Aerospace Partners for the Advancement of Collaborative Engineering

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Aerospace Partners for the Advancement of Collaborative Engineering (AerosPACE)

Introduction

For large companies (>100,000 employees) in aerospace industries, almost 18% of current employees are eligible for retirement. Within 2.5 years the percentage of employees eligible for retirement is projected to reach 25% [1] with the annual retirement patterns projected to increase by 50% over the next five to six years. Collectively a quarter of the nation's 637,000 aerospace workers could be eligible for retirement this year. This is a great concern for a nation with such a rich tradition of aerospace manufacturing.

Aerospace Partners for the Advancement of Collaborative Engineering (AerosPACE) is a collaborative University-Industry partnership with the vision of developing a capstone engineering design course that motivates students to enter the aerospace profession and fills gaps in student competencies related to working in the globalized workplace. Acknowledging that traditional undergraduate programs may not fully equip graduates with all critical skills needed for the complex challenges of the 21st century, the purpose of this paper is to present the fundamental concept and overall architecture for a unique capstone program where geographically dispersed, multi-university, multi-disciplinary teams of students collaborate with industrial professionals on challenging aerospace designs.

Engineering education research is also one of the objectives of AerosPACE. With the popularity and interest in massive open online courses (MOOCs) and flipped classes, some evidence suggests such methods may not be as effective as presumed [2] [3]. The AerosPACE course has been developed to enable research on engineering teaching and learning in a unique multi-disciplinary, multi-university environment.

In this paper the academic year 2013-2014 AerosPACE senior capstone project, where three multi-university teams of students collaborated with Industry to design, build, and fly a UAV capable of monitoring farmland to improve crop yield, is presented. The scope of the student project is defined by one semester completed at the time of submission of draft paper. Some results obtained from research accomplished during the first semester are also presented.

Background & Motivation

The Boeing Company is facing a critical workforce challenge that is typical for the aerospace industry that, as a whole, is responsible for 5.2% of the Gross Domestic Product [4]. At Boeing the average age of over 170,000 employees is currently 48 [5], nearing retirement eligibility. While the United States higher education system is producing more graduates in Science, Technology, Engineering, and Mathematics (STEM) than ever before, they represent a smaller percentage of all college graduates. Moreover, they are increasingly seeking employment outside of the STEM fields [6].

In addition to these workforce challenges, there is also a growing skills gap [7, 8, 9] which along with high attrition rates (45% of young professionals plan on leaving their current employer in the next five years [1]) presents a perfect storm for employers such as Boeing. In 2011 for example, Boeing spent $27 Million on STEM programs [5] to inspire the next generation of innovators at all levels of the education system to pursue a STEM career.

The AerosPACE course builds on two multi-university capstone projects carried out during the 2011 – 2012 and 2012 – 2013 academic years. The 2011 – 2012 project investigated how a multi-disciplinary team could coordinate tasks using a novel Computer Aided Design (CAD) tool that enables multiple users to simultaneously access and modify a model [10]. The project demonstrated that students from three institutions in three time zones could effectively collaborate on the design of an aircraft wing assembly. The 2012 – 2013 project successfully implemented a "multi-site, cloud-based capstone design project" within a cross-cultural, peer-to-peer design-build-test environment [11]. Within this environment students were exposed to the industrial principles of collaborative digital design and manufacturing, targeting complex cyber-mechanical systems. These previous projects were evaluated in order to develop a better program that could provide a long term pipeline of new talented graduates to support the workforce needs of Boeing. These previous projects were designed to be analogous to the Boeing Company which has 170,000 employees [12] in 70 countries collaborating on a daily basis.

One of the objectives of AerosPACE is to organize capstone teams from multiple universities and departments. In 1995 a study by Todd [13] determined that only 21% of capstone courses rely on interdepartmental projects. Very few references are found describing capstone projects with geographically dispersed, multi-university interaction. Whereas some collaborative projects can be found, for example in Electrical and Computer Engineering [14] as well as Aerospace Engineering [15], these are the exceptions rather than the norm.

AerosPACE can benefit academia by closing gaps between theory and practice, preparing faculty for transformed roles in digital education, preparing engineering students for the global marketplace, and enabling research into student learning via assessments and social network clickstream data. At the same time, benefits to the aerospace industry include building a pipeline of competent engineers, addressing business and social engineering challenges, and developing mentor/mentee relationships between current and future employees.

AerosPACE Organization

AerosPACE is a multi-disciplinary, multi-university collaborative capstone program bringing together stakeholders from industry, academia, and government to build core competencies for the next generation of aerospace innovators in a sociotechnical, collaborative environment founded in the learning sciences. AerosPACE focuses not only on bridging the skills gap through development of a curriculum based on industry-desired skills, but also provides a design, build, fly capstone experience to participating students. Technical skills are taught by the team of subject matter experts from academia and industry. Multi-university teams, with members located throughout the continental United States, collaboratively learn important soft skills (such as teamwork) in addition to hard skills (technical knowledge) desired by Boeing.

The AerosPACE curriculum views learning as a social-technical process whereby knowledge is co-constructed within a social network, mentored by peers, industry workplace experts, and university faculty through both face-to-face forums and a cyber-infrastructure. AerosPACE courses are intended to be rigorous in accordance with the existing high university standards.

The AerosPACE framework has four foundational elements: stakeholder engagement, incorporating learning sciences, advanced manufacturing, and collaborative social networks with learning analytics. These four elements work in unison to provide a holistic approach to close the knowing-doing gap and increase student engagement and participation in science and technology majors. The framework compliments competency development and transition into the STEM workforce as well (see Figure 1).

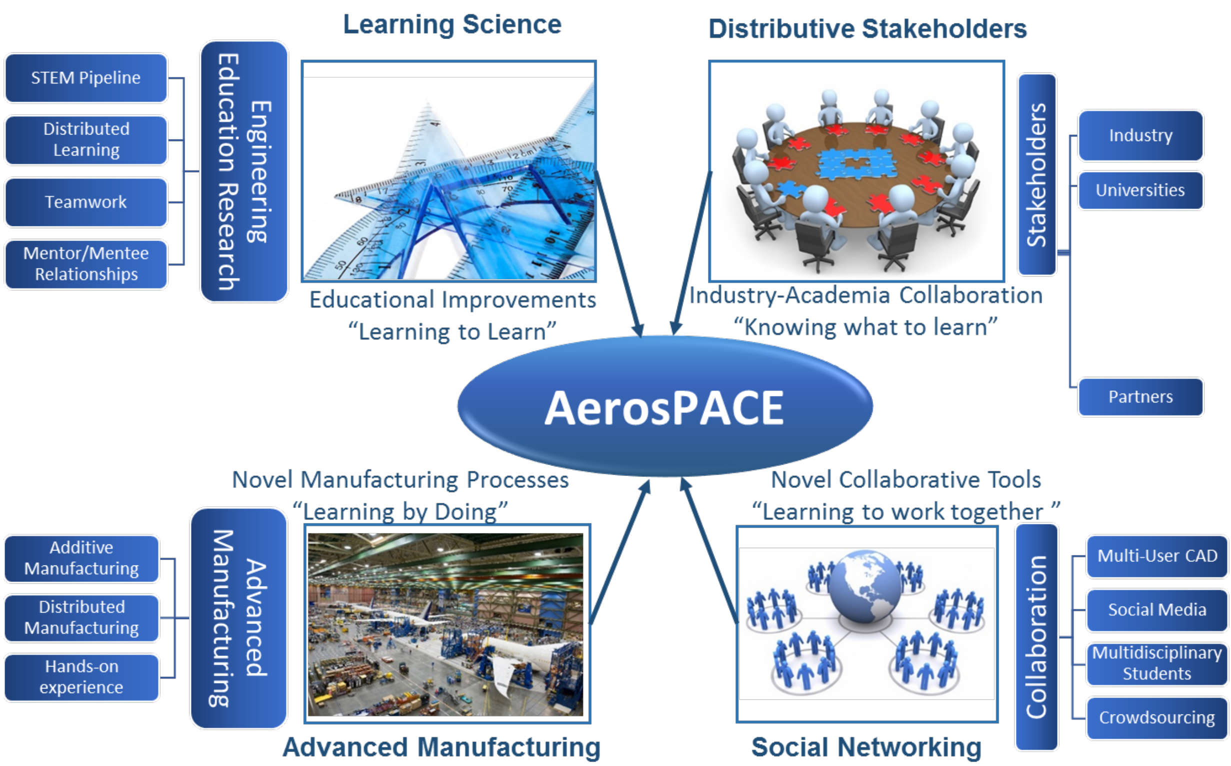

Figure 1. AerosPACE Framework

An AerosPACE Advisory Board was organized with members ranging from Senior Managers to recent college graduates working at Boeing as well as selected participants from different companies and government agencies. AerosPACE Advisory Board members were tasked to evaluate the design and process methods required for a multi-user environment, review program objectives and student project goals to ensure high quality and relevance, determine the experience needed by engineers and students within a multi-user environment, and assist in the promotion of the program. Advisory Board members also participated in design reviews of each team.

One unique and promising aspect of AerosPACE is the strong commitment by Boeing to make technical coaches available to the student teams. Two CAD coaches were assigned to each AerosPACE team to assist with design questions and modeling techniques. Additionally, one Finite Element Analysis (FEA) coach and one Computational Fluid Dynamics (CFD) coach are available to help all three teams with tool usage and analysis techniques. The Boeing coaches were also responsible for attending lectures and labs covering CAD, CFD, and FEA, attending weekly team meetings if possible, following team discussions on the AerosPACE web page (CorpU), and being available for questions and mentoring. To provide overarching communication consistency across the semester, one coach regularly attended meetings with team leads to review status and consult as necessary. The Boeing coaches were in addition to faculty coaches assigned to each team.

A unique program such as AerosPACE must rely on a robust learning platform to support students throughout the country across different time zones. A learning management system (LMS) had to be selected that can fulfill the various multi-dimensional needs of the program. AerosPACE adopted Carliner's definition of LMS being "a one-stop place to go for learning needs" [16]. The landscape of LMS providers is ever-changing, each offering a slightly different mixture of capabilities [17, 18, 19]. Traditionally, LMS systems focused mainly on making learning content available to students. However in recent years there has been a paradigm shift towards enabling collaboration within the LMS. This becomes particularly important for classes where students are not all collocated. In a traditional classroom environment, students can gain a sense of community through interaction in the classroom, but still desire useful tools for further collaboration in their LMS [20].

For AerosPACE, particular emphasis was placed on the collaborative capabilities of any potential LMS, as well as its ability to provide information on the user interaction with the platform, since interactivity with the LMS platform is a much better predictor of student performance [21]. The latter capability enables extensive research into how people learn in this unique environment. Based on Vygotsky's theory that learning is social [22] the CorpU online platform was selected due to its robust course interface and ability to provide communities of practice. Figure 2 shows the graphical interface for the AerosPACE CorpU platform. It was organized so that student activities were clearly identified for each week and to support interactions between instructors and class members from within the course material. For example, CorpU communities of practice enable students, faculty, and industry mentors to collaborate on specific technical problems by posting questions or comments, sharing files, or linking to other material.

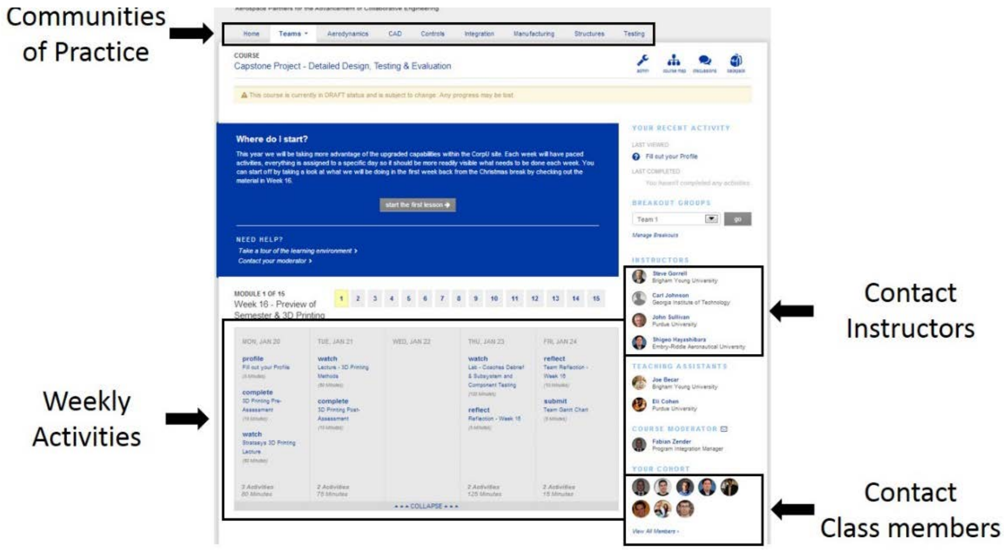

Figure 2. CorpU Graphical Interface

Research Questions and Methods

One of the research subjects within the AerosPACE course was the effectiveness of different student design team formation techniques (for example: ad-hoc vs. hierarchical - based on seniority - vs. "intelligent" formation methods). This information will be used to help create an automated design team formation software tool. Personnel profile development methods were also investigated to learn what the key characteristics are that need to be measured to evaluate someone for a position on a design team and how to best measure those characteristics. This information can provide techniques to enable a more efficient team creation process as well as more effective teams.

With respect to geographically dispersed multi-university teams, it was observed that it was difficult for a student to be the only team member at a specific geographic location. The AerosPACE course is gathering information to describe the characteristics and/or experiences of team members who are not located with the majority of their teammates, including what weaknesses or difficulties they experience, what strengths or advantages they gain, and how they and their co-located peers tend to see each other. This research can help predict when someone will be an exceptionally good candidate to work at a distance on a design team and identify what the characteristics or traits are that set a great remote teammate apart.

The research methods considered to answer questions like how to best form geographically dispersed design teams, and who is a good candidate to be a solitary, dispersed team member include experimentation, observation, and evaluation. Experimentation includes using team formation methods and comparing them to "control" groups. Observation includes getting to know the students on the different teams through in-person observation and personal interviews. AerosPACE enabled the authors to see how the students and teams change over the project, what kind of tools they use to communicate, what was frustrating to them, and what kind of things really help them to get their jobs done. Feedback was obtained from the academic faculty and Boeing coaches regarding what they thought of the different techniques and what they observed from the teams that are using the different methods. Students evaluated the different methods using online surveys. Both technical achievement of the teams and individuals, and how satisfied the students are with their experience were evaluated.

The 2013 – 2014 AerosPACE Project

The academic year 2013 – 2014 AerosPACE course was a collaboration between The Boeing Company, Brigham Young University, Embry-Riddle Aeronautical University, Georgia Institute of Technology, and Purdue University. The project is similar to what General Motors has established with PACE [23] in regards to automotive design where international student teams obtain access to partner software and industry experts to compete in a variety of design competitions. The course was founded on a Request for Proposal (RFP) that asked students and faculty from multiple universities and majors to collaborate to design, build, and fly a UAV that can monitor agricultural fields to help improve crop yield.

Thirty six students from four universities were organized into three design teams. Participating students were asked to complete a survey that measured motivation, social skill, and technical skill. It was determined to organize teams based on a "core" of six to eight students from the same university. Other selection criteria were based on a desire to avoid teams with a member who was the only member from his/her school, have at least three students per team who show characteristics of a leader to provide each team with a potential overall leader, and two others who could be assigned as Integrated Product Team (IPT)/sub-team leaders (i.e. structures, controls). Each team was also assigned two graduate students as team members in addition to the teaching assistants that were available to all teams. It was desired for each team to have comparable scores in the following three competencies: motivation, social skill, and technical skill. Since Computational Fluid Dynamics (CFD) seemed to be the rarest technical skill, it was ensured that each team had at least one CFD "expert" (80th percentile and higher) and another student per team who had decent understanding. Additionally, each team was assigned faculty coaches from participating universities.

The original RFP contained a project description, background, detailed requirements, instructions, and a list of deliverables. The RFP asked each student team to design, build, and fly an unmanned aerial vehicle (UAV) capable of mapping farmland using an agricultural sensing payload. Figure 3 describes some of the mission specifics such as launch and recovery, cruise, altitude, and covered flight area overlaid to the aerial map.

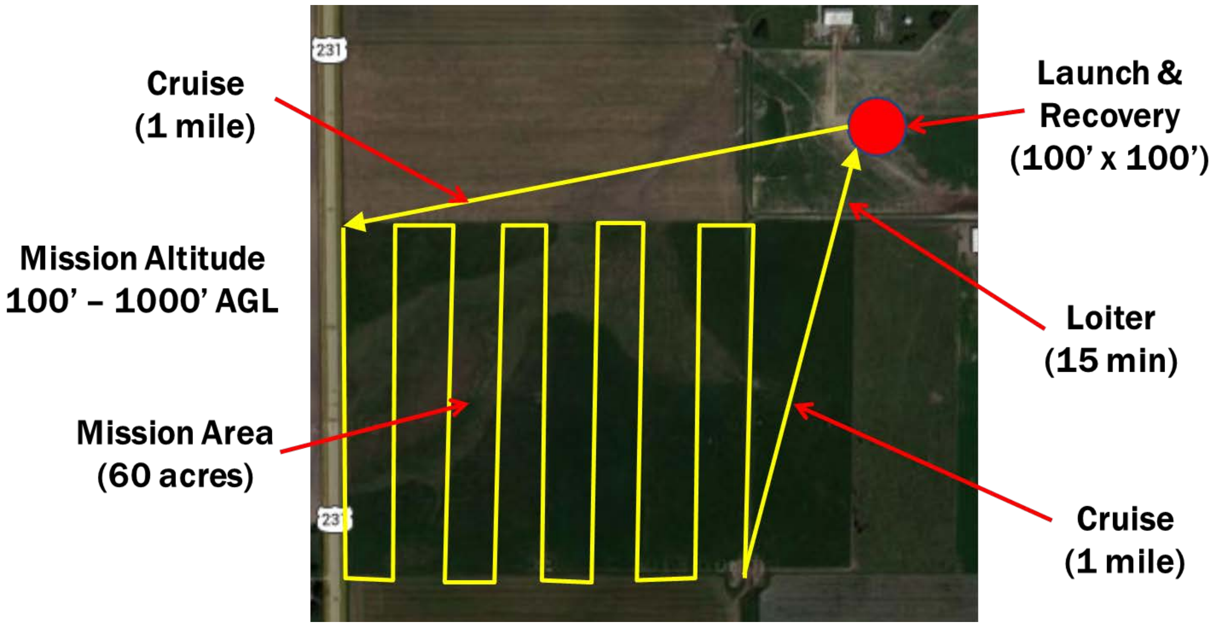

Figure 3. Some UAV Mission Specifics

The RFP informed students it was expected each design would address technical areas of aerodynamics, materials, propulsion, manufacturing, structures, weight, controls, assembly, testing, and reporting. Major milestones included a Conceptual Design Review (CDR), Preliminary Design Review (PDR), Manufacturing Readiness Review (MRR), and final presentations which includes a flight demonstration. A written report was required at the end of the preliminary design phase as well as a final report.

The RFP further stated that structural design of the UAV should include spars, ribs, wingskin, wingbox, joints, launch and recovery hardware, and materials selection. A high-fidelity Finite Element Analysis (FEA) should also be done. The design must leverage additive manufacturing meaning at least one significant part of the UAV should be made from an additive manufacturing process. Since time is required to assemble, fly, and test the aircraft, much of the detailed design results from CFD and FEA tools may not be incorporated into the UAV. Detailed computational analysis results will be validated with experimental results from the UAV and be used to make recommendations for an improved future UAV.

Students were instructed through weekly lectures and labs presented and recorded on the Cisco WebEx Online Conference System. Times of the lectures and labs were chosen based on when the majority of students could attend. Lectures were offered once per week to teach students general design principles, review technical details that should be understood to design the UAV, and methods for conceptual, preliminary, and detail design as they pertain to aircraft. In addition to the lecture, a two-hour lab was scheduled each week to provide instruction on tools such as Excel spreadsheets developed by the Georgia Institute of Technology and Purdue University for constraint sizing and analysis, OpenVSP (vehicle sketch pad) for configuration selection, AVL and XFLR5 for airfoil, static stability, and trim analysis, and MotorCalc for electric propulsion analysis. Students were also introduced to Siemens NX for CAD, CD-Adapco STAR-CCM+ for CFD, and ANSYS Workbench for FEA.

Examples of Progress

By the end of the first semester each design team had completed the conceptual design phase and about 75% of the preliminary design phase. Teams had presented a Conceptual Design Review and Preliminary Design Review to the AerosPACE Advisory Board. The purpose of this section is to demonstrate what the multi-disciplinary, multi-university teams were able to accomplish after one semester.

Figure 4 shows Team 1's interpretation of the UAV mission profile. Each team was asked to respond to the RFP and throughout the conceptual and preliminary design phases a clear understanding of the mission requirements was emphasized.

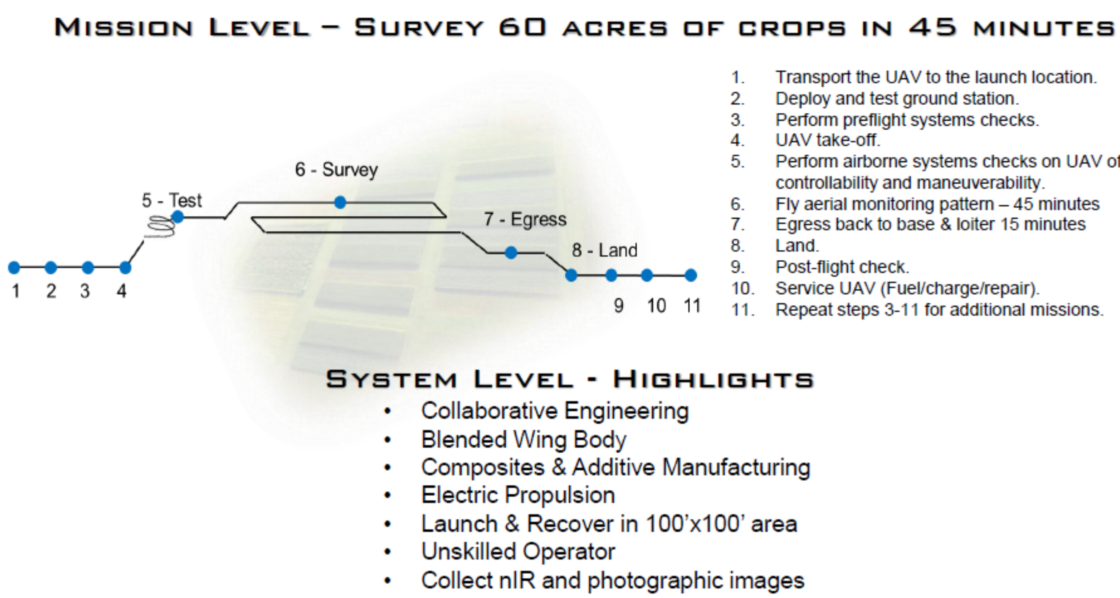

Figure 4. Team 1 PDR Requirements

An important outcome of the conceptual design phase is a constraint diagram to identify feasible design space based on takeoff, maximum speed, ceiling, rate of climb, and turn requirements. Figure 5 shows how Team 1 chose a wing loading of 1.4 lbs/ft^2 and a power loading of 25 W/lbs for their conceptual design.

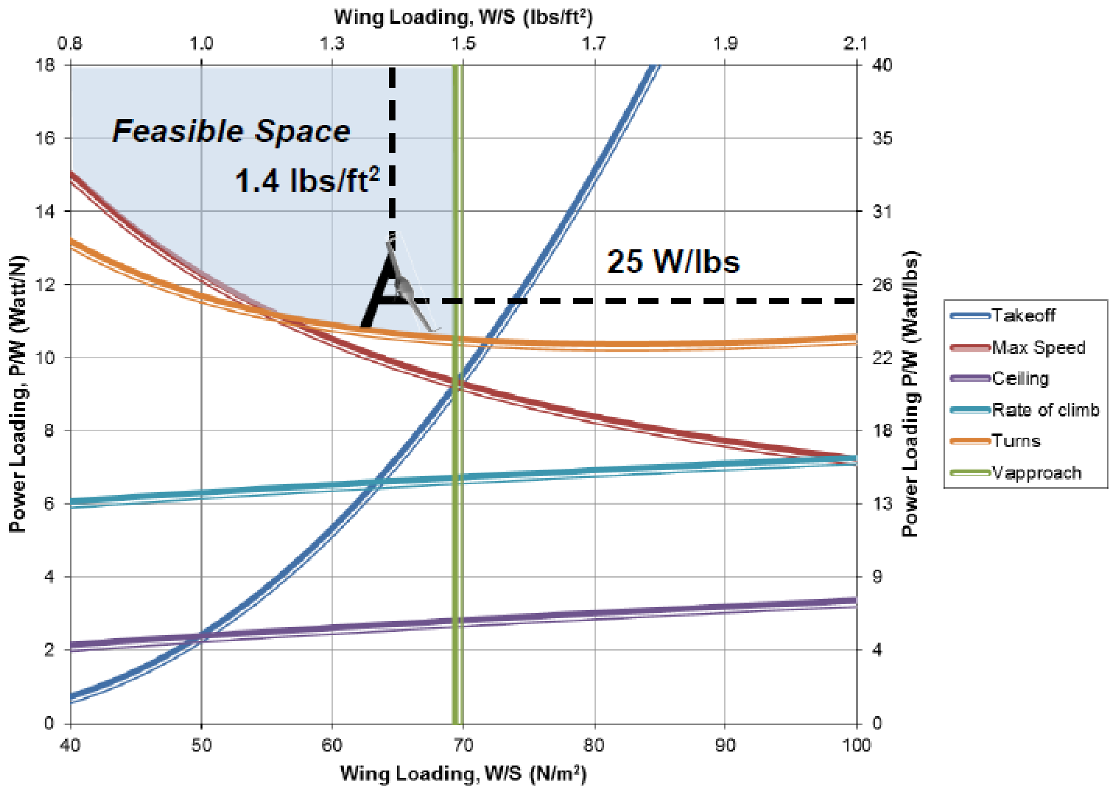

Figure 5. Team 1 CDR Constraint Sizing Analysis

Figure 6 shows the weight and center of gravity analysis done by Team 2 and presented in the PDR. It shows the various parts that must be incorporated into the aircraft, their estimated weight, and the resulting location of the center of gravity. The Team 2 design was predicted to weigh just under the RFP constraint of 12 lbs.

Part	Weight (lbs)	X CG (ft)
Skin, Structures and Attachments	3.9	2.44
Ardupilot Mega 2.6	0.099	1.5
Pitot Tube	0.0088	2.5
Nikon, Lens, Filter	1.7	2
Servos(7)	0.45	3.8
Spektrum Receiver	0.021	2.8
Motor	0.64	0.5
Speed Controller	0.119	1
Battery	3.99	2.9
Propeller	0.1125	0
Skid Plate	0.75	2
Total	**11.8**	**2.40**

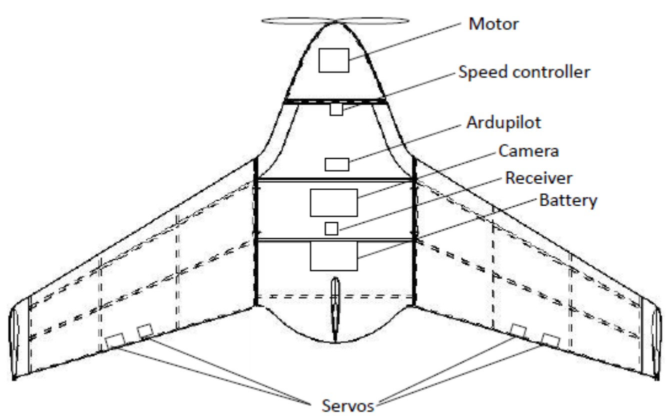

Figure 6. Team 2 PDR Weight and CG Analysis

During the PDR Team 3 proposed to 3D print their entire UAV. Purdue University has done this before and found additive manufacturing to be cost effective, require less assembly time and fewer fasteners, and components can be easily replaced. Figure 7 shows Team 3's plan to print their structure in 4 sections reinforced with carbon fiber spars.

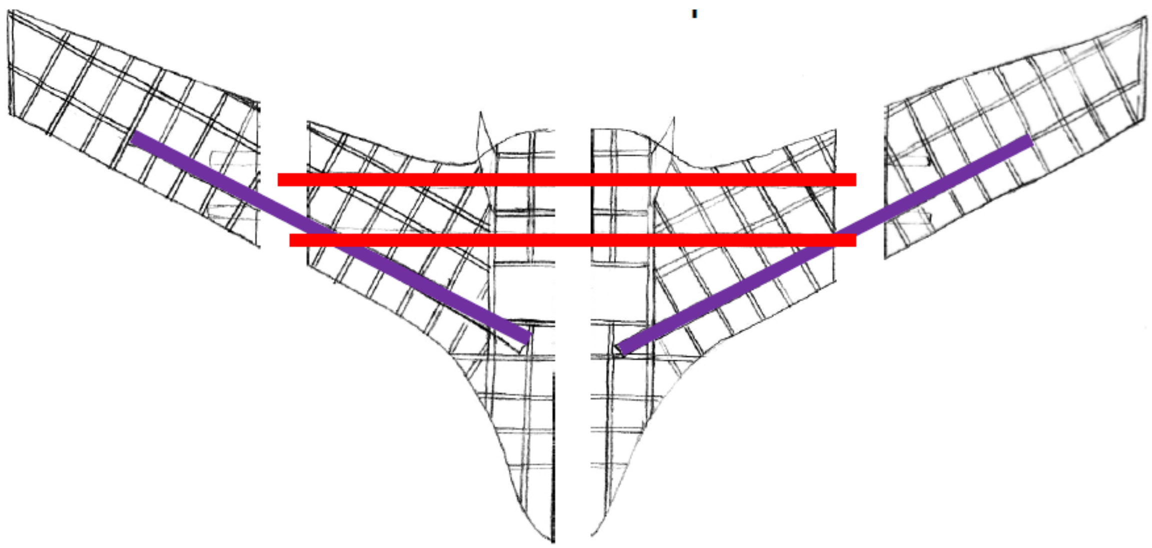

Figure 7. Team 3 PDR Printing Plan.

Research Analysis

Analysis of AerosPACE organization, teaching and learning during the first semester was based on three surveys given to all the students. One survey was given in the middle of the semester to evaluate student satisfaction with their teams, IPT's, and the processes used to form them. Two peer review surveys were given at the middle and end of the semester. In these surveys the students were asked to rate their teammates in four areas: motivation, technical skill, social skill, and leadership ability. Students also had the opportunity to write a short recommendation for one or more of their teammates in each of those areas. The final survey given at the end of the first semester also asked students to point out those aspects of the AerosPACE course that went well and what could be improved. What we consider to be the most notable results from the surveys and research are now presented.

At the beginning of the semester it was desired to set up each of the three teams with approximately the same level of ability in the fundamental areas of motivation, technical skill, social skill, and leadership ability. "Intelligent" team formation techniques were used to form the IPT's on Team 2, while Teams 1 and 3 used other, more traditional methods: Team 3 used more of an ad-hoc method, and Team 1 used a more seniority based method to organize their IPT's. After letting the teams work for approximately half a semester, they were surveyed at twice on topics such as how satisfied the team members were with their overall team and IPT experiences (see Table 1). Two different metrics were used to measure the success of a design team: 1) Level of satisfaction of team members with the experience, and 2) The success of the product of their design process as measured against both the requirements of the RFP and the budgetary and schedule constraints of the project.

Table 1. Explanation of the referenced surveys and some of the topics covered by each

	Date Administered	Team Satisfaction	Team Ratings of Fundamental Areas (Social, Technical, Motivation & Leadership)	Individual Team member ratings / recommendations
Team Formation Evaluation	October, 2013	X	X	
Peer Evaluation Round 1	Mid November, 2013			X
Peer Evaluation Round 2	Mid December, 2013	X	X	X

Some of the most important things learned from the research thus far are that communication and trust are key to having team members who are satisfied with their experience. By far, the skill that most students felt their teams were weakest in was social skills, which includes communication and trust.

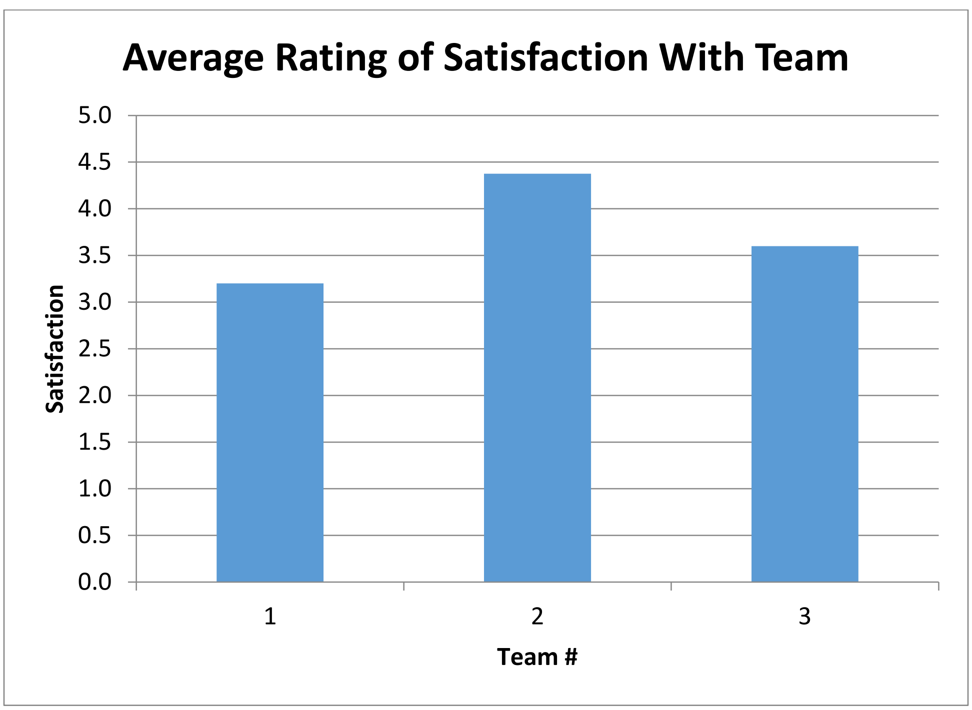

Figure 8. Results from Survey 1: Team Formation Review.

During the first round of surveys, Team 2's results indicated a correlation between higher ratings in trust and communication with higher overall satisfaction with their team. As can be seen in Figure 8, at the time of the first survey, Team 2 had a significantly higher overall satisfaction rating with their team. In the same survey, Team 2 also rated their team significantly higher in Communication than the other teams, as can be seen in Figure 9.

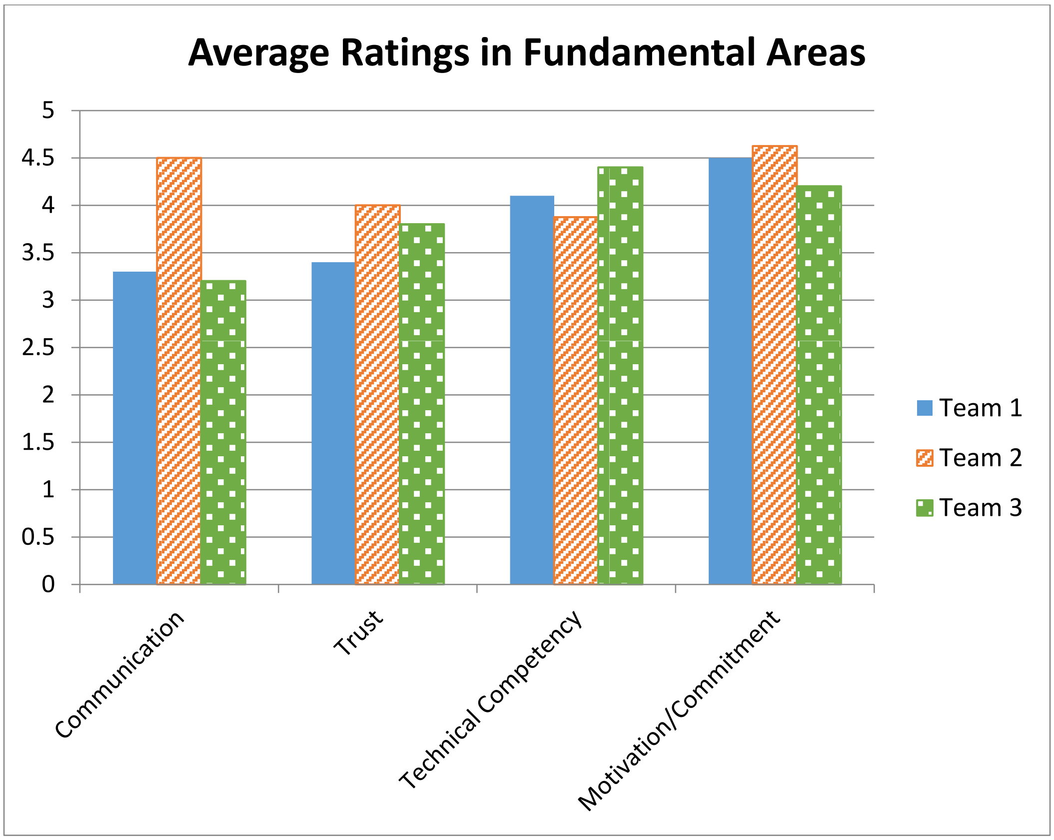

Figure 9. Results from the Team Formation Review Survey.

Between survey rounds, Team 1's communication and technical skill ratings increased significantly. The team's overall satisfaction rating also increased (see Figure 10). The constant in both the case of Team 1 and Team 2 was that team communication improves overall team satisfaction. These data seem to support the hypothesis that communication within a team affects team-member's overall satisfaction with their team and that improved communication among members of a geographically dispersed team will lead to higher levels of team satisfaction. These conclusions are also supported by qualitative results of interviews with students.

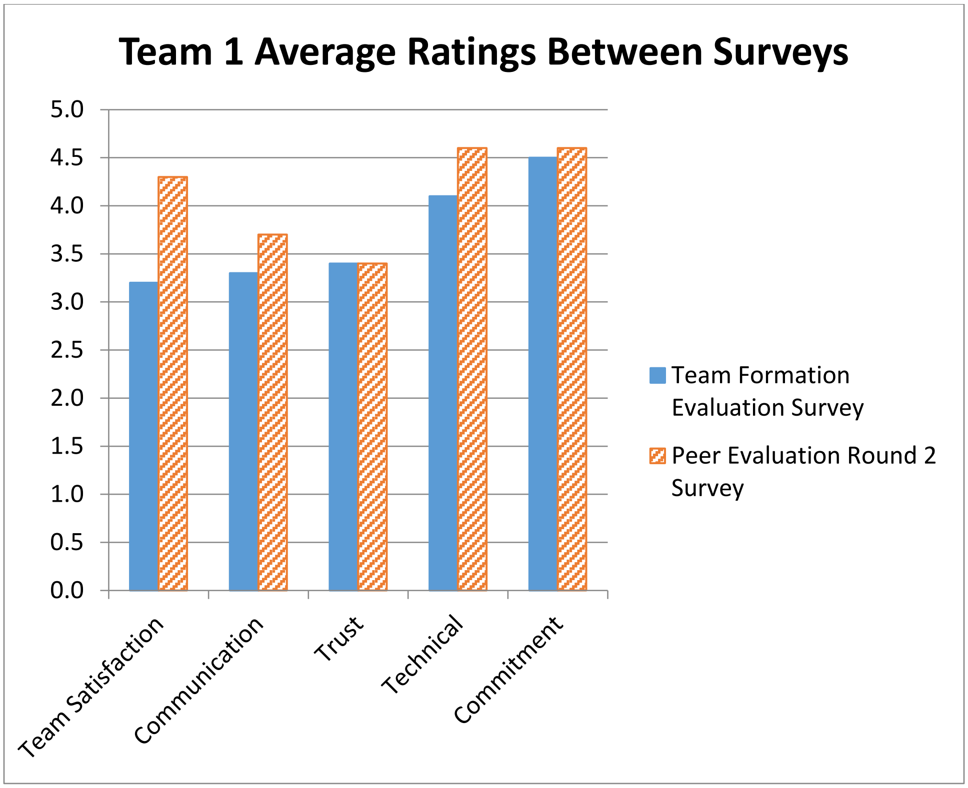

Figure 10. Average results from surveys of Team 1 given at different times.

From personal interviews and survey data, it also became apparent that tools that make communication easier for these geographically dispersed teams are highly valued. In general, students spoke very highly of WebEx and Google Drive and how those tools help them.

While the CorpU platform proved successful in many ways, it was not perfect. When presented with five possible upgrades, students overwhelmingly selected an integration of Google Drive into the LMS as the most important upgrade. These results highlight the ongoing transformation of LMS's; end users now expect Product Data Management (PDM) capability, which until recently was only used in high-end, sophisticated Computer Aided Engineering (CAE) software. This is likely due to the rise of cloud computing and file sharing facilitated by Google Drive and other products like Dropbox. Students expect similar novel capabilities out of all technological platforms, including their LMS. An initial analysis of the clickstream data reveals that while a large number of students typically perform multiple actions on most days, there are still quite a few students who have only limited interactions with the LMS. Whether or not this has an effect on individual learning is subject to further study.

Working successfully with a team remotely can be very difficult, but is possible, and seems to depend significantly on the initiative of the remote worker. A general trend found in most of the teams was that the remotely located team members ("non-core" students) tend to have fewer strong collaborative relationships than "core" students. However, it has also been demonstrated that when these remotely located students are willing to take the initiative to reach out and volunteer for a position, suggest an idea, or learn a new skill, they can be very productive team members. We would like to understand how we can identify people who will take that initiative and find ways to encourage all to do so.

A survey at the end of the first semester asked students what went well and what could be improved. The most common responses to what went well were that students enjoyed the project they were working on, enjoyed working with their team, were pleased with the amount they learned, and the support they received from faculty coaches. The most common responses to what could be improved were lectures and labs, support for learning NX, and practical value of assignments given. This suggests the delivery of the course material is an area requiring additional attention as the AerosPACE program is developed.

Summary

This paper presents the Aerospace Partners for the Advancement of Collaborative Engineering (AerosPACE) project. AerosPACE is a multi-disciplinary, multi-university collaborative capstone program bringing together stakeholders from industry, academia and government to build core competencies for the next generation of aerospace innovators in a sociotechnical, collaborative environment founded in the learning sciences. The 2013 – 2014 project has three multi-disciplinary teams with students and faculty from four universities collaborating to design, build, and fly a UAV that can monitor agricultural fields to help improve crop yield for a growing global population.

The three multi-university student teams completed the conceptual design and about 75% of the preliminary design of their UAV. Each team was mentored by faculty coaches and Boeing coaches to help students learn skills individually and apply them to succeed as a team. The AerosPACE Advisory Board has participated in a Conceptual Design Review and Preliminary Design Review.

Useful research has been accomplished during the first semester of AerosPACE. For example, 1) working in geographically dispersed locations makes teamwork more challenging, 2) a student's satisfaction with their team correlates to the level of communication and trust they have with their other teammates, and 3) tools that enable communication such as WebEx and Google Drive were highly valued.

Participating students enjoyed the AerosPACE experience and recognized they were learning skills that will help them in the workplace. Similarly, industry and academia experienced the benefits a cooperative approach to capstone courses provides to their respective learning goals for employees and students.

Acknowledgements

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Appendix:

The following surveys were administered electronically during the first semester of the AerosPACE program to the participants. They are presented in the order they were administered. Survey 1: Team Formation Review. Due to IRB restrictions parts of surveys with student names are not presented.

If you wish, you may indicate your AerosPACE ID.
If you want your survey to be anonymous, you do not need to answer this question.

The questions in this survey relate to the team formation process used up to this point in the course. Please answer the questions to the best of your ability with the knowledge you have up to this point in the course.

Team Formation:

Think of the team (1, 2, or 3) that you are part of. How satisfied are you with your team?

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

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Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
○	○	○	○	○

Please briefly explain why:

How would you rate your team's overall communication?

Very Poor	Poor	Fair	Good	Very Good
○	○	○	○	○

How would you rate your team's overall level of trust between its members?

Very Poor	Poor	Fair	Good	Very Good
○	○	○	○	○

How would you rate your team's overall level of technical competency?

Very Poor	Poor	Fair	Good	Very Good
○	○	○	○	○

How would you rate your team's overall level of commitment to achieving the project goals?

Very Low	Low	Neutral	High	Very High
○	○	○	○	○

What could be changed to improve the communication?

What could be changed to improve the communication?

What made the quality of the communication good?

Does your team have a student leader?

- ○ Yes
- ○ No

When was (s)he chosen?

- Click to write Choice 1
- Click to write Choice 2
- Click to write Choice 3

Click to write the question text

- Click to write Choice 1
- Click to write Choice 2
- Click to write Choice 3

What type of process was used to select your team's student leader?

- students chose
- coach(es) chose
- Other (please describe):

Please rate your satisfaction with this *method* of choosing the team's student leader (*not* your satisfaction with the leader him/herself).

Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
○	○	○	○	○

What could have been done to improve the method of leader selection?

Please rate your team's collaboration thus far:

Very Poorly	Poorly	Average	Well	Very Well
○	○	○	○	○

Referring to the previous question, to what do you attribute the rating you gave? (drag and drop the most influential factors in the order of influence, 1 = most influential)

Other (please describe):

Good communication

High level of motivation among team members

Willingness to consider others' ideas

Quality of software tools

Other (please describe):

Timezone / Geographic differences

High level of trust among team members
High level of technical expertise
Quality of Leadership

In what are do you feel is currently your team's greatest strength?

- Motivation
- Technical Skill
- Social Skill
- Leadership

In what area do you feel is currently your team's greatest Weakness?

- Motivation
- Technical Skill
- Social Skill
- Leadership

Please rate your (student) team leader in the following areas:

	Very Poor	Poor	Fair	Good	Very Good
Setting Clear, Measurable Goals					
Setting Attainable Goals					
Facilitating Team Communication					
Appropriately Involving Team Members / Delegating Responsibilities					
Resolving Disputes or Disagreements					
Inspires / motivates our team					
Helps our team have fun					
Technical Aptitude					
Other (please specify):					

Would you recommend your team leader as lead for another, similar project?

Definitely No	Probably Not	Unsure	Probably Yes	Definitely Yes

Would you recommend working on your team to a friend?

Definitely No	Probably Not	Unsure	Probably Yes	Definitely Yes

Integrated Project Teams:

What type of method has been used by your team to organize the Integrated Product Teams?

How would you rate the process used to form your IPT's?

Very Poor	Poor	Fair	Good	Very Good
○	○	○	○	○

How many IPT's are part of your team?

1	2	3	4	5	Other (please specify):	Don't Know
○	○	○	○	○	○	○

To how many IPT's do you belong?

0	1	2	3	4	5
○	○	○	○	○	○

Survey 2: Peer Evaluation Round 1

This survey allowed students to evaluate the members of their team (1, 2, or 3). Each team was given its own version of the survey. Team 1's is shown here.

You will now be asked to rate each of your peers in certain categories. Your individual ratings will be kept private. At no time will any student be allowed to see the ratings assigned to him or her by any other individual student. You will be asked to rate your peers at multiple points throughout the course. Thus, *you should not consider your rating of a given person in a given category to be a final judgement of that person's character or anything similarly serious.* If you are not sure what to put or do not feel strongly one way or another, please default to "Fair".

A brief explanation of the categories follows:

Motivation / Commitment How motivated do you feel this person is to participate in the AerosPACE project?

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The majority of the survey includes evaluating student by name and therefore a significant part of the survey is not presented.

How well does (s)he keep commitments? Is (s)he passionate about his/her work? Does (s)he demonstrate a desire to learn more and improve her/his skills and understanding?

Technical Skill: How knowledgeable and/or experienced is this person? What level of working knowledge does (s)he demonstrate in the areas concerned? How effective at implementing this knowledge is the person? How well does this person learn and apply new topics or concepts?

Social Skill: Does this person know how to work well with others? How well does this person communicate her/his ideas, thoughts, and opinions? Does (s)he make other team members feel valued? Can (s)he disagree without being disagreeable? Does this person come to meetings as agreed upon and and participate? Does (s)he ask insightful questions or prompt thoughtful discussion?

Leadership: Whether the person is an official leader or not, does this person demonstrate leadership characteristics? How well does this person delegate, lead thoughtful discussion, make sure all voices are heard, help to make decisions, take on responsibility for successes and failures, etc.? How well does this person do when asked to make a tough decision on behalf of the team? *Note: some participants desire to NOT be leaders and would likely appreciate honesty by their peers when rating their abilities.*

Please rate each of your peers in the following areas:
(Please rate yourself as well)

Please describe why you want to offer your recommendation for this person's Technical Skill:

Please describe why you want to offer your recommendation for this person's Social Skill:

Please describe why you want to offer your recommendation for this person's Leadership:

Survey 3: Peer Evaluation Round 2 and other topics

This survey allowed students to evaluate the members of their team (1, 2, or 3), rate their experience with their team, and comment on the course as a whole. This survey repeated many elements of the first two surveys to provide chronological comparisons while also introducing some new questions.

Think of the team (1, 2, or 3) that you are part of. How satisfied are you with your team?

Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
○	○	○	○	○

How would you rate your team's overall communication?

Very Poor	Poor	Fair	Good	Very Good
○	○	○	○	○

https://s.qualtrics.com/ControlPanel/Ajax.php?action=GetSurveyPrintPreview&T=1uvyui 1/10

The majority of the survey includes evaluating student by name and therefore a significant part of the survey is not presented.