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A Case Study on the Impact of Communication Practices on the Productivity of a Design Team

Tryston Blake Gilbert

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by

Tryston Blake Gilbert

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Abstract

The 2013-2014 UAH Student Launch team was analyzed from the perspective of team dynamics and compared to the previous year's team. Their Myers-Briggs types were recorded, strengths and weaknesses of the current team organization scheme were analyzed, and the information was used to generate solutions for team formation, subteam leader selection, and other practices for use by future teams.

Honors Thesis Advisor: Dr. David Lineberry
Research Engineer

Advisor  Date 5-2-2014

Department Chair  Date 5-2-2014

Honors College Director  Date 5-5-14

In the modern classroom, workplace, and project site, the most important work is too great for an individual to accomplish. Instead, teams and groups form together to work on these large projects. Working in groups involves expertise on the topic at hand, good work ethic, and common sense, but those are the same qualities an individual would need to accomplish the task. The formation of a group adds many other dimensions, including the sharing of information, compartmentalization of responsibilities, and the need for a sense of trust among group members. Often, the difficulties of working with others are more of a hindrance to successful group membership and quality of work than the difficulty of the task in question.

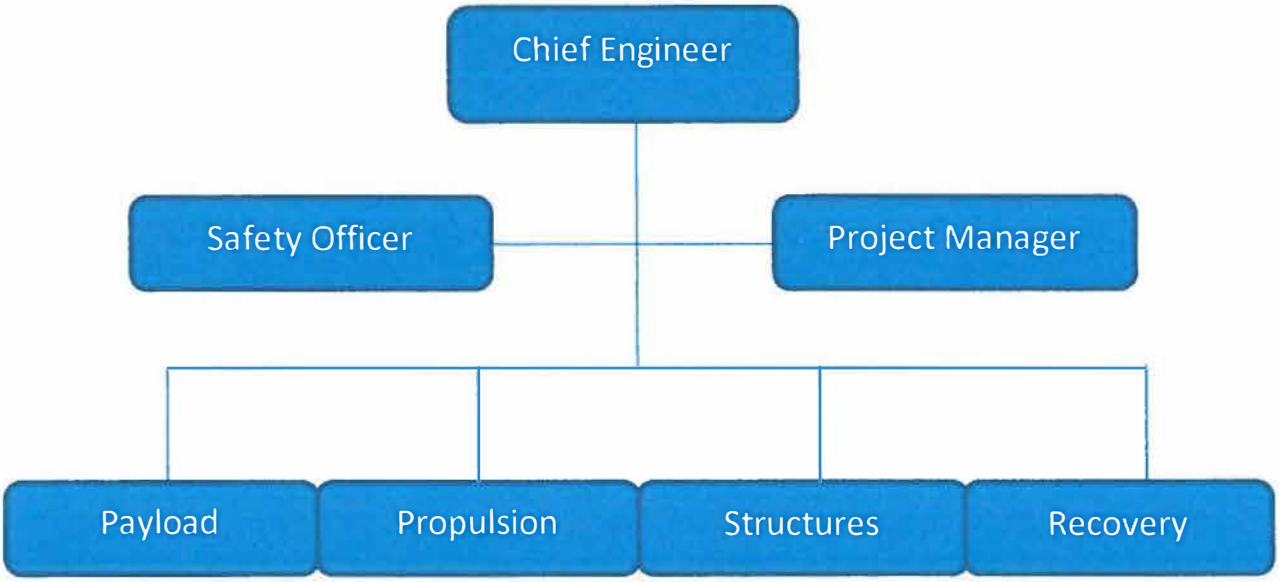
The difficulties that arise between group members are often difficult to understand. People on both sides may perceive the other as not taking something seriously, having very little knowledge – and thus little authority – on a given topic, or as having a personal vendetta against another member. With a little bit of coordinated effort to understand different team members perspectives, personalities, and preferences, a team can become a more cohesive and effective unit than it otherwise would be.

To study one case of how a team's human elements affected it's success, a few surveys and interviews were performed to analyze this years Student Launch Initiative team at UAH. Charger Rocket Works is formed every year from Mechanical and Aerospace Engineering students who take the Rocket Design Senior Project course. The team designs a rocket to fly one or more scientific payloads in NASA's University Student Launch Initiative competition. This year, an additional payload is being flown for Nanolaunch 1200, a NASA project to create a small-scale launch vehicle capable of putting microsatellite payloads into Earth's orbit.

In previous years, students who enrolled in this course had overall negative experiences concerning their teammates and the project as a whole. While some of these grievances were certainly due to the demanding nature of the project, the majority had more to do with tension between team members. One of the goals of this case study was to detect similar issues as they arose within this year's team, but members this year have had outstandingly positive opinions of each other. When this became clear, this study's focus shifted to determining *why* there was so little tension compared to previous teams, and understanding what contributed to inefficiencies in the design and work process.

Organization of last year's team

The 2012-2013 SLI team followed a layout typical to many design teams where each group focused on a particular component of the product, in this case, the rocket. The teams were typically small, hosting roughly two to four members per team. They were organized as in the following figure.



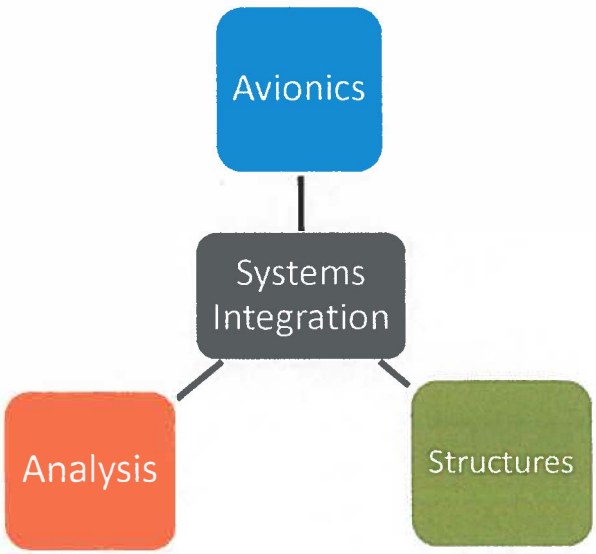
In this scheme, the four teams are overseen by the three managerial positions who focus on systems level issues, challenges, and plans. The Payload team focuses on the scientific payload to be launched. The Propulsion team focuses on trajectory, motor selection and integration. The Structures team designed and constructed the airframe to accommodate the other systems. The Recovery team focused on the parachute and electronics needed to recover the rocket successfully. The Chief engineer made decisions when multiple design options were available and aided in the design processes of the other teams. The Safety officer checked all designs made by other teams to verify that they met the safety requirements of the competition. Finally, the project manager planned meetings, set up deadlines, delegated tasks and performed other duties to organize the way the team met its goals.

In practice, some conflicts caused a lot of strife in this team. The Chief Engineer and the Structures Team Lead had some interpersonal conflict that affected the rest of the team and eventually caused the Chief Engineer to decide to resign from that leadership capacity. While it is impossible to say who was at fault, interviews with members of that team have stated that the Structures Team Lead offered very little of his time to the team – shrugging off responsibilities when people depended on him and neglecting to show up to important events. Other perspectives were that the Chief Engineer felt disrespected by this Team Lead and made some hasty and irrational decisions in response. Members of the recovery team, in particular, felt that her leadership was lacking, and wound up meeting separately from the rest of the design team because they had so little faith in the way things were being done. The conflicts festered out of view because the Chief Engineer and the Structures Lead expressed many of their grievances with each other through a private email thread.
This is not an uncommon problem in engineering design teams. The majority of engineers register as Introverts on the Myerrs Briggs personality test, meaning they find argument

exhausting and tend to avoid it. However, avoiding a source of conflict rarely neutralizes it, and it can become a larger problem when it's not confronted. In the case of this team, even though people weren't openly talking about the problem, everyone had their own thoughts about it, so it affected each member's perception of one or both of the members involved.
The instructor eventually resorted to calling an outside group unity and teamwork expert to visit the team. Unfortunately, the Team Lead whom many people had issue with didn't even make it to this expert's talk. Eventually, the team member who had no part in the conflict and the ones who managed to get past it came together and created a rocket for the competition, but it wasn't really a team project the way it was expected to be. Many people from the team never wanted anything to do with one another after it was all over.

This Year's Organization

This year, the team brainstormed a few different ways to organize the team. The decision that was settled on was one where teams were organized according to the type of work they were doing, instead of what section of the rocket was being worked on. The three subteams were Analysis, Avionics, and Structures. Analysis did airframe structural analysis, Computational fluid dynamics, flight simulations, and other mathematically challenging assignments. Structures handled the physical design of the entire rocket, managing Computer aided design files, laying up Carbon Fiber parts, building subscale component testing rockets, and ordering hardware for assembly. Avionics handled all the electronics in the Rocket, such as those for the payloads, recovery system, and tracking devices. There was still a central management team, but it only contained two dedicated members – the Safety Officer and Chief Engineer. The other members were the team leads of the various subteams. The organization can be described with the following diagram.



This method of organizing the team has many benefits, listed below.

- People can work primarily on the kind of tasks that interest them.
- Management is merged with the subteams through the team leads. The Systems Integration team makes the big decisions about the project as a cohesive unit, where each member has a degree of authority. Since they are also members of their respective subteams, this improves team cohesion overall and removes extra overhead that can restrict communication
- Larger team size means that for any given task, several people are available to work on it.
- Since every team's expertise is required for many of the components, there is a lot of communication between subteams, which breeds interdependency and cohesiveness. The two-way communication ensures that a great deal of thought goes into each aspect of the design.

This system also has some problematic characteristics, to which this study proposes solutions.

- Team Leads can become information bottlenecks a variety of ways
    - A team lead who wishes to do much of the work on their own starts poor delegation habits, which deprives his team of initial design knowledge. When the workflow increases beyond what one person can do, the team members who have to take up the slack are not caught up to the current state of the project.
    - This can also lead to team members' not having an accurate perception of the scale of work that needs to be done, so that they have a reduced sense of urgency.
- Team Leads can become overworked and overwhelmed due to being involved with tasks and with managing other team members who may lack initiative due to the reduced sense of urgency discussed above.
- Individual Team members have an incomplete view of the project, and may not know what their work accomplishes, because a lot of the work is centralized.
    - This last point has been partially remedied this year by encouraging members of different subteams to work directly together, rather than waiting for information and assignments to come from the team leads.

This year's team members have maintained a more optimistic outlook on the project than the previous year's team did. The team structure likely contributed to this, but the personalities of team member and their perception of the design challenge mattered as much or more.

Entitativity Scale

Entitativity is defined as "the degree of having the nature of an entity, of having real existence". It is a metric by which the 'groupness' of a collection of people can be measured.

An entitativity scale developed by UAH Professor Sandra Carpenter was used to survey the class to determine how well the group exhibited this quality. 7 questions measure seven different qualities of a group, as perceived by the person taking the survey, on a scale of 1 to 5.

A copy of the Entitativity survey looks like this:

How much does each characteristic apply to the group?

1 Strongly Disagree	2 Somewhat Disagree	3 Neither Agree nor	4 Somewhat Agree	5 Strongly Agree

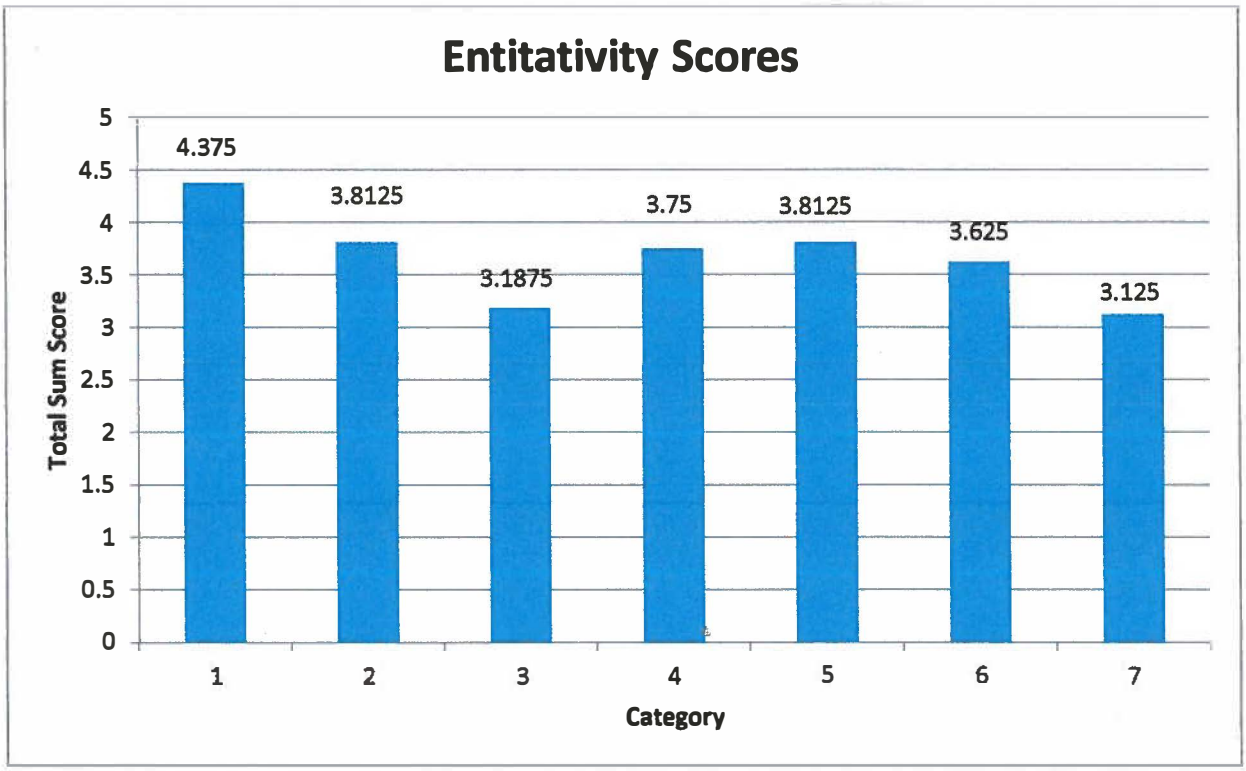
Quality	
1. Different members of the group have different "jobs" as members (roles, tasks)	
2. If something good or bad happened to one member, it affects all members	
3. This group is a coherent entity, rather than just a bunch of individuals	
4. The group has an organized structure	
5. Group members stick together and remained united	
6. Group members are interdependent, depending on each other	
7. The group resists any forces attempting to disrupt it	

The questions measure the following qualities in this order:

1. Different roles
2. Common Fate
3. Coherence
4. Organized Structure
5. Unity
6. Interdependence
7. Resistance to Disruption

The survey was administered to 17 of the teams 18 members (the 18th never found the time to finish it) so the results are very descriptive of the teams perception of itself as a whole. This survey was taken during the time that the Flight Readiness Review was being written, so at this

point, the design team was in it's performing stage. Work was being done at such a rapid pace that the roles each member were in were maintained – no forming or adjustment of members roles within the group were shifting any longer. The results from each member who took the survey were averaged and placed in the following graph.



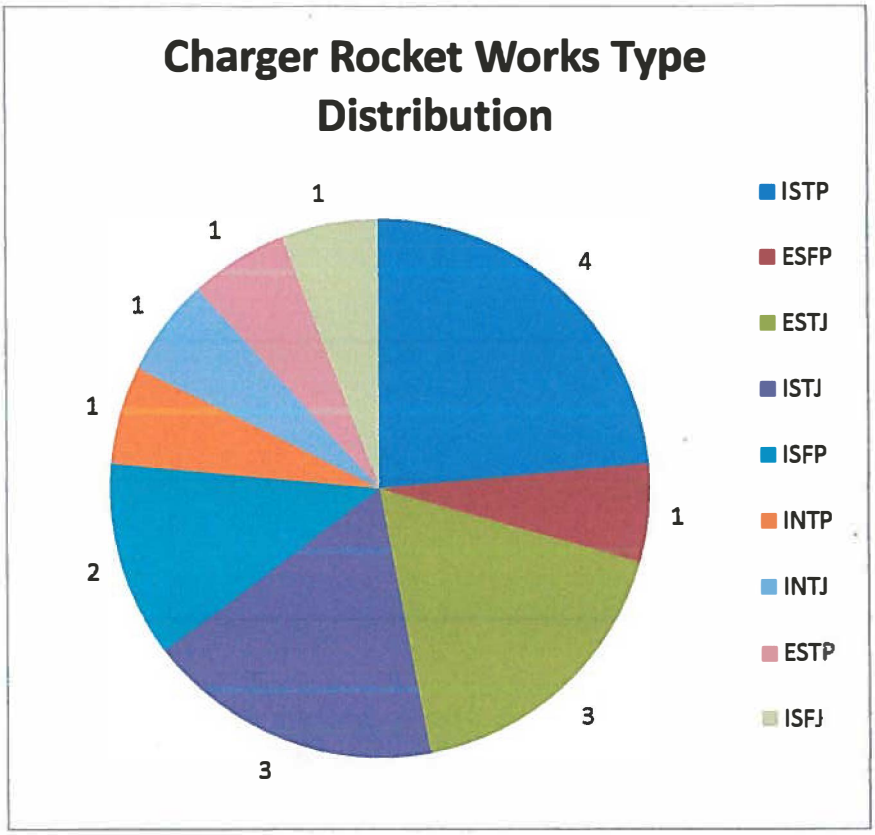
Here, the numbers along the horizontal axis correspond to the questions above. Overall, the team gave itself above average scores in all categories. The lowest values seen are for Coherence and Resistance to Disruption.

The apparent lack of coherence is very likely related to the aforementioned "information bottlenecking" through the team leads. Only being able to see one facet of the project left the individual subteams in a state of isolation from one another. When this became apparent and the instructor and leads asked the subteam members to work directly with one another, merely forwarding leads on emails to keep them informed rather than waiting on their instruction, this improved.

The meager Resistance to Disruption is probably related to the same issue because of the poor sense of urgency felt by the average team member. The proposed solutions to this include requiring that team members attend more test launches, improving the quality of presentations in midweek meetings, and further direct communication between members. In all of this, the goal is to give each team member more chances to see the state of the entire project and how their work affects it.

Myers-Briggs Type Indicator

In order to gain a sense of the personalities present within the design team, the Myers-Briggs type indicator was administered as a survey. For the sake of brevity, the full description of the test is not included here. Suffice it to say that the test groups individuals into sixteen possible categories along four axes. These axes describe where individuals like to focus their attention, how they look at the world around them, how they make decisions, and how the deal with the outer world and its problems. Information on the Rocket Design Team's results is below.

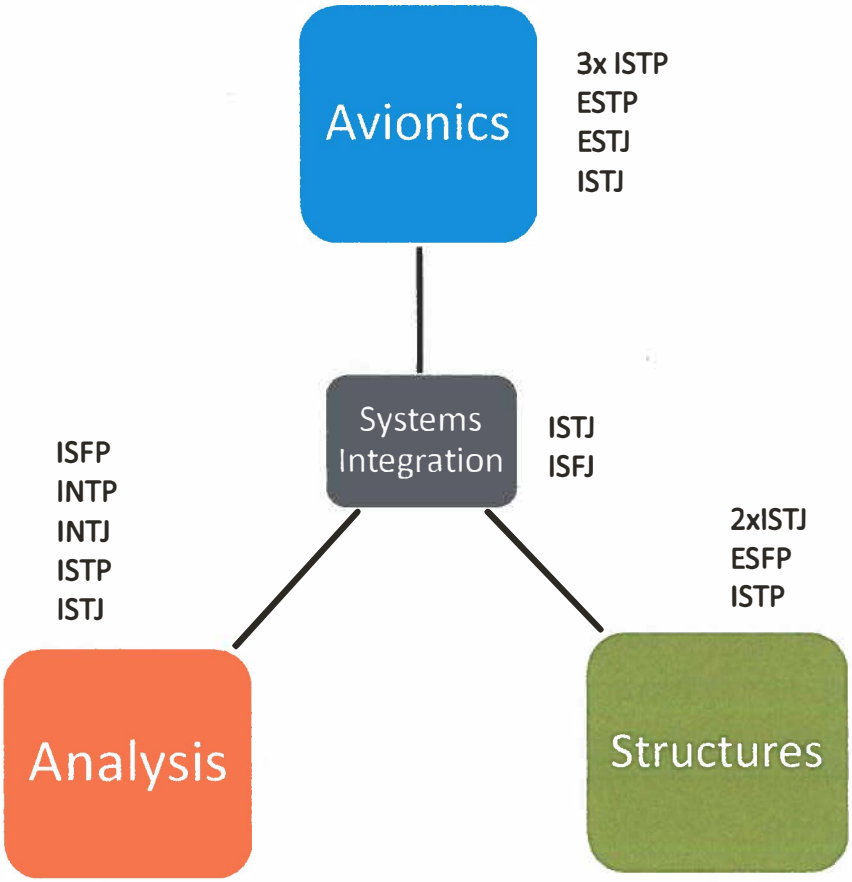


Total Occurrences of each type on the Charger Rocket Works Team

E	5	I	11
S	14	N	2
T	13	F	3
J	7	P	9

The average member of the design team tests as Introverted-Sensing-Thinking-Perceiving. This is not surprising, given that the discipline of engineering is often attractive to Introverts and people who are detail oriented (Sensing). The discipline also calls for objective, fact-based decision making (Thinking). The mixture of Judging and Perceiving types was seven to nine, being the most balanced axis on the team. This is also not surprising because both types of action are called for in engineering design. Perceivers value flexibility and spontaneity, preferring not to make a decision or settle on a course of action until all possible factors are accounted for. Judgers Value organization and structure, prefer to make decisions quickly and accomplish goals through structured schedules with deadlines, expectations, and standards.

Group communication experts agree that the ideal group is composed of a smattering of all types. In such a group, members keep each other from missing details or deadlines; they manage to make important and effective decisions without making any given member feel undervalued; they run meetings effectively, but can produce results once the meetings adjourn and they work on their tasks individually. This team was composed too thoroughly of certain types to become that perfect ideal, but some of the subteam groupings were suboptimal from that ideal perspective. One interesting trend that can be seen here is that the Analysis team was the only team consisting entirely of Introverts. By definition, introverted people need time to think before they speak or act, and prefer to work alone. There were instances where the team members there didn't communicate adequately what they were doing or needed the other members to do, probably because they were focused on the task itself. Also, the only two Intuitive people on the team were on the Analysis team. One of them could have been useful in bringing big-picture perspective to another team if they were elsewhere. Also, every member of the Avionics team was a Thinking and Sensing type. Distributing the few Feeling types (there were three) among the subteams would have been a challenge since there was one more subteam than feeling type. The two dedicated Systems Integration members varied only on the Thinking-Feeling axis, which could have contributed to the overall success of the team structure by balancing team social dynamics with the goals the team needed to achieve. The prevalence of Sensing, Judging, and Introversion betweeb those members kept them moderate, but effective, in their role. Sensing means they were detailed enough to be aware of what the rest of the team was doing, even though their role demanded they focus on the bigger picture. Judging



meant that they could choose from among the options that the Perceivers on the team realized and pick a solid course of action for everyone else to follow.

The team was originally organized based on where the members' interests lay. However, there were many members who didn't feel very strongly about which subteam they joined. In these cases, it may have been more optimal for these people to be placed where their personality could balance out the others on the subteam. If this survey were handed out in the initial days of the class, when the group was still meeting and forming, it could perhaps aid in a more effective distribution of personality types.

Qualitative Analysis of Charger Rocket Works

The final means by which the team was analyzed was by interviewing the Team leads on an individual basis. These interviews were conducted shortly after the completion of the Critical Design Review, when some tensions ran high and several members were up all night finishing this important document. The leads were asked what obstacles they believed slowed the completion of the CDR, whether they felt respected and effective as leaders, and rather they would, given the choice, make any changes to the structure or operation of the team.

A common theme, as observed by the leads, was that none of the subteams were very organized or disciplined. Information would get lost between members, and structure would be sacrificed for the sake of getting work done expediently when deadlines began to approach. Some of the leads admit that they expected more initiative, but just as they were eager to take a leadership role, they were frequently more eager to perform well than their peers. They felt respected by the other team members, they just wished that the others would put a little more effort in. For organizational changes, many team leads said they wish there were more dedicated members in Systems Integration – in particular, there was desire for an Editor-in-Chief who would focus on documentation. Another Proposed position was a business contact, who focused on networking with local businesses for funding and manufacturing purposes, as well as upkeeping the team's image through the team website and interactions with other entities. This would take these duties off of the shoulders of the Safety Officer and Chief Engineer so that they could focus more on the primary roles of their position. This would make the central team bigger, but in practice, there have been enough people in the subteams to accomplish given tasks, provided everybody put forth a good effort, so with better management, slightly smaller teams would likely get the same jobs done.

Hypothesis and Discussion

No team is perfect. All have their own unique conflicts, norms, and inefficiencies. However, there is always possibility for improvement, and while this team structure has performed above average, there are a few conceivable ways that future teams could improve upon its example.

The largest things that people, both leads and low-level members, complained about were the lack of urgency and transparency in the current arrangement, where the Leads essentially made up the core of the team. In the beginning of the project, the only two positions for which votes were called were Chief Engineer and Safety Officer. Within the subteams, the Leads just volunteered when the teams formed. Predictably, the people who volunteered for these positions were very knowledgeable, very experienced, or at least very interested, in the subject matter that particular subteam would handle. This sort of "Subject Matter Expert" (the term used loosely for a student project) will be eager to take on difficult tasks that need doing. This could be seen in the early stages of this project, when the leads took on the majority of the work and started creating preliminary design, writing programs for analysis, or researching the resources that may be used. Often, they felt that they were up to the task and that there was no need delegating a task they could do themselves. This is typical of Introverted-Sensing types who like to focus on details more than they like distributing work among others.

Eventually, the workload became so large and required such detail that the leads couldn't possibly handle it and HAD to begin delegating. However, by this time the rest of the team was somewhat left in the dark about where the design was going – not entirely, but enough that they couldn't just jump in to the current design like they knew everything about it. The tasks they had worked on previously were isolated instances and they had no sense of where they fit into the grand plan. The team leads rapidly felt overworked because they had not only taken on a huge amount of the work themselves, but in some cases they were only members with the skillset to do so, and on top of it all, they still had a subteam to manage.

Proposed Solution A

Rather than have the team leads volunteer, or even directly voted for, a personality test like the Myers-Briggs Type Indicator could be administered by the instructor early in the process. Then, once the people who strongly wished to be on a specific team had signed up for it, the instructor could assign the rest based on their personality. The instructor could then also *suggest* team leads based not on proficiency with subject matter, but on personality. The lead's primary focus would continue to be leading: making sure the subteam was on task and felt competent with what they were doing. Meanwhile, the "subject matter expert" could do what they do best and focus on the difficult tasks they enjoy without having the extra burden of managing other people. The team lead, meanwhile, could aid the rest of the team with design work when needed, but would not let it detract from the main task of being the team lead.

Proposed Solution B

There is debate as to whether the first solution would work, as frequently, the "subject matter expert" would assume a leadership role in practice anyway. The argument is that the other

members would look up to their experience and knowhow, and the team lead would be a leader in title only. An alternate solution would be to let the leader volunteer, as this should place a competent, eager person in the position. However, make a separate position within the team for Systems Level Liaison. The Liaison would follow the team leads example for his duties with the subteam, but would be the member that was also part of the Systems Integration team in the leader's place. This would allow the experienced team lead to manage a functioning team while leading by example, but keep the team in communication with others through the use of the Liaison.

Proposed Solution C

The final proposed solution is to keep the current team lead structure, where the eager volunteer becomes the leader, but to accompany that with some placement-by-personality and some education about successfully managing a team. Other members of the subteam may be placed by either personality or interest in that teams subject matter, but the lectures in the beginning of class could offer tips on successful delegation, examples of past leading and management strategies, and tips on effective communication within the subteam and between teams. This would be the smallest deviation from the current system, but may prepare the volunteer subteam leads with knowledge about leading others that they didn't get in their other experience.

Conclusion

Studying the human dynamics of a design team can reveal many interesting facets of a design team that may not be immediately apparent. It can uncover the source of conflicts and frustrations that team members have experienced, and it can help arrange things in such a way that those frustrations are avoided altogether. With a project as historically tense as the University Student Launch, it can certainly make a difference to take the time to look at what sort of practices can make team member's experience on the project a positive one.

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