Project Research II:

BIRDS-3 Satellite Project's Approach to Project Management

Abhas Maskey (Student ID: 17595903)

Laboratory of Spacecraft Environment Interaction Engineering

Kyushu Institute of Technology

Advisor: Prof. Mengu Cho

1. Introduction

Joint Global Multi-Nation BIRDS Satellite Project (BIRDS) of Kyushu Institute of Technology (Kyutech) targets non space fairing nations to build, test, launch and operate their first satellites in under two years. BIRDS-1 had first satellites for Bangladesh, Ghana and Mongolia while BIRDS-2 had for Bhutan. BIRDS-3 mission statement was to successfully build and launch Nepal and Sri Lanka's first satellites. In April 17, 2019, BIRDS-3's constellation of three CubeSats were part of the payload bound for the International Space Station (ISS). On June 17, 2019, the satellites were deployed in orbit and have since been operational. All major missions have been completed. Fig. 1 shows project timeline.

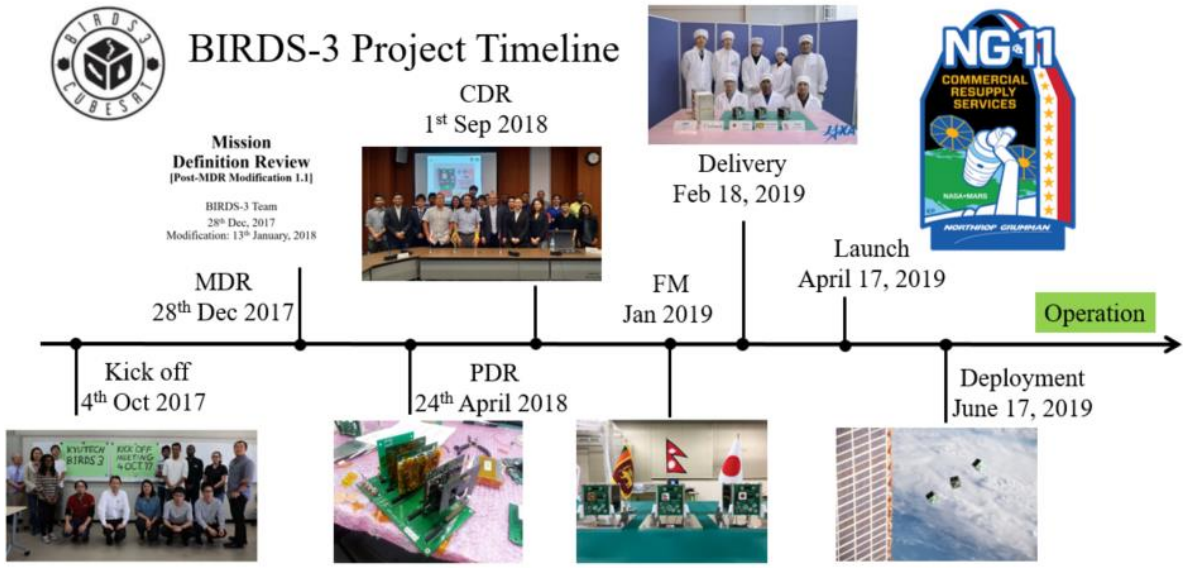

Figure 1. BIRDS-3 Development and Operation Schedule

BIRDS organizational structure has Principal Investigator (PI), staff, stakeholders and students. The supervision is done by PI and staff. The requirements and funding are provided by stakeholders from participating countries. The students are given the leadership role by assigning a Project Manager (PM) and is given full autonomy. BIRDS-3 had three PMs for the first three months from October to December 2019. After that, the team elected PM to lead the project for the rest of the time.

This report summarizes the work conducted by the PM of BIRDS-3. The role of the PM is defined in Chapter 2, BIRDS-3's work process in Chapter 3, team habits in Chapter 4. Chapter 5 concludes the report.

2. Project Manager Responsibilities

2.1 Traditional Responsibilities

Schedule: Make sure that the team understands what is expected in each phase of the development, testing and operation period. Schedule meetings, design reviews, book satellite testing facilities and ensure that coordination with IARU and JAXA is taking place on time.

Build Team Work: Understand that humans are first emotional and then rational beings. Understand the psychology behind the team and its members. Leverage that understanding to foster better working environment, team work, and ensure better mental and physical health of the members.

Coordinate: Coordinate, and ask help and support from other satellite teams during development, testing and operation. Ensure that there are no communication gap between teams that leads to misunderstandings later. Also coordinate and keep the staff informed of the work that is going on.

Assign: Divide work to members fairly. Make sure that if a portion of the team is overworked, that portion receives rest and others cover when necessary. Assign work according to capability of students and systematically improve member's capacity by providing them necessary incentives to work.

Explain the Why: With each step, explain the "Why." Explain the reason behind actions. Explain the importance of the work people are doing. Encourage people to understand underlying problems and explain why they were issues in the first place. This way, bring out a greater depth in understanding.

2.2 Extended Responsibilities

System Development: Since BIRDS-2, the PM is also assigned a subsystem to work on besides the base management that needs to be completed. This is usually the case either because 1) there is no one more suited to take over a system 2) there is not enough human resource

Last Resort: For BIRDS-3, the PM covers the work of anyone who calls in sick, has internship, has thesis work or has to leave for emergency reasons. The PM also checks all designs and test procedures before implementation. This way, if mistakes are made, the buck stops with PM.

3. BIRDS-3 Processes

3.1 Skill Building

BIRDS-3 identified key skills required for the project early on and made a concentrated effort to improve everyone's base levels. The skills were 1) PCB designing 2) C Programming 3) CAD 4) Soldering. With the volunteering help of BIRDS-1, BIRDS-2, HORYU-4 and its own members, BIRDS-3 hosted a series of short trainings on the skills. Team members who learned quickly then supported other members in raising their levels.

This early effort proved vital as the project matured. For instance, previous teams had one person assigned for PCB design, with another as a backup. As majority of the work in a CubeSat is PCB design, the load was higher during CDR and FM. This led to numerous mistakes during critical times and took a toll on the schedule.

BIRDS-3 avoided that as 1) PCB for each subsystem was assigned to the person in charge of the system 2) everyone was able to cross check 3) a series of checking processes were implemented before PCB manufacture. As a result, during the project, there was only one case of PCB error where the connector was placed reversed. To rectify this mistake, the structure lead was incorporated into the cross checking process to ensure that PCBs were consistent with CAD. The structure lead was previously trained on PCB design software and could easily comprehend a problem, if any.

3.2 Decision Making

There were two ways BIRDS-3's PM made a decision and implemented an action. Certain decisions relied on a vote of members of the team while others required stringent implementation without consent of the members. The balance was critical to establish certain control over the team, yet provide the freedom of expression for everyone to voice their concerns and disagreements. Details on how and when such decision making process was imposed has been discussed below:

Democratic Decision: Decisions that were made to 1) continue or discontinue a certain action after a period of experimentation 2) approach a certain challenge/problem 3) allow members to leave the team to complete a personal work were democratic in that they required input and ideas of everyone. In these circumstances, all members were asked on their opinion, perspective and view point. Only then did the PM make a decision and implement it. This democratic process was best served when

PM listened to everyone first and only then voiced his opinions later. That avoided possible confirmation biasing or changing of views by members.

Executive Decision: Decisions that required 1) stringent change of habit 2) organizational structuring 3) immediate actionable items were made without the consent of the team. Such decisions were usually very unpopular and if gone through the democratic process, would have found considerable resistance to change. Since PM had to think of long term gains for short term losses -and as long as these decisions were fair and explained properly- making direct decision was necessary. To ensure such decisions were not overturned, PM made the decision look in such a way that the greatest loss had to be tolerated by him. Case in point, the 9 AM rule where members were asked to be present at BIRDS room at 9 AM. In order to enforce such sudden change in habits, the PM had to come to 8:30 AM every day to 1) set an example 2) to check. As the PM had to come earlier, he was at a bigger loss in implementing his own executive decision.

3.3 Experimental Improvement

The PM had to ensure that there were incremental improvements in how the team functioned and worked. New ideas and systems requires a period of time to be tested and checked before it can be part of the workflow process. This allows decisions to either 1) continue 2) modify or 3) drop after feedback from the team. Ideas that seem logical would sometimes be less efficient than what was first perceived. An example is given in the next paragraph.

In agile software development, SCRUM is a popular workflow technique. One of the hallmarks of the technique is a 15 minute team meeting set every day at the earliest time to update on the progress. Each team member is allowed to speak. Team members discuss 1) issues 2) what they did 3) what they want to do. The BIRDS-3 experimented with similar daily meetings for two weeks and found out that for satellite projects, the work completion was slower. Usually a week was required before members could state tangible progress. The daily meetings were changed to meetings on every Mondays.

In case of 9AM rule, the experiment lasted longer as team member's sleep cycle needed time to adjust. After a month of encouraging students to be on time, talking to team members and looking at the long term benefits of having everyone at the same place at the earliest time possible, the PM decided to continue with the rule. This way, experimentation allowed the PM to make better decisions.

3.4 Minimal Working System First

Nepal and Sri Lanka's first satellites were built with BIRDS-3. The future of sustainable space program in these countries hinges on the performance of their first satellite. Working satellites provide both political and social backing. The aim was to build a satellite with maximum impact with the simplest system possible.

At every step, the team asked themselves what the bare minimum working system looked like. Once minimum was achieved, the team then worked on to improve functionality and reliability. This approach is different from teams which put very difficult requirements with many functions first. The hardware and software development work becomes complicated and worsens during critical times. If work remains, that has to be passed on to the next development stage. Such actions can put strain on the fixed, time-constraint schedule while allowing mistakes to slip in.

SNUSAT-1/1b from Seoul National University made that error. Rather than focusing on a simple system, the team designed the satellite to incorporate as many functions as possible. All functions could not be tested on time. There were hardware mistakes time and again. The software was unnecessarily complicated and debugging was much harder. Not all functions were able to be tested on the ground.

The satellites did not function in space until SNUSAT-1b sent beacon after a year in orbit. Until this day, the SNUSAT team is unable to explain why as there are no ground testing results. BIRDS-3 team, therefore, reversed the design philosophy to keep it simple, keep it working and have all functionality tested.

3.5 Scheduling

BIRDS-3 scheduling process is based on lessons taken from HORYU-4 satellite project. Horyu-4 used a reverse-scheduling technique where a checkpoint such as a design review is first fixed. The necessary parameters for that design review is outlined and the scheduling process begins thereafter. The next paragraph illustrates the idea.

In case of Critical Design Review (CDR), a system-level proof of concept has to be presented. Given that the CDR is scheduled at December's end, all environmental tests on the Engineering Model (EM) has to be completed in the first half of that month. Environment tests require EM to be integrated and the basic functionality working. In that case, system-level integration has to commence at the beginning of November. For integration, all PCBs and structures have to arrive on time. There should be enough time to rectify errors. In such cases, PCB design has be completed and ordered by beginning of October, worst case. The reverse-scheduling logic proceeds further in a similar fashion.

What the technique does is by first enlisting and systematically breaking down the steps towards a checkpoint and then reverse-scheduling each step from that point backward, the PM can estimate whether there is enough time for each development to take place and estimate the time buffers for mistakes. Planning fallacy is extremely common where teams underestimate the time required for something to be completed. To tackle this, the PM can sometimes hide certain schedules from the team in order to create a consistent "state of urgency" similar to development process used at fast product cycle output companies like Samsung.

For instance, using the same example as before, if CDR is at the end of December, the PM can over-book the testing facilities from mid-November up to mid-December to test EM. However, team members are only given the information that the facility has been booked up to end of November. This allows 1) PM to encourage the team to work in a concentrated, faster rate to meet a fake deadline 2) enough time if something goes wrong during the testing as the test facility is still booked.

3.6 Communication

What makes BIRDS satellite project so unique is also the reason why it makes project management so challenging. The essence of any functional team lies on how effectively members can communicate between one another. BIRDS are a team with different nationalities, and people from completely different cultural and working backgrounds. The PM has the challenge of ensuring that there is a baseline uniformity in working habits and importantly, in how the team communicates. The most critical of all, communication between foreign and domestic students as Japanese are the backbone of any BIRDS team.

Between the use of Japanese and English, English has the upper hand as 1) it is the lingua-franca for science 2) hierarchy is not present and is direct 3) it is only the Japanese who have to improve how to listen and speak. If foreign students are to learn Japanese, they would have to learn from the very beginning. In the initial stages of the project, there were number of cases where A was explained, B was understood, C was implemented, resulted in D and wasted everyone's time. Since formation and understanding of language is a minutely incremental process, a stop-gap solution was implemented in BIRDS-3 as described in the next paragraph.

After each meeting, the Japanese students were asked individually what portion of the discussion was not understood. Everyone was requested to be as direct as possible while also asking specific questions when the reply was “maybe.” To investigate what Japanese really think, the PM consistently asked the same question a couple of times in order to ensure that what they said and what they think matches. While socially awkward and not natural, such systems allowed the Japanese to convey information better. As the project progressed, the conversations became more direct.

Foreign students were also asked to simplify spoken English by minimizing use of complicated and long sentences to explain a point. Often, a white board or a piece of paper was used in between members. Each point or decision was asked to be repeated by the other person to see if the information had been properly understood. Although the process took more time and effort, it reduced the chances of error in the future. This saved time later in critical stages of the project by allowing team members to understand what was exactly expected from each other.

3.7 Leadership Decentralization

While PM leads the team, there are often times when leadership roles have to be switched in order for a member to have proper control and have an action completed. For instance, during Long Range Tests (LRT), the COM lead was empowered to lead the testing efforts. During software system level integration, OBC lead took leadership. During solar panel assembly, EPS lead took charge. Likewise, during FM, Structure lead took leadership role. The PM ensured, from the background, that everyone followed the instructions and supported the member in charge. This role-switching had the advantage of 1) training students to take leadership positions 2) taking responsibility for their actions 3) training to plan ahead and think of worst case scenarios 4) making them feel important and part of the process.

4. Team Habits Discussion

4.1 9 AM Rule

All team members had to come to BIRDS room by 9 AM. There were a number of instances where members who came early had to work with people who came late. This was especially true during system integration period. Any problems that needed to be solved had to wait until the member in question arrived. This led to unnecessary waiting and time wasting. A period of time had to be allocated in such a way that all members were guaranteed to be present in the development room. BIRDS-1 and BIRDS-2 had core work time implemented. BIRDS-3 moved it up to morning at 9 AM but allowed members to leave at any time. The logic was that whatever got stuck on the previous day could be either solved or discussed first thing early morning. This way, there would be some headway in the project by midday.

4.2 Scenario Preparation

PM was responsible to ensure the team was ready for each and every scenario. An effective method had been to imagine an action beforehand. The action was broken down into several smaller steps. The step-wise exercise allowed teams to identify what could go wrong. Scenarios were outlined and plans were made to mitigate if something were to go wrong.

This preparation was not only useful to prepare for worst-case situations. The process saved time in identifying what tools and equipment were needed for Device under Testing (DUT). During Long Range Tests (LRT), the team had to go to Mt. Sarakura several times. There was no excuse for missing out on important test materials required to do the testing. Before leaving the lab, imagining the test as if it was done allowed members to pinpoint what items were needed to be taken, what actions were

required and what could go wrong. All of BIRDS-3's three LRT was successfully completed without hiccups.

Scenario preparation was also useful during FM integration. The time spent inside the clean room was limited as wearing additional clothing such as mask, clean robe and gloves for a prolonged period of time was not ideal. Tiring members could then make mistakes which would put unwanted strain in the schedule. All scenarios for the day were discussed before moving into the clean room. Only a limited amount of work had to be completed to keep process simple. This kept students fresh and prepared. The process ensured that when things did go wrong, there was no panic. This way, BIRDS-3 team was able to complete FM as scheduled and on time.

4.3 Short Core-team Meetings on Monday and Friday

The 9 AM rule also created the basis for short early morning meetings. The formal meetings with the staff were set every Wednesday. This allowed students to interact in a formal setting, however, there were number of informal issues which would either be ignored or not discussed in front of staff. Such situations required another set of meetings.

Initially, the meetings were only implemented on Mondays. The PM would outline the work that needed to be complete for the week and make sure each member understood the steps to complete the work assigned to them. The Monday meetings would also check what work was not done in the previous week and understand the issues and bottlenecks. Instead of punishing or castigating a member for not completing, "how should we help you to finish the work" approach was taken. The result of this discussion often led to finding solutions to underlying problems, allocating resources and helping each other when needed.

Friday meetings began after CDR when preparation needed further discussions. Monday prepared the team for what had to be done for the week. Friday looked back at the week to discuss what was not done, problems and challenges, and if any member would require to come during the weekend.

4.4 Unnecessary Travel Discouraged

During the entire development time of the satellites, members were discouraged to take personal travel that involved weekdays. If a single member was allowed to take time off and travel, the PM had to be fair and allow the rest of the members to travel as well. This would create unnecessary delays in development time, not to mention the lag time in which the person is again mentally switched to work.

To offset travel restrictions, BIRDS-3 team took team trips together instead to Nagasaki, Izumo and Itoshima after every important checkpoint. This allowed members to better connect with one another, discuss topics other than satellites and create a better bond that would create a basis for better working conditions. The idea was loosely based on Membership Trainings (MT) that university clubs and laboratories in Korea undertook for a few days to take a break from break-neck pace at which work was done.

Members were, however, given time off to work on their thesis, examinations, conferences and internships. They were also given breaks when load on a single member was higher for a sustained period of time. During this time, the PM would step in and cover the work that was assigned until the member was back.

4.5 Monthly Potluck

Monthly potlucks were organized at the last Saturday of every month. The tradition allowed 1) members to cook together and share 2) talk about other issues than the project 3) meet new people. BIRDS-3 had invited other satellite teams including HORYU, BIRDS-1, BIRDS-2, BIRDS-4, Tenkoh and SPATIUM teams for potluck events. The potluck provided a platform of informal exchange between team members and build connections over good food and drinks.

5. Conclusion

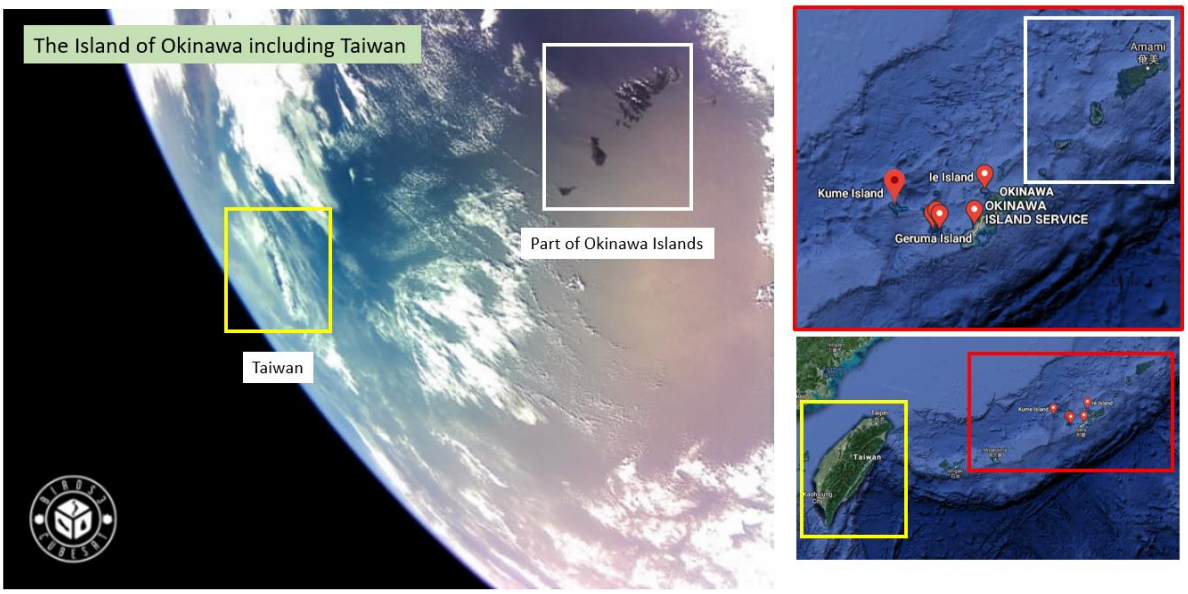

Figure 2. At the time of this writing, the BIRDS-3 satellites are in their tenth month of operations.

This paper discussed the underlying principles, habits and working structure of BIRDS-3. The report elaborated on what worked and what the logic behind the actions were. The PM was ultimately responsible to form the backbone that created a working culture, ensured that the project ran on time and that work was distributed fairly.

At the time of writing, the satellites are at tenth month of operations. Fig. 2 shows image of Taiwan and islands in Okinawa, Japan. The current challenge for the PM has been to further streamline the operations process, incentivise people to conduct the satellite operations and coordinate between members of the BIRDS Ground Station Network (GSN). The operations are predicted to last for two years in total.