ISTS 2006-u-04

Experimental rocket project in Gifu for launching within a campaign organized by French association Planete Sciences in La Courtine

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** Space Club Gifu

Abstract

This paper presents an experimental rocket project UCG-05 in Gifu. An amateur rocket UCG-05 is developed by Space club Gifu and Sasaki lab in Gifu University for attending the launching campaign organized by French association Planete Sciences (http://www.planete-sciences.org/) in La Courtine. The objectives of UCG-05 are in two fields. Primary objective is monitoring the vital activities of plants on the ground. For this objective, the quasi-satellite with two digital cameras will be on board the second stage. One of cameras is equipped with a near infrared filter. Secondary objective is accomplishment of the flight and confirming the designs of the two stage rocket. All the phases of the flight, including the launch, the stage separation, the recovery of each stage with a parachute, is monitored and tested. The UCG-05 has been launched on July 29th 2005 gathering several French associations and University clubs (as shown in Fig.1). The two-staged experimental rocket reached 1000m and was able to capture a few images (optical and near infrared) of the ground.

1. Introduction

Uchuu Club Gifu (UCG) has been evolved from the activities of long lasting endeavor of the YAC-Kagamigahara Chapter. The experimental rocket is the third attempt of the Gifu group, who also developed similar rockets in 1992 and 1997. First it was YAC-γ-92 Rocket in 1992, the second

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Fig.1. The Launch of UCG-05 Rocket(27th July, 2005 La Courtine in France) .

KHR-96 in 1997 and the third USG-05 in 2005. The first one was the single stage rocket with which the velocity and the acceleration were measured. KHR-96 had the two-stages, with no propulsion on the second stage. It had the velocity sensor, disposable camera and the video camera on board. Both flew to the altitude of approx. 1 km.

The members of UCG have found the future possibilities of small experiment rockets and Hi-Tech Water Rockets as a mean of tools in higher education, in the area of space technologies and flying robots. Thus the team or the group was formed among college students, engineers and owners of small firms.

Primary objective of UCG-05 is monitoring the vital activities of plants on the ground. For this objective, the quasi-satellite with two digital cameras will be on board the second stage. One of cameras is equipped with a near infrared filter and the other camera is normal one. Secondary objective is accomplishment of the flight and confirming the designs of the two stage rocket. All the phases of the flight, including the launch, the stage separation, the recovery of each stage with a parachute, is monitored and tested.

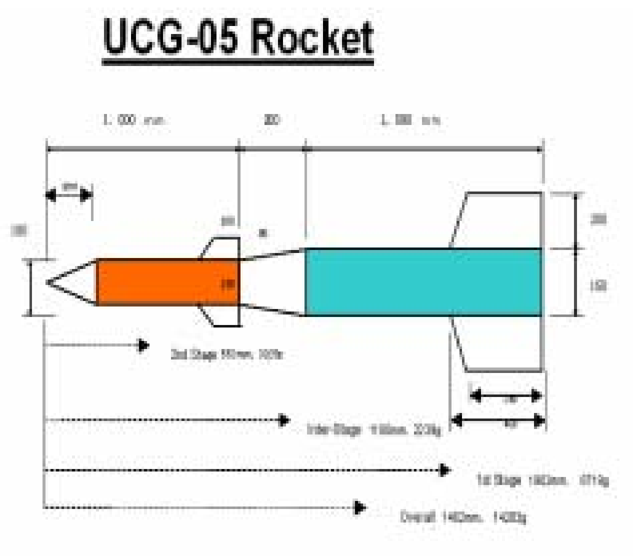


Fig.2. Configuration of UCG-05 Rocket.

2. Definition of an Experimental Rocket

The CNES and PLANETE SCIENCES qualify as an experimental rocket any rocket that matches the following points:

The rocket is created within the context of an amateur club as a team project; the team relies on a methodical experimental approach and rigorous project management. The rocket takes part in an experiment, main objective of the project.

- It is propelled by one motor, issued by the CNES.
- The rocket's conception must allow for an operation and a launch which does not breach the security regulations.
- It respects the specification book.

Note: The design of specific motors, certified by professionals and the CNES, will be considered in exceptional circumstances.

In this case, a visit will be made by an accredited member of PLANETE SCIENCES

Furthermore, the rocket will be launched during the annual national campaign, as a consequence of having successfully passed the final checks.

3. System description of UCG-05

UCG-05 Rocket is the follow-on of YAC-γ-92 Rocket and KHR-96 Rocket. The configuration of this rocket is more or less the same as that of KHR-96, which has two stages. However, the recent progress of the electronics has been incorporated. UCG-05 Rocket has the several unique features such as;

1) It has a Quasi-Sattelite with digital cameras, one of which has a Near Infrared Optical Filter, as a payload. Also 3 redundant computers system is tried.

2) It has a digital movie unit to monitor the stage separation, and several Linear CCD arrays to measure the attitudes and the vibration of the rocket during its flight.

3) On the first stage, the distributed controls of many functions with using several micro-computers.

4) It is designed so that the vehicle is reusable and ready whenever it has a payload. Namely, the Club has the intention to join the launching campaign regularly with the same rocket and with different missions.

The configuration of UCG-05 Rocket shows Figure 2.

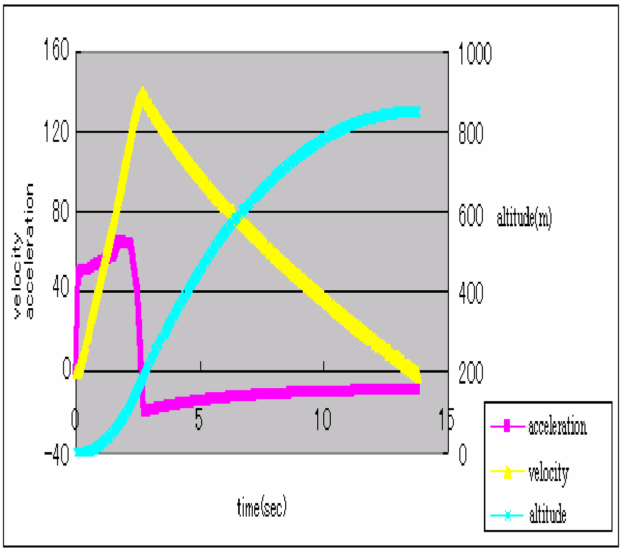


Fig. 3. The flight profile of UCG-05.

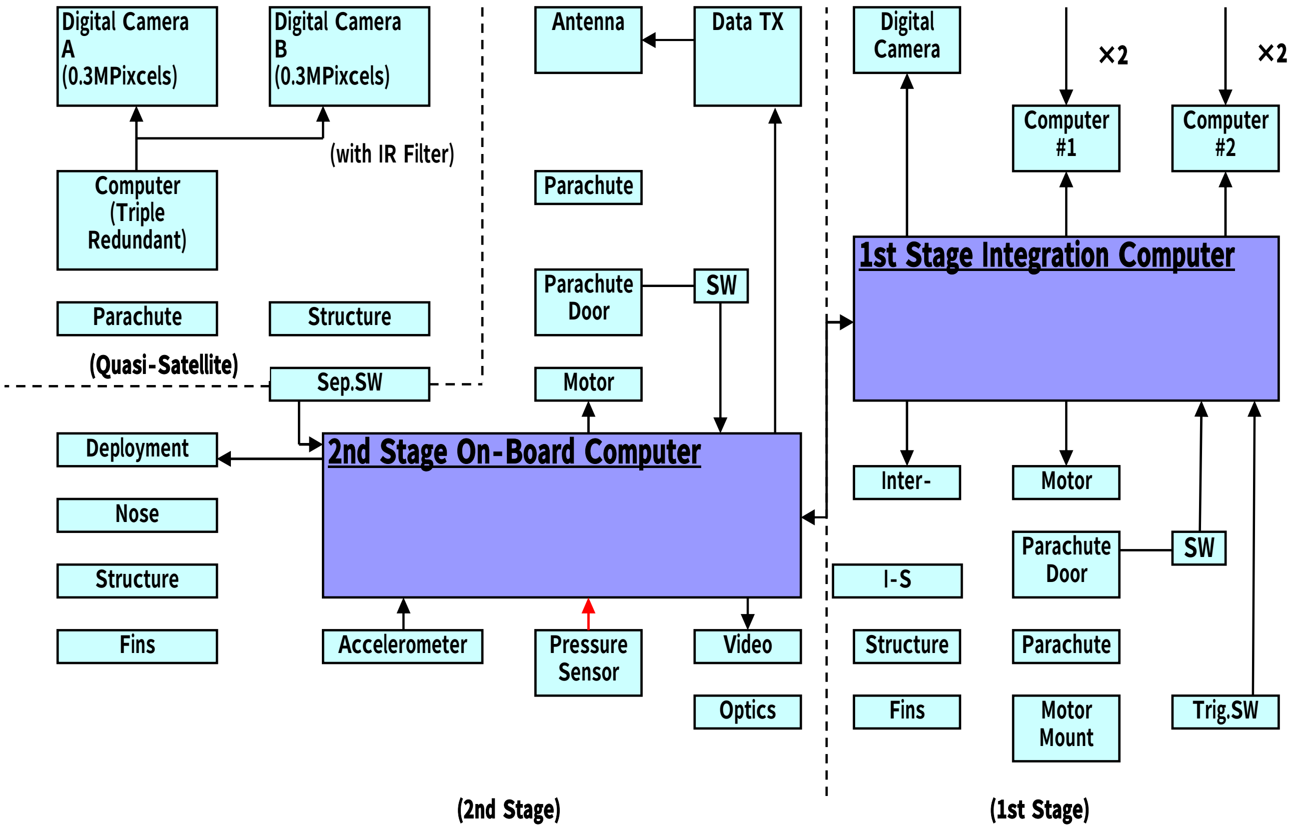


Fig.4. Block diagram of UCG-05.

4. Computer System of UCG-05

The computer system on the 1st stage has the common feature, and each experiment or sensor unit has its own small computer, which handle the raw data directly. The small computers for each experiment are PIC16s.

Essentially the computer system controls the time sequence of the UCG-05 rocket, and gathers the data from several sensors. This time, nothing much sophisticated controls for the computer system. However, it has the capability such as flight controls in the near future.

The main (mother) computer is PIC18. This computer accepts the signal of the trigger SW, and control the sequence of the rocket until the second stage is jettisoned. After the jettison, the computer on each stage controls the sequence of the respective stage. On the 1st stage, the major events are as follows;

・Accept the trigger SW ON (the internal power ON).
・Start the internal timer.
・Start measuring the altitude and the vibration.
・Start recording the video camera (both down- and up-looking)
・Initiate the second stage jettison.
・Confirm the stage separation.
・Initiate the 1st stage parachute door OPEN.
・Confirm the parachute door OPEN.
・Stop the measurements after 10 min. or earlier of flight.
・Stop recording the video camera after 10 min. or earlier of flight.

The communication and the data transmission to the second stage are discussed after the system is clearly defined.

There was the trouble with KHR-96 Rocket in1997. The sequence of the parachute deployment was too early to have the normal operation. Namely, the sling was cut from the 1st stage when it was deployed. The reason for this event was that the load on the sling was large because of the early deployment of the parachute while the speed of the rocket was still large.

On the second stage, the computer (PIC18) accepts the outputs of the accelerometer and the pressure sensors. The major events are as follows;

・Accept the trigger SW ON (the internal power ON).
・Start the internal timer.
・Start measuring the acceleration and the pressures.
・Start monitoring the attitudes and vibration.
・Start the digital camera.
・Initiate the stage separation.
・Confirm the stage separation.
・Initiate the payload bay door OPEN.
・Confirm the Payload bay door OPEN.
・Initiate the Quasi-Satellite jettison.
・Confirm the Quasi-Satellite jettison.
・Initiate the parachute door OPEN.
・Confirm the parachute door OPEN.
・Stop the measurements after 10 min. of flight.
・Stop the digital camera after taking maximum number of pictures.

These events is defined in detail as the design of the rocket is progressed Major flight sequences are controlled by two main computers, and are as follows;

1) Trigger - by the lift off SW ------ Time count zero and initiate the flight computers.

2) +0 sec ------ Initiate all the computers and the sensors.

3) + A sec ------ Engage the Stage Separation Mechanism and Separate the second stage from the first stage. 'A' should be around 13 seconds.

4) + A+0.5 sec ------ Engage the parachute door of the first stage to deploy the parachute.

5) + A+1.5 sec ------ Engage the Quasi-Sat Deployment Mechanism to throw the Sat. out.

6) + A+3.0 sec ------ Engage the parachute door of the second stage.

These operations are quite critical since they should avoid two incidences. Namely, we would like to avoid the collision course between stages and Quasi-Sat., and to avoid the deployment of the parachutes at high speeds. In the above sequence, we would like to engage the parachute door of the 1st stage soon after the stage separation so that 1st stage is left behind to avoid the collision with the second stage. Then 1 second later, we would like to have Quasi-Sat deployed from the second stage. Hopefully at this moment, 1st stage should be a few meters behind the 2nd stage. The parachute of Quasi-Sat should be deployed soon after the ejection of the satellite. Finally 1.5 seconds later, the parachute of 2nd stage is deployed and the Quasi-Sat is far behind 2nd stage. From this picture, A should be the time when (velocity zero - 3.0 seconds - alpha). The rocket reach its maximum height in less than 20 seconds and comes back on the ground in 3 minutes and 30 seconds. The block diagram of UCG-05 indicates Fig. 4.

5. Monitoring the vital activities of plants

It has been recognized that vegetation reflects different optical spectrum from those of deteriorated plants. The live plants reflect more energy than the dead at near infrared (NIR) wavelength. Thus, if the response at NIR is changed into the color red (false color), then the healthy plants look like reddish and their presence is emphasized. On the Quasi-Satellite, two digital cameras are on board as shown in Fig.5. One of these cameras is equipped with an IR filter which blocks the light under 0.76 μm by 50 %. After the measurements, the following data reduction is made to intensify the vital part of plants;

1) Change the red component in the natural color (Camera #1) into green.

2) Change the green component in the natural color (Camera#1) into blue.

3) Change the NIR component (Camera #2) into red.

4) Combine all these three into one false color image.

Then the final false color image clearly shows the area of live plants. To check the cameras for this experiment, some LEDs with different wavelengths have been used. The images of Chez-ez! Foxz have been obtained with and without Near Infra-Red. The camera with NIR filter has the response at the wavelengths of 950 and 850 nm, which are the indication of the chlorophil. Besides the above primary mission, 3 Redundant Computers System is tried on the Quasi-Satellite. This redundant system accepts the trigger signal from the computer on the 2nd stage, and identifies the command by checking the outputs of three computers.

It has been found, in the Preliminary Experiment, that the system is feasible. However, the evaluation is rather qualitative, and yet the quantitative evaluation has to be defined. Probably the NIR image is most important, and the responses in these wavelengths should be quantized, together with the response of the camera's sensor elements.

Since the information in NIR wavelength is most significant, the response in these wavelengths will be emphasized in the following manner;

NVDI = (NIR - Red) / (NIR + Red)

where NVDI is the Normalized Differential Vegetation Index.

Using the system which is on board the Quasi-Satellite, the responses of cameras in relation to the activities of plants is examined. Three different types of specimens is prepared;

1) The leaves of young and live plants
2) The leaves of fully grown plants
3) The leaves of dead plants

The responses of the cameras to these specimens is measured and compared to obtain the reference data.

The measured and processed data are shown in Fig. 6, Fig.7 and Fig. 8.

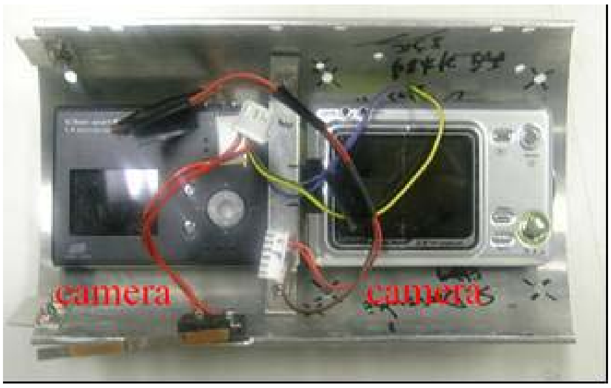


Fig.5 Two digital cameras system of Quasi-Satellite

Fig.6 Normal image

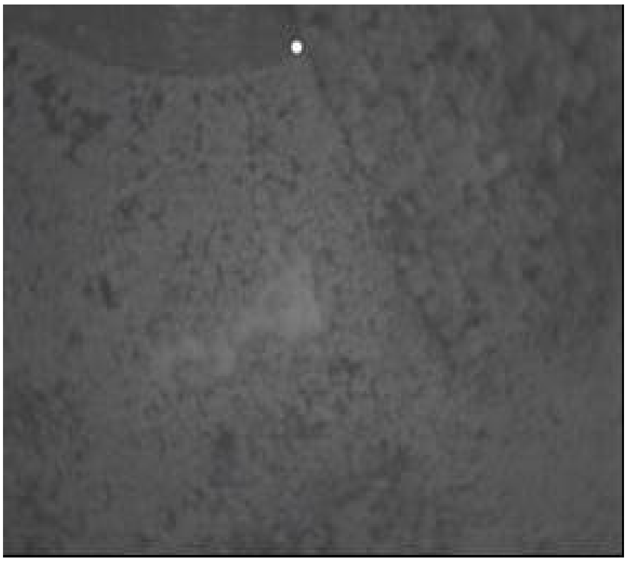


Fig.7 IR filtered image

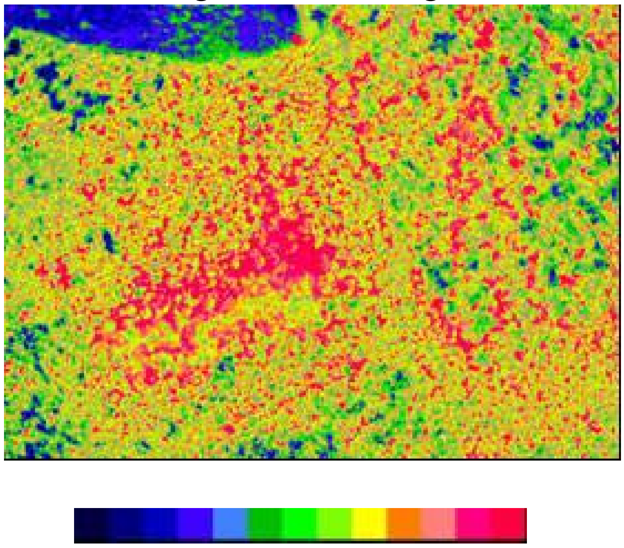


Fig.8 NDVI

6. Sensors

There are several sensors on board the 1st and 2nd stages. Some of these sensors are standard equipments in the future launches.

1) 1st stage:

Digital Camera - This camera monitors the stage separation, and may see the deployment of Quasi-Sat. if it's lucky.

Attitude Monitors - These sensors are developed to monitor the attitudes of the rocket itself. It has a thin bar floating on the viscous fluid. The inclination of the bar is measured by the linear CCD array. These data are sampled at 10 Hz, and stored in the memory up to 10 min. of duration.

Vibration Monitors - These monitors are to measure the steady acceleration of the rocket during its ascent. The fixed mass of 50 grams is supported by the spring on both sides. The system is tuned 22 Hz and the vibration below this frequency is monitored.

2) 2nd stage:

Video Camera - This camera looks forward and aft through the split mirror on the 1st stage fuselage.

The main purpose of this camera is to monitor the stage separation. It may monitor the ground of launching site.

Acceleration sensors -These sensors monitor the accelerations of the 2nd stage in two directions. The part of these sensor data are transmitted down to the ground station.

Pressure sensors -Two pressure sensors measure the total pressure and the static pressure to obtain the speed of the 2nd stage.

7. Conclusion

An amateur rocket UCG-05 is developed by Space club Gifu and Sasaki lab in Gifu University for attending the launching campaign organized by French association Planete Sciences in La Courtine and has been launched on July 29th gathering several French associations and University clubs. The two-staged experimental rocket reached 1000m and was able to capture a few images (optical and near infrared) of the ground. We summarize and make some conclusions about our project as follows:

The video on 2nd stage monitored the separation of the stages. Although the 2nd stage was recovered, the memory of this equipment could not properly be restored. The rocket could not be recovered for three days after the launch, and it had even rain during these 3 days. It wasn't the good condition for the video camera. Finally we could not recover the images of this equipment. The camera on 1st Stage monitored the separation of stages and the deployment of parachutes. The attitudes monitors and the vibration monitors were not on board the 1st stage, because of the lack of preparation time. The pressure sensors were not connected to the AD converters, because 2 out of 4 ADC were not functioning properly, because of the soldering problem. The accelerometer was under investigation.

As a whole, the program was a success. However, the system was rather weak in two aspects;

1) Data acquisition, including sensor data & images, should be given more attention to guarantee the data recovery.

2) Telemetry system should be reconsidered to guarantee the data transmission.

Finally, the authors would like to conclude that this project is excellent for the students to study and learn mechanical and electronic design, manufacturing, electronic circuit, computer programming and mechatronics.

Fig.9 Recovery of 1st Stage – In the Bush

Acknowledgement

This program has been created by the members of 'Space Club-Gifu' and Sasaki Lab. in Gifu University and the club has been invited by Science Planet of France to participate in their launching campaign at the site of La Courtine in France. Furthermore this program has been financially supported by the several organizations. We would like to express sincere thanks for their help and support.

Especially, the authors would like to express their sincere gratitude to Dr. Guy Pignolet of the Science Sainte Rose. Without his interest & support, this project had not been created.

UCG-05 ROCKET POST-FLIGHT QUICK REVIEW

Aug. 2005

Space Club-Gifu
Japan

- Contents -

1. Objectives

Uchuu Club-Gifu (UCG, Club-Espace de Gifu) has been evolved from the activities of long lasting endeavor of the YAC-Kakamigahara Chapter(YAC-K). In the beginning, YAC-K built a small experiment rocket and joined the World Wide Launching Campaign (WWLC) at Moumelon-le-petite in 1992.

Since then, YAC –K developed several ideas of small experiment rockets and water rockets, also hosted the Idea-Water-Rocket-Contest at Kakamigahara Aerospace Museum every year.

The members of UCG have found the future possibilities of small experiment rockets and Hi-Tech Water Rockets as a mean of tools in higher education, in the area of space technologies and flying robots. Thus the team or the group was formed among college students, engineers and owners of small firms.

UCG-05 Rocket has been in concept for quite some time now. This is the third try of this kind in Japan. First it was YAC-γ-92 Rocket in 1992 , the second KHR-96 in 1997 and UCG-05 in 2005. The first one was the single stage rocket with which the velocity and the acceleration were measured. KHR-96 had the two-stages, with no propulsion on the second stage. It had the velocity sensor, the disposable camera and the video camera on board. Both flew to the altitude of approx. 1 km.

UCG-05 has almost the same configuration as that of KHR-96. However, much progress in recent electronics has been incorporated. The objectives of this rocket are in two fields;

<u>Primary objective</u> : Monitor the vital activities of plants on the ground (Earth Observation).
To do this, the Quasi-Satellite with two digital cameras, one of which is equipped with a near infrared filter, will be on board the second stage.

<u>Secondary objective</u> : Accomplish the flight and confirm the designs of the two stage rocket (Engineering).
All the phases of the flight, including the launch, the stage separation, the recovery of each stage with a parachute, will be monitored and tested.

2. Team Members

Organization for UCG-05 Rocket Development

Team Leader : Professor Sasaki★
Sub Leader : Associate Professor Takahashi

Program Management	Dr. Ogimoto★, Mr. Nakamura★
Quasi-Satellite	Mr. Mizutani, Mr. Saeki, Mr. Akiyama, Mr.Sakou★
Rocket	Mr. Nakano★, Mr. Imamura★, Mr. Kudoh Mr. Ishida★, **Mr. Kato★**
Data Handling	Mr. Imamura★

Advisors : Ms. N Akiha (Tokyo), Dr. Guy Pignolet (Sainte Rose) ★
Translator : Ms. Takako Ogimoto★, **Ms. Mayo Matsushiro★**

Note ★ **: who will join the campaign in La Courtine.**

3. Part I (Primary objective)

- Major results
  - Quasi-Satellite(QS) did not separate properly from 2nd stage. Instead, it clung on 2nd stage with half deployed. However the images, both normal and Near Infra-Red(NIR), have been obtained as shown in Fig.3-1

  - The post flight analysis will be made soon, as has been done for the images obtained with the Hi-Tech Water Rocket shown in Fig.3-2.

Normal Image　1

Normal Image　2

Normal Image　3

NIR Image　1

NIR Image　2

NIR Image　3

Fig.3-1 Images by the Quasi-Sat Cameras（Upper Row：Normal Images　Lower Row：NIR Images）

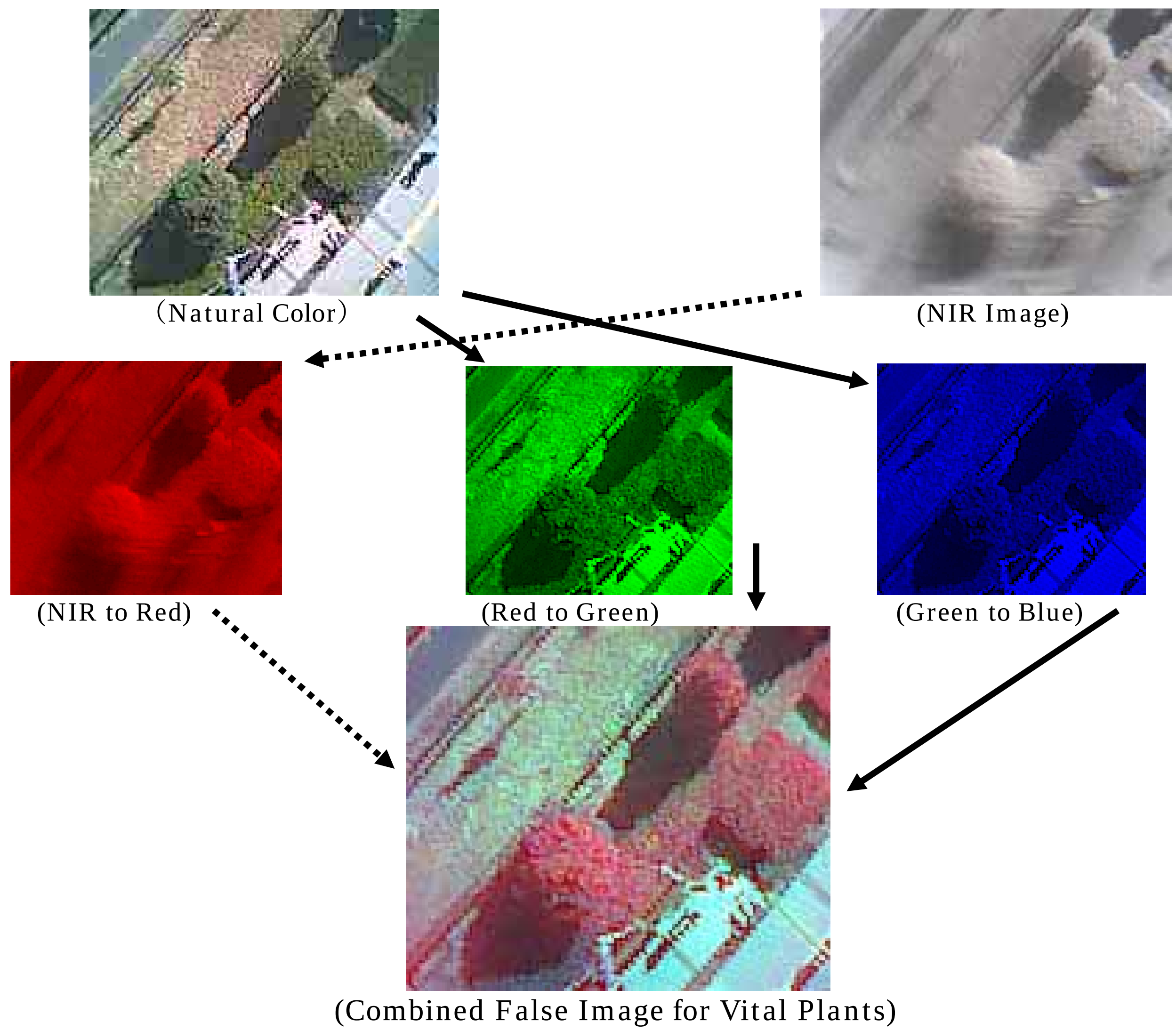


Fig.3-2 <u>Data Processing</u>

4. Part II (Secondary objective)

- System description

UCG-05 Rocket is the follow-on of YAC-γ-92 Rocket and KHR-96 Rocket. The configuration of this rocket is more or less the same as that of KHR-96, which had two stages. However, the recent progress of the electronics has been incorporated.

UCG-05 Rocket has the several unique features such as;

1) It has a Quasi-Satellite with digital cameras, one of which has a Near Infrared Optical Filter, as a payload. Also 3 redundant computer system will be tried.
2) It has a digital movie unit to monitor the stage separation, and several Linear CCD arrays to measure the attitudes and the vibration of the rocket during its flight.
3) On the first stage, the distributed controls of many functions with using several micro-computers.
4) It will be designed so that the vehicle will be reusable and ready whenever it has a payload. Namely, the Club has the intention to join the launching campaign regularly with the same rocket and with different missions.

(Configuration Fig.4-1, and Blockdiagram Fog.4-2 are shown.)

UCG-05 Rocket

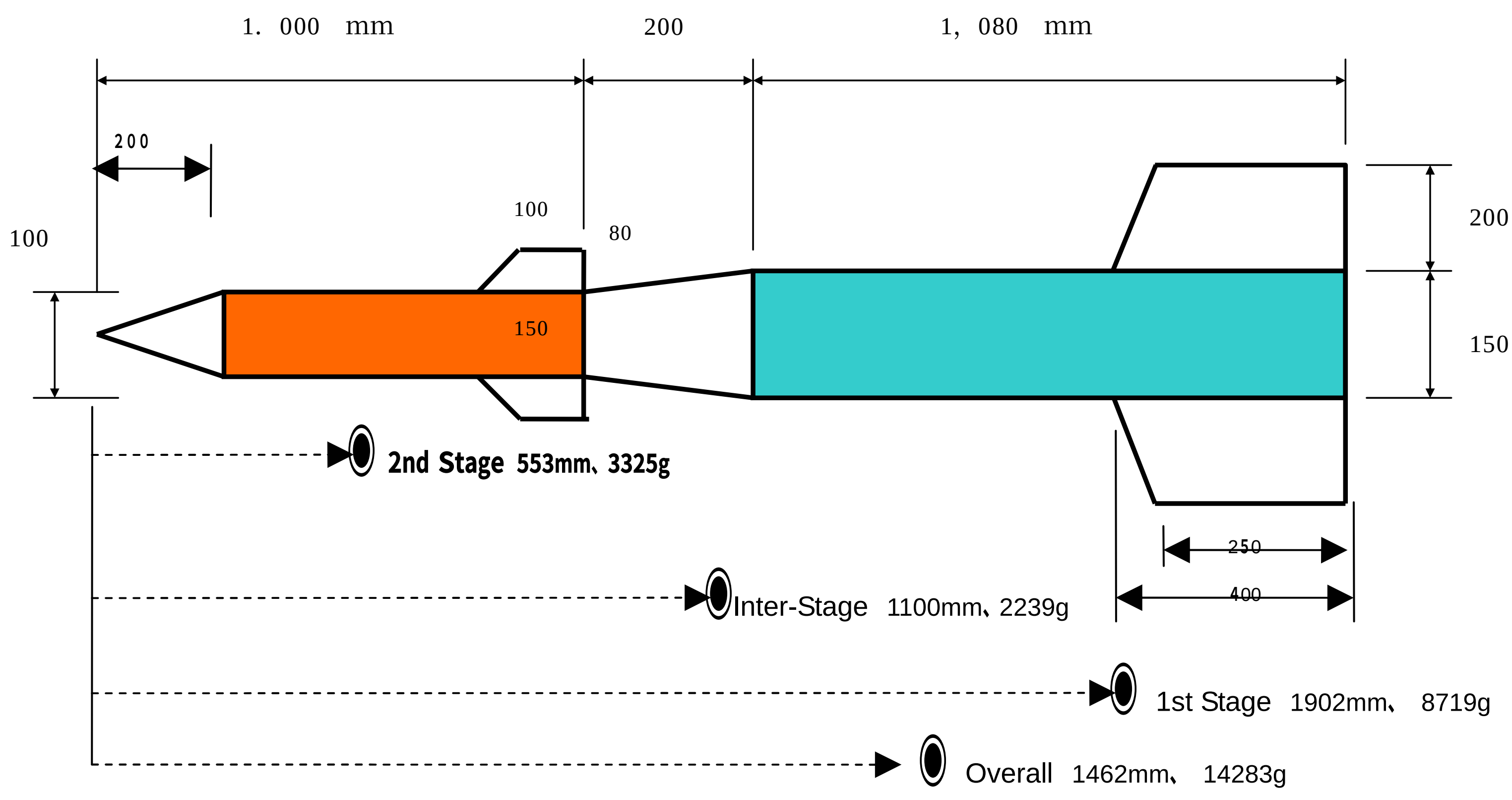


Fig.4-1　Configuration

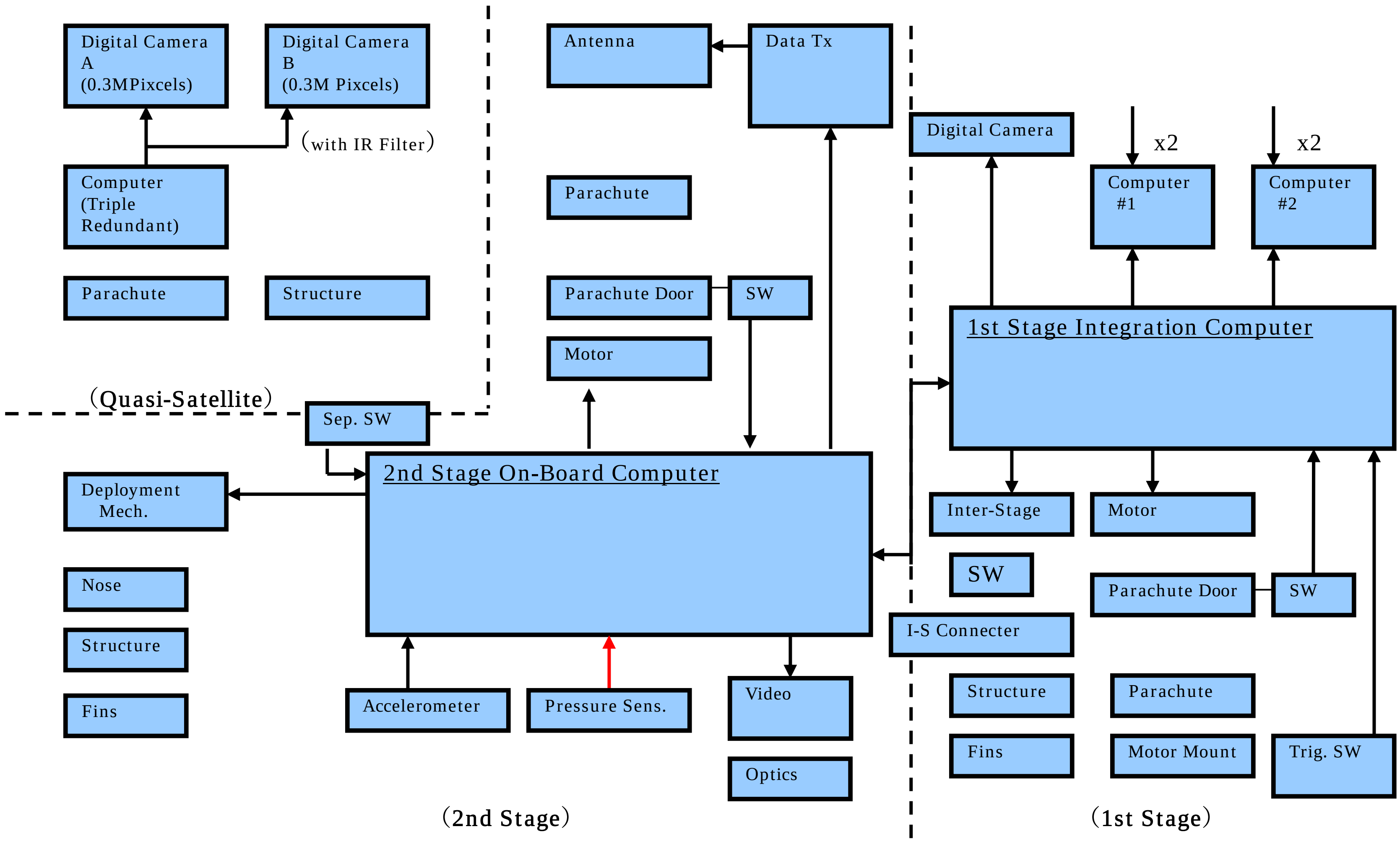


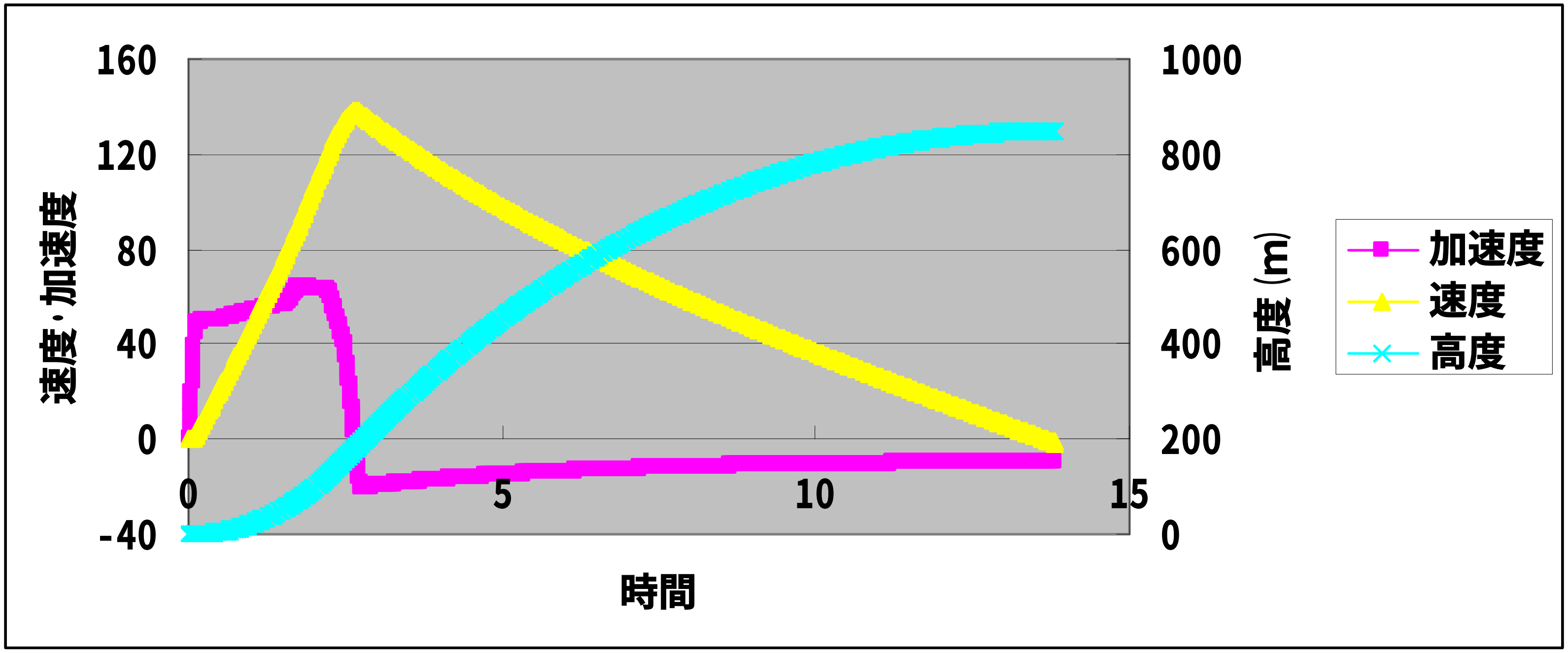
Fig.4-2 UCG-05 Rocket Blockdiagram (2005/07/29)

- Flight performances

The flight profile is shown below, Fig.4-3. Major performances are as follows, provided that the weight is approx. 15 Kg and the drag coefficient 0.3;

Maximum Altitude	:	848 meters at 13.7 seconds
Maximum Acceleration	:	64 meters/sec2 (approx. 6.4Gs)
Maximum Speed	:	138 meters/sec

Fig.4-3 Flight Trajectory : Altitude, Velocity & Acceleration vs Time



These figures will be evaluated through the accelerometer measured data.

- Flight Sequence

Major flight sequences were controlled by two main computers, and are as follows;

1) Trigger - by the lift off SW ------ Time count zero and initiate the flight computers.
2) +0 sec ------ Initiate the power supply ,and all the computers and the sensors.

3) + 8.5 sec ------ Engage the Stage Separation Mechanism and Separate the second stage from the first stage. 'A' should be around 13 seconds.
4) + 9.5 sec ------ Engage the parachute door of the first stage to deploy the parachute.
5) + 10.5 sec ------ Engage the Quasi-Sat Deployment Mechanism to throw the Sat. out.
6) + 11.5 sec ------ Engage the parachute door of the second stage.

These operations are quite critical since they should avoid two incidences. Namely, we would like to avoid the collision course between stages and Quasi-Sat., and to avoid the deployment of the parachutes at high speeds. In 1997, with KHR-96 rocket, we had the catastrophic results in which the deployment of the 1st stage parachute was occurred while the rocket still had some climbing speed and the sling wires were cut due to the strong drag force on the parachute. As a result, we lost 1st stage and its missions.

In the above sequence, we would like to engage the parachute door of the 1st stage soon after the stage separation so that 1st stage will be left behind to avoid the collision with the second stage. Then 1 second later, we would like to have Quasi-Sat deployed from the second stage. Hopefully at this moment, 1st stage should be a few meters behind the 2nd stage. The parachute of Quasi-Sat should be deployed soon after the ejection of the satellite. Finally 1.5 seconds later, the parachute of 2nd stage will be deployed and the Quasi-Sat will be far behind 2nd stage. From this picture, A should be the time when (velocity zero – 3.0 seconds – alpha).

The rocket will reach its maximum height around 13 seconds after the launch and comes back on the ground in 3 and a half minutes.

- Major Results

Video Camera: The video on 2nd stage monitored the separation of the stages. Although the 2nd stage was recovered, the memory of this equipment could not properly be restored. The rocket could not be recovered for three days after the launch, and it had even rain during these 3 days. It wasn't the good condition for the video camera. Finally we could not recover the images of this equipment.

Digital Camera: The camera on 1st Stage monitored the separation of stages and the deployment of parachutes. The separation of the stages are shown in Fig. 4-4.

Sensors: The attitudes monitors and the vibration monitors were not on board the 1st stage, because of the lack of preparation time.

The pressure sensors were not connected to the AD converters, because 2 out of 4 ADC were not functioning properly, because of the soldering problem.

The accelerometer : Under investigation.

As a whole, the program was a success. However, the system was rather weak in two aspects;

1) Data acquisition, including sensor data & images, should be given more attention to guarantee the the data recovery.
2) Telemetry system should be reconsidered to guarantee the data transmission.

Before the Separation (Ascent, Rear-Forward)

After the Separation (Descent, Rear-Forward)

Separation (Ascent, Rear-Forward)

Fig.4-4 Stage Separation (1st Stage Digital Camera)

5. Summary

This program has been created by the members of ‘Space Club-Gifu’, and the club has been invited by Science Planet of France to participate in their launching campaign at the site of La Courtine in France. Furthermore this program has been financially supported by the following organizations;

1) ‘Mizu to Midori’ Funds for International Exchange Program of Gifu Prefecture
2) UNICS Co. Ltd. of Higashi Osaka
3) Akiha Funds of Tokyo
4) Enomoto – BeA Co. Ltd. of Gifu
5) Kakamigahara Aero Equipment Co. Ltd. of Gifu
6) Tokuda Industries Co. Ltd. of Gifu
7) Ukai Co. Ltd of Gifu
8) Kato Manufacturing Co. Ltd of Gifu
9) Tenryu Manufacturing Co. Ltd of Gifu
10) Nikko Automation Co. Ltd of Gifu

Furthermore, several newspapers & TV stations has been interested in this program. Those are;

1) Asahi Newspaper
2) Gifu Newspaper
3) NHK TV Station (Ch 39, Gifu Local)
4) Chukyou TV Station

Several photos are presented in Fig. 5-1 and Fig.5-2, and the schedule on site is shown in Table 5-1.

Fusée UCG-05

Japon

Club Espace de Gifu
& Romance Space Club - Université de Gifu

Lancement

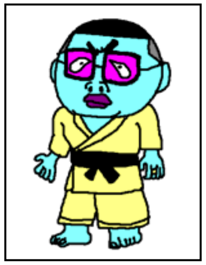
29 juillet 2005
La Courtine - France

Spécifications

Mission :
Observation de la Terre
Quasi-Satellite
(observaation des plantes
par caméra numérique
avec filtre Infra-Rouge)、

Dimensions : 15cm φ x220cm
Masse : 14 Kg
Type : Bi-étage
Altitude : environ 1 Km
Equipement :
Accéléromètre
(Capteur de Vitesse)
(Capteurs d'Attitude)
(Capteur de Vibrations)
Vidéo et photo numérique

Partenaires



UNICS Company Ltd.
NI Factory
Akiha Funds
ENOMOTO Bae Ltd.
Kakamigahara Aero Equipment
TOKUDA IndustriesLtd.
Fondation Mizu-to-Midori
de la Préfécture de Gifu
Science Sainte Rose
Planète Sciences
CNES
Ambassade de France au Japon
KATO Manufacturing Ltd.
UKAI Company Ltd.
NIKKO Automa Ltd.

Fig. 5-1 French Brouchure

(Inspection)

(Get-Together）

LA COURTINE ■ Des dizaines de fusées expérimentales lancées cette semaine au camp militaire

150 jeunes parés au décollage

ACCUEIL ■ Pose de la première pierre, à Naillat, d'une structure pour personnes âgées ou handicapées

(Local Newspaper)

(Mr. Oono of JAXA Paris Office）

(Before Launch)

(Launch　-07・29)

Fig 5-2(1/2)　The Lauch of UCG-05 Rocket (2005・07・24－31、　La Courtine　France）

(Descending of 2nd Stage)

(Recovery of 1st Stage – In the Bush)

(Recovery of 2nd Stage - On the Tree)

Fig 5-2(2/2) The Lauch of UCG-05 Rocket (2005・07・24－31、 La Courtine France）

Table 5-1 On Site Schedule

Date	July 23	24	25	26	27	28	29	30	31	Aug 01	02	Remarks
	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	
Controls												
Launches							UCG-05		Recovery			
Arrive La Court.		▲ 1st party		▲ 2nd party		▲ 3rd party						
Japan Day						▲						
Farewell									▲			
Leave La Court.									▲			
Leave Paris										▲		
Arrive Japan											▲	

1st Party : (8)

Ogimoto, Nakamura, Sakou, Imamura, Ishida, Katoh, Nakano, Pignolet

2nd Party : (1)

Sasaki

3rd Party : (2)

Ogimoto(Takako), Matsushiro