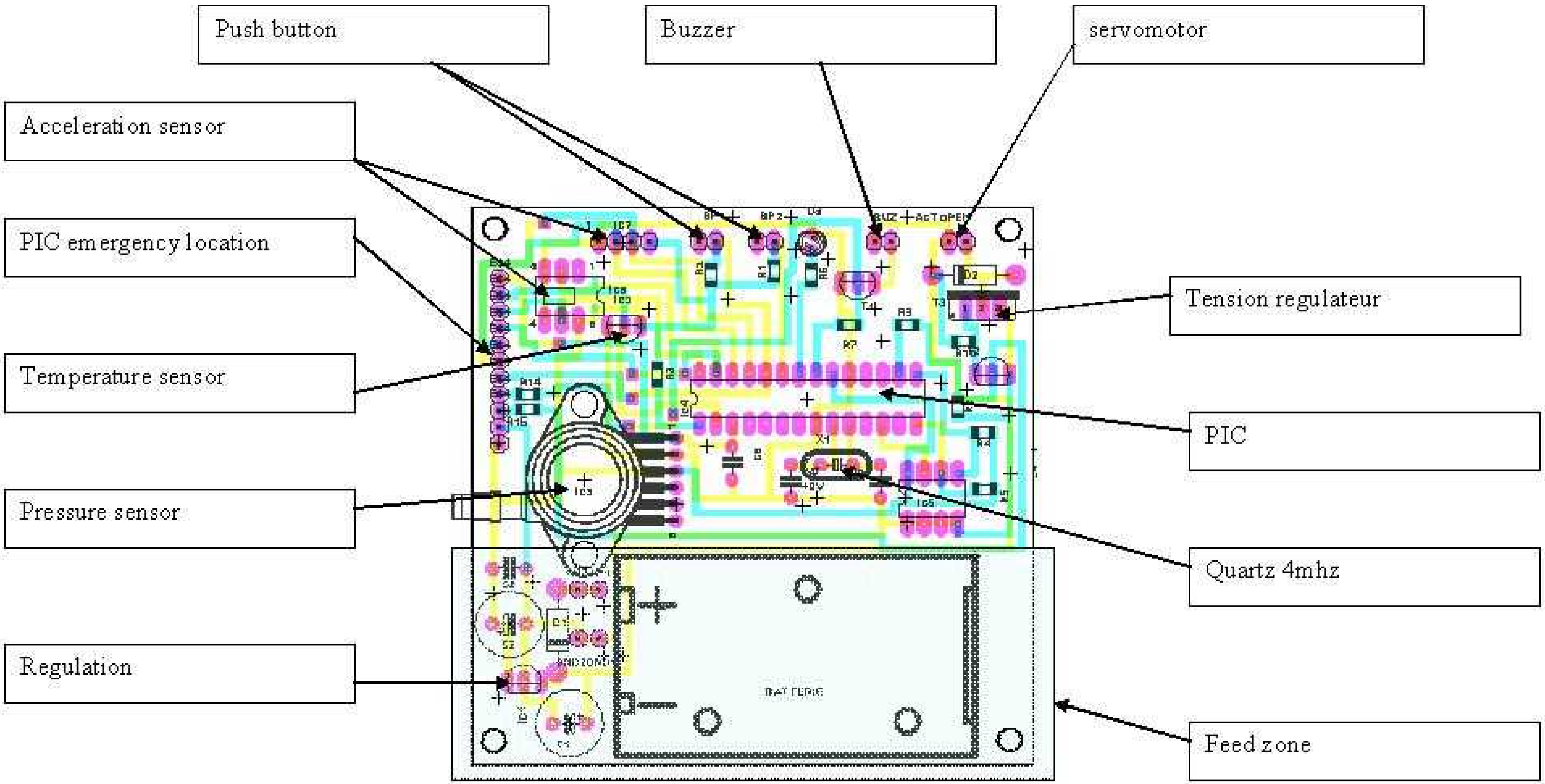
old up the parachute in the correct way.

ut correctly in its place in the cube.

lose the cube.

ush the switch briefly in order to set up the servomotor to keep the lid’s hook

II/ ELECTRONIC PARTS:



II/ ELECTRONIC PARTS:

- Quasi-satellite functionning:
  - Push several times on the switch in order to put the pale in the correct position.
  - Switch it on during a long time as far as we can hear the buzzer one time.
  - Put the quasi-satellite in the rocket. After 20 seconds we can hear an other « buzz »: the next time the switch will be off, the quasi-satellite’ll start to take measures.
  - After 3 seconds the parachute will be ejected.
  - During the quasi-satellite’s ejection and its fall, it takes preasure, acceleration and temperature measures.
  - After a few minutes, the measures’ catch stops, then the buzzer ring as far as the battery brokes down. It allows to find it more easily at La Courtine.

II/ ELECTRONIC PARTS:

- Acquisition process:
  - Remove the battery.
  - Remove cautiously the memory component out of the quasi-satellite.
  - Put it on the serial port card.
  - Set up the battery of 9V DC.
  - Switch on SW1.
  - Connect the card to the computer with a serial cable.
  - Launch DATA TRANSFERT to transfert measures.
  - Open RX DATA in order to see all values.

III/ PROGRAM FUNCTIONS:

- Program summary
  - I2C write
  - I2C read
  - Pressure, acceleration and temperature capture
  - Serial port configuration

Reunion quasi-satellite 2007