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From thin-air to flat-sat in 12 months; the TwenteSat student project

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TwenteSat aims to build a twin-satellite interferometer in space, a research satellite system in preparation of the OLFAR project. The project will be completely done by students that work on a voluntary basis. The target is to have a flat-sat of at least one of the satellites ready in a short timeframe, the reason for this is the wish to get relatively quick results as most students can't work on the project for a long time, ideal would be 12 months A.K.A. 1 year of study. The first research on the project was done by September 2013 and most of the recruiting and acquiring finances still has to be done at this point in time. As a result of this the student team will face several problems. They have to adapt to working with a quickly changing group as the Twentesat student project experiences a generally high workforce turnover, and they need speedy access to money while still being highly unknown to the outside world. This paper analyses the group's activities and future plans on how to achieve their goal of quickly building a flat-sat. As it is not possible to trust on the fact that students will stay involved for a long time projects will have to be divided in small tasks that students can start on quickly, won't take too long, and can be done independently from other tasks. This will help future educational student projects to launch more successfully and with less problems.

I. INTRODUCTION

This research will create a method of organisation that hopes to improve the creation of nano-satellites in a small timeframe, specifically aimed at working with volunteering students as your main workforce. The Twentesat foundation, with their LOAS project[1], will be used as a case throughout the research. LOAS is a twin-satellite interferometer, a research satellite in preparation of the OLFAR project.

The advantages of students are that they have a high education and are often willing to work for other things than a financial reward, they can be satisfied with improving their Curriculum[2]. This can significantly reduce the costs involved with the overall project.

Working with volunteering students also has its disadvantages as was experienced by Twentesat:

1. You will have a high employee turnover.

1.1. Students cannot be enticed with financial rewards and there is a change that they will not stay with the project for a very long time because of this.

1.2. Students will finish their study. Changing their opinions about how they want to be rewarded for their work.

2. Students will want to see results from their work (that they can mention on their CV for).

2.1. Satellite development time is often several years.

3. Students have low work experience in general.

3.1. They are very young and often have no engineering experience at a full time job. This influences their knowledge but could also influence their expectations and satisfaction.

This research aims to create a form of organisation that is based on working with the above mentioned problems and optimally utilises volunteering students. The research goal is to increase the speed of Twentesats project and to make it easier to create successful student projects in the future. The research question in this paper is: "What form of organisation best suits a technical project that has volunteering students as its main workforce?"

This paper will first look at the aforementioned problems with using volunteering students and will look to literature to find factors that come into play. Then a framework to model an organisational form is devised that should help to optimally utilise volunteering students. This framework will be used to create a proper organisational structure for the Twentesat foundation and a conclusion will follow.

II. DEALING WITH USING STUDENTS

II.I High employee turnover

A high employee turnover can be harmful to a company but if you look at economic performance other factors play a much bigger role in the variance[3]. With volunteers you cannot offer financial rewards, one of the hygiene factors of job satisfaction according to Herzberg's two-factor theory[4], and hygiene factors seem to be highly important in the public sector: *"those who worked in the public sector tended to value the extrinsic or hygiene factors significantly higher than those in the private sector."*[5].

II.II. Creating results

Having a sense of personal achievement is one of the motivating factors of Herzberg's two-factor theory, as well as getting recognition for your work (Herzberg, Mausner, & Snyderman, 1959). From the experiences with Twentesat we can say students want to see some tangible results of the time they invest into the project, preferably a result they can show off with.

II.III Low work experience

"Comparison of newly hired nursing graduates in their first hospital staff nurse positions and newly hired experienced nurses employed in the same hospitals revealed that the two groups were indistinguishable with respect to turnover patterns and rates, job hunting behavior, and job satisfaction levels."[6]. So it seems that the low working experience does not influence turnover or satisfaction persé but it could still be bad for their job knowledge.

III. FRAMEWORK SOLUTION

To overcome the high turnover ratio you need to assign tasks to the students that they can finish in a short time. This increases the change that they finish the task before they lose interest, that less work is wasted if they stop suddenly and the task can't be properly taken over and to increase their sights on have a result to show for. The framework will thus have to make an organisational form that can handle many small tasks to get the required results. Small tasks require a smaller budget in general so often you can start working on these tasks more quickly.

To overcome the low working experience without having to build that up yourself you'll have to look at the experiences the students do have. As students will have and/or do student assignments during their study this framework recommends to build the task descriptions in a similar fashion to what the students are used to in their study[*]. Not only will the students have some experience with this way of working, students also might perceive this extra experience as valuable to their study. This experience can help them to get started faster and achieve results faster.

As the work is divided in many small tasks and you want to have something to show for quickly, both to improve student satisfaction and to apply for financing, you will have to do a lot of work parallel. This requires careful planning from the organisers of the project. Not only will they have to divide the work on the satellite in many small projects, each tailored to the student that is given the task, you will have to give highly specific specifications due to the high requirements for satellites. Replacing one component for another similar object can have a big impact on some factors like centre of gravity for example. You will also have to think of the software, especially when working parallel, you have to decide on a very clear communication protocol in advance so each section of the satellite can be simulated/tested individually.

In figure 1 the above is illustrated in simple steps. These tasks are to be made during the design phase of the project and should help students to go straight into the development phase without much training in the overall satellite objectives. Students should be able to fulfil each task as if it were an individual student assignment. In the next section this paper will look at how this framework can be applied to Twentesat to have an organisation that is framed around working with projects that are divided in small tasks.

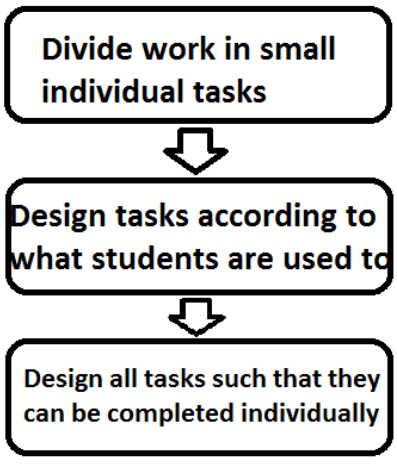

Fig. 1: Guideline on splitting the project into tasks for students.

[*] The way assignments generally work can differ between countries, universities, faculties, studies and even different tracks in a study. Tasks that are familiar to students from one study may be very alien to students from another study.

IV. TWENTESAT

Twentesat is a foundation founded by students. It aims to allow students to create satellites and its first project is LOAS (Low-frequency Astronomy Satellite). As the participating students were all technical students at the projects start Twentesat had a rough start with a lot of people leaving the project early on. As mentioned in the introduction this was mainly caused by students expecting results while satellite development is a long-lasting project.

LOAS is actually a twin-satellite interferometer that aims to measure low frequency signals in space. It has the goal to provide useful information for the Orbital Low Frequency ARray (OLFAR) project that has the mission to measure low frequency signals (<30MHz). Because of ionospheric scintillation below 30MHz these astronomic signals are hard to pick up at earth. A single space telescope measuring signals with these frequency would have to be huge and so interferometry is used. Twentesat aims to do interferometry at 30MHz, close to what OLFAR hopes to achieve but still comparable with data on earth, with two satellites. Problems for Twentesat are in intersatellite communication between two small cubesats and achieving an optimal baseline.

After the LOAS project was dragging on for a long time without much process the project was kicked back into the definition phase, currently the definition phase is being finalised soon and work on the design phase is about to be started again. In this small case study one of the pitched design ideas will be analysed and the framework from this research will be applied.

One of the big problems with picking up low frequencies is the long baseline you need. For OLFAR a baseline of over a 100 kilometres would be ideal but this was not deemed achievable by Twentesat for their project. Though the definition phase does state that a longer baseline is better, a specific baseline distance is left to be decided in the design phase. One of the pitched ideas is to use a tether of a 100 meters long. For this you need to build a tether capable of surviving space and able to withstand the force the satellites have on the tether, while still being compact enough to fit in a cubesat. This tether has to be unfolded and the tether has to remain tense to achieve a constant baseline. You can divide this part of the project into the following tasks:

1. Making the tether.
   - 1.1. Decide on achievable length.
   - 1.2. Decide on material for tether.
   - 1.3. Create tether.
2. Unfolding the tether.
   - 2.1. Design unfolding mechanism
   - 2.2. Create unfolding mechanism
3. Keeping the tether tense
   - 3.1. Find orbital/attitude situation
   - 3.2. Design mechanic to keep tether tense in orbit.
   - 3.3. Create above mechanic
4. Integrate everything into 1 system

As Twentesat currently only has students from the University of Twente every task has to be assigned in a way typical for the university. For example the European Credit Transfer System (ECTS) can be used to give the tasks a project or time rating. You should try to keep these low. As you will probably use mostly mechanical engineers you will have to look at how assignments for the mechanical engineering study are typically given and supervised and you should adapt the task to this system. This way the student should be able to start working instantly.

In this case it will be hard to design each task so that they can be done individually as there are a lot of dependencies. The design of the unfolding mechanism is dependent on length and material for example and so is the mechanism that has to keep the tether tense. But after you decided on length you can start working on deciding on the material and to find the orbital situation, after these tasks are done you can have people start with the design tasks and the creation tasks can all be done in parallel. Every task can have its own final research result and every task group (making the tether, unfolding the tether, and keeping the tether tense, integrating everything) will produce its own tangible end result that the students can show off with.

Problems in this case are that tasks are still dependent on the results of other parts and you can't fix this with providing clear specifications. This would be less of a problem in software if you can provide a clear communication protocol in advance for example.

V. CONCLUSIONS & FURTHER RESEARCH

As it will be hard to keep volunteering students with the project you will need to organise the project in such a way that you can divide it in very specific small tasks that produce a clear result. Financial rewards are an important factor to battle a high workforce turnover and as students will want to work for free if it improves their CV you can better have them produce results quickly. By first dividing the project in small tasks, designing and presenting them in a form students are familiar with, and by making them as independent from other tasks as possible you can quickly set students to work to quickly produce results. This way there is not much time lost if a student stops before the project is finished as it will only impact a relatively small task, students are also never far from achieving some results.

V.I Limitations

It has to be kept in mind that not every task can be independent from other parts of the project and delays in one task can still influence other tasks, not can everything be done in parallel. Furthermore it requires strong planning from the management and an in-depth

knowledge of the subject to be able to create a very specific task. To manage all the tasks you will still need a management team that stays for a longer time period.

V.II Further research

Further research can be done on lowering the workforce turnover rate, even though no financial rewards will always have a big impact this paper didn't much focus on the other factors that come into play. It will also be very useful to get an early estimate of how long students will remain with the project so you can give them the tasks that take longer or place them in a management position.

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