Abstract
This paper describes the observance of a project by the University of Alabama – Huntsville, to introduce undergraduate students to a teamwork environment. The parallel research/education effort, sponsored by the U.S. Army Aviation and Missile Command, established an Integrated Product Team (IPT) to design an Unmanned Air/Ground Vehicle (UAGV). The IPT project uses industrial mentors to guide 3 teams of engineering, business, and liberal arts students in a competitive design project. Three international teams of undergraduate students competed to present the best configuration of a UAGV. A key aspect of this course was the integration of students and faculty from different disciplines and the use of mentors to assist the student teams. This paper includes an overview of the teams’ actions during the semester of the project, including the project management activities, and also includes the results of the surveys administrated by the observers. The observers focused on the teaming, task structure, outside assistance, tools, priorities and the leaders actions used to accomplish various project objectives.

Introduction
The University of Alabama in Huntsville (UAH) has established an Integrated Product Team (IPT) project to introduce students to a teamwork environment. The IPT project uses industrial mentors to guide teams of engineering, business, and liberal arts students in a competitive design project. The IPT 2001 project was to design an Unmanned Air/Ground Vehicle (UAGV). The project is a parallel research/education effort sponsored by the U.S. Army Aviation and Missile Command. Three international teams of undergraduate students competed to present the best configuration of a UAGV. The teams consisted of mechanical, aerospace, electrical, computer and industrial engineering students. Each team also included students from ESTACA, an engineering college in France. The teams were made up of a total of 15 members. A key aspect of this course is the integration of students and faculty from different disciplines and the use of mentors to assist the student teams. This paper describes the project management activities observed during the semester of the project. It includes an overview of the teams’ actions during the project and also includes the results of the surveys administrated by the observers. The observers focused on the teaming, task structure, outside assistance, tools, priorities and the leaders actions used to accomplish various project objective.

The observers were two Engineering Management graduate students enrolled in an Industrial Systems Engineering and Engineering Management (ISEEM) special topics course. This course
was designed to observe, survey, and document through the use of the team development process, a Senior Design class taught by Dr. Robert Frederick, associate professor in the Mechanical and Aerospace Engineering Department (MAE) at the University of Alabama in Huntsville. The course requirements included that the graduate students: 1) Attend meetings and observe project design teams in action, 2) Observe and document various project management and class effectiveness elements, 3) Act as resource person to MAE design teams for project management, systems engineering, marketing, and personnel administration help, 4) Deliver and monitor check lists and their usage, 5) Meet bi-weekly with ISEEM professors to update status and refine requirements, 6) Give a midterm presentation or an open house presentation display and report, and 7) Provide a final written report and multimedia presentation to the Executive Committee.

The observers focused on the project management activities that included teams and how they formed, characteristics of the leaders, methods of handling tasks, use of outside assistance, tools used to complete tasks, and how priorities were defined. This report serves as the summary document of the senior design class including the observations, surveys, and conclusions.

**Course Background**

In high-technology business, companies are using multi-disciplinary teams. Decreasing product costs and reducing time to market demands that specialist from diverse backgrounds learn how to work interactively under a set of system-level requirements. Top companies must be able to put together products in conjunction with domestic and international business partners using advanced technologies in a dynamic political/economic environment. A company can typically spend one to three years orienting a new hire to function effectively in a team. UAH has established a project course that will orient its students to these important issues before they graduate.

The senior design class or IPT 2001 was to study, analyze, and develop multiple conceptual designs, which merge robotic techniques and automation technologies into a hybrid UAV/UGV vehicle system. The effort began in September 2000 with background work performed by four different classes at UAH. These classes interacted with customer representatives and mentors to develop a Concept Description Document and to assess related technologies. Three integrated product teams were formed to develop concepts to meet the project objectives. The teams worked together in Phase 1 on a baseline design and technology assessment. In Phase 2, each team developed four alternative concepts for consideration and selected one preferred configuration. Phase 3 consisted of each team refining and developing a proposal for their selected concept. The student teams were composed of senior-level mechanical and aerospace engineering students from UAH and ESTACA, a college in France. Industrial mentors, who focus on particular disciplines required for the design, assisted the team. Student report teams also assisted the project in the areas of technical communication, marketing, systems engineering, electrical design, and web page development (Frederick, 2001).
Literature Review

Literature related to this project includes a vast amount of research on types of teams, team effectiveness, team personality composition and effective team communications of successful teams. The results of the documented theories below are located in the Findings section of this paper.

In the book, *The Wisdom of Teams*, Katzenbach and Smith (1993) recommends that an organization should focus on performance and team basics which includes problem solving skills, technical/function, interpersonal; mutual accountability, small number of people, individual; commitment – specific goals, common approach, and meaningful purpose. Additionally, Katzenbach and Smith (1993) describes the stages that teams go through before becoming a high performance team in their Team Performance Curve. Figure 1 depicts the curve.

Katzenbach and Smith’s (1993) description of the stages are as follows:

1. A working group is a “group for which there is no significant incremental performance need or opportunity that would require it to become a team.”
2. A pseudo team is defined as “a group for which there could be a significant, incremental performance need or opportunity, but it has not focused on collective performance and is not really trying to achieve it.”
3. A potential team is “a group for which there is a significant, incremental performance need, and that really is trying to improve its performance impact.”
4. A real team is “a small number of people with complementary skills who are equally committed to a common purpose, goals, and working approach for which they hold themselves mutually accountable.”

5. A high-performance team is “a group that meets all the conditions of real teams, and has members who are deeply committed to one another’s personal growth and success.”

Another theory evaluated/observed during this study was Douglas McGregor’s (1966) Theory X and Theory Y management styles. According to McGregor, a Theory X management style makes the following assumptions: 1) Management has responsibility to make sure goals are achieved; 2) People must be controlled; 3) People are passive and must be bribed or coerced into working; 4) People are basically lazy; 5) People will avoid responsibility; 6) People are self centered; 7) People resist change at all costs; and 8) People are gullible and not very bright. However, a Theory Y management style makes the following assumptions: 1) Management has responsibility for success; 2) People will actively participate and regard mental work as natural as rest or play; 3) People will seek out responsibility; 4) People are self directed; 5) People want to grown and learn; and 6) People are generally underutilized.

A final theory evaluated during this project was the Managerial Grid developed by Blake and Mouton (1964). The Managerial Grid evaluates a management style and assesses its concern for people and its concern for production on a 1-9 scale, with 9 being the high number.

**Observation Methods**

The data collected for this project included team evaluations, determination of personality types, self-evaluations, performance evaluations, team progress check sheets, team evaluations by customers and class observations.

**Findings**

Several surveys and evaluation parameters were measured during the semester. The observers or the instructor of the course provided all surveys and evaluations. The evaluation methods used and the observers’ findings are described below.

**Performance Evaluation Form**

The performance evaluation form provided by The Boeing Company was designed to provide guidance to Boeing managers who are responsible for assessing the contribution of engineers as part of their engineering salary review process. The professor and the team leaders used the document in this course to assess project participation. Team leaders assess the team members and the professor assessed the team leaders. The evaluation criteria included assessment of performance levels in five elements.

The five elements and what they assessed of the team leaders and members were: 1) Accumulation of Responsibility, assessed the responsibilities accumulated; 2) Accumulation of Skills, assessed the flexibility to handle a wide range and complexity of job assignments; 3) Leadership, assessed the initiative and tendency to attract followers; 4) Quality and Quantity of
Work, assessed the ability to communicate the results and timeliness with minimal oversight; and 5) Attitude, assessed the willingness to accept assignments outside one’s “comfort zone.” Each of the evaluation elements was assigned points based on the perceived performance level ranging from 0 to 10, and then averaged to obtain an overall total score.

The elements were evaluated based on the following perceived performance levels: a) Exceeds Job Requirements- Overall performance is exceptional and consistently at a level greater than expected, were assigned points between 7 and 10; b) Meets All Job Requirements – Consistently meets job objectives, were assigned points between 4 to 6; c) Meets Most Job Requirements- Work is acceptable but improvement in consistency of overall performance is necessary to meet all job objectives, were assigned points between 1 and 3; and d) Does Not Meet Job Requirements- Performance is less that expected and needs considerable improvement to meet job objectives, were assigned zero (0) points.

Table 1 includes the performance evaluation total score of each team leader as observed by the instructor. The team composite score is the average of all members’ scores as observed by the team’s leader. This evaluation was administrated during Phase 2 of the project. The professor assessed each team leader as exceeding the job requirements with total scores greater that 7. Team 2, the eventual winner, was evaluated as the best performing team. The team leaders assessed their team lower. They believed that their respective team was meeting all job requirements with scores of 5.3 and 6.8.

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<tr>
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<th>Team 1</th>
<th>Team 2</th>
<th>Team 3</th>
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<td>Team Composite</td>
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Table 1. Performance Evaluation Total Scores

Team Progress Checksheet

The team progress check sheet evaluated team members rating of their team’s level of focus, progressing speed, establishment of roles, use of time, communication within the team, contribution of members, self-esteem, learning of team, results, agreement on next project steps, and on the overall satisfaction of the teams accomplishment. A composite of all eleven questions was used to determine the overall progress of each team. Figure 1 describes the progress of team 1; note the “dip” with the second evaluation. At this time the team was under hard scrutiny as to whether their design would work or not. This time period tested their teamwork skills and as a consequence, the team “fluttered” somewhat. However as time progressed their teamwork skills improved, which is reflected in their upward trend of the survey results.
Figure 1. Team 1 Progress

Figure 2 describes the progress of team 2; note the continual progress of teamwork for this team. This reflects their desire from the beginning to be an effective team.

Figure 2. Team 2 Progress

Figure 3 describes the progress of team 3. While this team started out on a positive note, the team soon could not function properly, hence the downward turn in their progress as a team. This data indicates that the survey may be a good instrument for measuring team progress throughout the semester.

Figure 3. Team 3 Progress
Customer Evaluations

Team evaluations by the customer were performed at the conclusion of each of the three phases of the project. The evaluation of Phase I of the design was deemed satisfactory. The approval to continue the project indicated that the customer believed that the baseline had enough merit for further study. The Phase II evaluation focused on absolutes, mechanics, substance, and oral presentation. Each team was ranked from 1 to 4 on each item above. Taking a composite of the team score, team 2 was in first place at this time, followed by team 3 and then team 1. It should be noted that team 1 received a warning during this phase because they did not have their figures with their paper. Customer evaluations for Phase III were not disclosed at the time of this report. According to the professor, the teams were ranked in order of 2,1,3. It should also be noted here that team 1, while having received a warning for Phase II, actually turned in their paper 12 hours early – signifying that teamwork can make the difference in meeting deadlines.

Self Survey

This survey evaluated the leadership characteristics of the team leaders. It was designed to determine the type of leader of each team. This survey classed the leaders by the level of their need to be affiliated with others and the level of their need to be directive. Table 2 includes the 2000 and 2001 results. Team 2 for the past two years has won. No pattern can be ascertained at this time. Further studies must be undertaken to determine what effect these attributes have.

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<tr>
<th>Team</th>
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<td>3</td>
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Table 2. Self-Survey Results

Other Observations

Other project management observations of all teams include attributes such as “Production through People” and “Close to the Customer” as described in the book *In Search of Excellence*, (Peters and Waterman 1980). The “Production through People” observations were the team leader and members had trust in others, they freely communicated their ideas, the leaders allowed teams to set their own goals, a family atmosphere existed, and the team members were given autonomy to complete their assignments. The “Close to the Customer” observations included that the teams wanted to get to know the customer to ensure that they met their needs. It was also observed that each team took a systems approach to meeting the project’s objective. This systems thinking is described in the book *The Fifth Discipline*, Senge (1990). It was observed that the teams took a system thinking approach to connect all portions of the project.
and think of the entire project as one single entity. The teams generally had a shared vision where the team had a desire to reach the same goal.

**Team Findings**

Team 1’s leadership style was observed to be a Compromising Management Style as described by Blake and Mouton’s (1964) Managerial Grid. The reason that this team was believed to be this style of management is because their decisions were not optimized but were always compromised; the team did not seem to set their goals too high. They appeared to just want to complete the assignment. Team 1 was believed to be a “Potential Team” on the Team Performance Curve previously described in the literature review section, because they displayed no collective accountability.

Team 2’s leadership style on the Managerial Grid, could be best described a Team Management Approach. This team involved the entire team in decisions, focused on reaching goals, mutual respect of all team members, freely communicate ideas, and they were strived to find the best answer for the problem. Additionally, the entire team trusted and respected each other. This team was believed to be a High Performance on the Team Performance Curve. Most of this team’s members were committed to one another’s personal growth and not individual growth. As a result, this commitment was transcended to the team.

Team 3 was also a Team Management Approach style of management. However this team’s commitment to this style of management was not to the level of team 2. This team could be best described as a Real Teal on the Team Performance Curve. The team members of this team had complementary skills and were generally committed to a common goal. However, this goal was to beat the other teams and not to determine the best answer for the problem.

**Conclusions**

In general, many teaming characteristics were observed during this observation. It was observed that each team leader and the team members had Theory Y assumptions as described by McGregor (1966). The team leaders believed that the team members would seek out responsibility and wanted to contribute to the project and that each member was basically self-directed when given a responsibility.

Conflicts were very limited due to the fact that project objectives were very specific and each team had to follow certain guidelines to meet these objectives. The team members realized that there was also a strong need for them to function as a team. This need also led to a family atmosphere within the teams and a sharing of resources by the team members. The class meetings were not only to discuss the project, but also became a social element for many team members. These factors all lead to a more effective team and the team that had more of these characteristics saw the rewards at the conclusion of the project by being selected as the best in this year’s Integrated Product Teams competition. Team 2 was recognized as the having the best design for the IPT 2001 project.
Recommendations

The following recommendations are made to improve the class for next year:

1. Conduct the SELF survey before and after the semester to see if there were changes in how the team leader felt they managed after having an experience in it. Careful attention needs to be placed on whether the team leader who wins is a high affiliate.

2. Have three team members to observe the class instead of two. Advertise in the fall in all of the EM and ISE graduate classes to get three students to observe the classes. Have each member observe only one class and report on its results at the end of the semester. Therefore each team can be evaluated continuously throughout the design process.

3. Design a database to incorporate all of the surveys, past, present, and future. Therefore all of the information would be easily accessible to everyone and can be calculated by the computer and not by human means. This would also be a way to determine who in a team had not filled out the surveys.

4. Have a fall class where the team leaders are trained in certain management techniques and program management tools. Therefore all of the team leaders would have some knowledge of management skills and tools, and be able to use them in their respective team environments. A baseline for what each team has available to assess from an engineering management perspective would be a constant.

Acknowledgements

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References