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.

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.

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

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>150mmφ x 1,680mmL</td>
</tr>
<tr>
<td>Weight</td>
<td>13.7 Kg wet</td>
</tr>
<tr>
<td>Payload</td>
<td>3 Quasi Satellites</td>
</tr>
<tr>
<td>Sensors</td>
<td>Video, Digital Camera Acc., Speed Meter</td>
</tr>
<tr>
<td>Structure</td>
<td>Aluminum, GFRP</td>
</tr>
</tbody>
</table>

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.
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).

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.

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>2,000mmW x 1,600mmL</td>
</tr>
<tr>
<td>Weight</td>
<td>6.5 Kg</td>
</tr>
<tr>
<td>Control</td>
<td>GPS receiver + CPU</td>
</tr>
<tr>
<td>Launch</td>
<td>Catapult-like Device</td>
</tr>
<tr>
<td>Recovery</td>
<td>Net</td>
</tr>
</tbody>
</table>

**Table 2: Major Specs for Souki-UAV**

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.

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

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

<table>
<thead>
<tr>
<th>Items</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOIN-Sat</td>
<td>Digital Camera</td>
</tr>
<tr>
<td>Reunion-Sat</td>
<td>Acc., Temperature &amp; Pressure</td>
</tr>
<tr>
<td>UCK-Sat</td>
<td>Ultra-Violet, Temperature &amp; Pressure</td>
</tr>
</tbody>
</table>

**Table 3: Sensors on Board Quasi Satellites**

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.

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 contain 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)?

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).

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.

Acknowledgements

This is the forth paper of the first author, and covers his activities over last 15 years. During this period, many people and organizations supported this endeavor. They are; Ms. Tomoko. Akiha of YAC-J, Mr. Guy Pignolet of Science Sainte-Rose, Mr. Marc Zirnheld of Planete Sciences, Mr. Christophe Sicluna of Planete Sciences, Mr. Nicolas Chaleroux of Planete Sciences, and other people from...
Planete Sciences and CNES. My family, Kuniko, Kenichiro and Takako also supported him in many ways. The authors would like express their sincere gratitude to all these people.

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Reunion quasi-satellite 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:
I/ MECHANICAL PARTS

Electronics card’s fixation:
I/ MECHANICAL PARTS

Procedure:

- Screw the side of the quasi-sat.
- Place the two 9V DC batteries in place.
- Screw.
- Hold up the parachute in the correct way.
- Put correctly in its place in the cube.
- Lose the cube.
- Push the switch briefly in order to set up the servomotor to keep the lid’s hook.
II/ ELECTRONIC PARTS:

- Push button
- Buzzer
- Servomotor
- Acceleration sensor
- PIC emergency location
- Temperature sensor
- Pressure sensor
- Regulation
- Tension regulator
- PIC
- Quartz 4mhz
- Feed zone
II/ ELECTRONIC PARTS:

• Quasi-satellite functioning:
  – 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 another « 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 pressure, acceleration and temperature measures.
  – After a few minutes, the measures’ catch stops, then the buzzer ring as far as the battery breaks 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