UNIVERSITY OF WASHINGTON

William E. Boeing Department of Aeronautics & Astronautics

AA/INDE 470 - Paper 2

Project Plan - AIAA DBF

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1 Statement of Work

1.1 Work Breakdown Structure

The Work Breakdown Structure displays how the project work will be delegated. Within the WBS, a list of tasks is provided for each category of work to help the team understand each part of the project and what they are being asked to do. The WBS is also eventually used to create a specific list of tasks and a Rough Order of Magnitude Schedule.

In figure 1.1, the Work Breakdown Structure for the DBF project is presented.

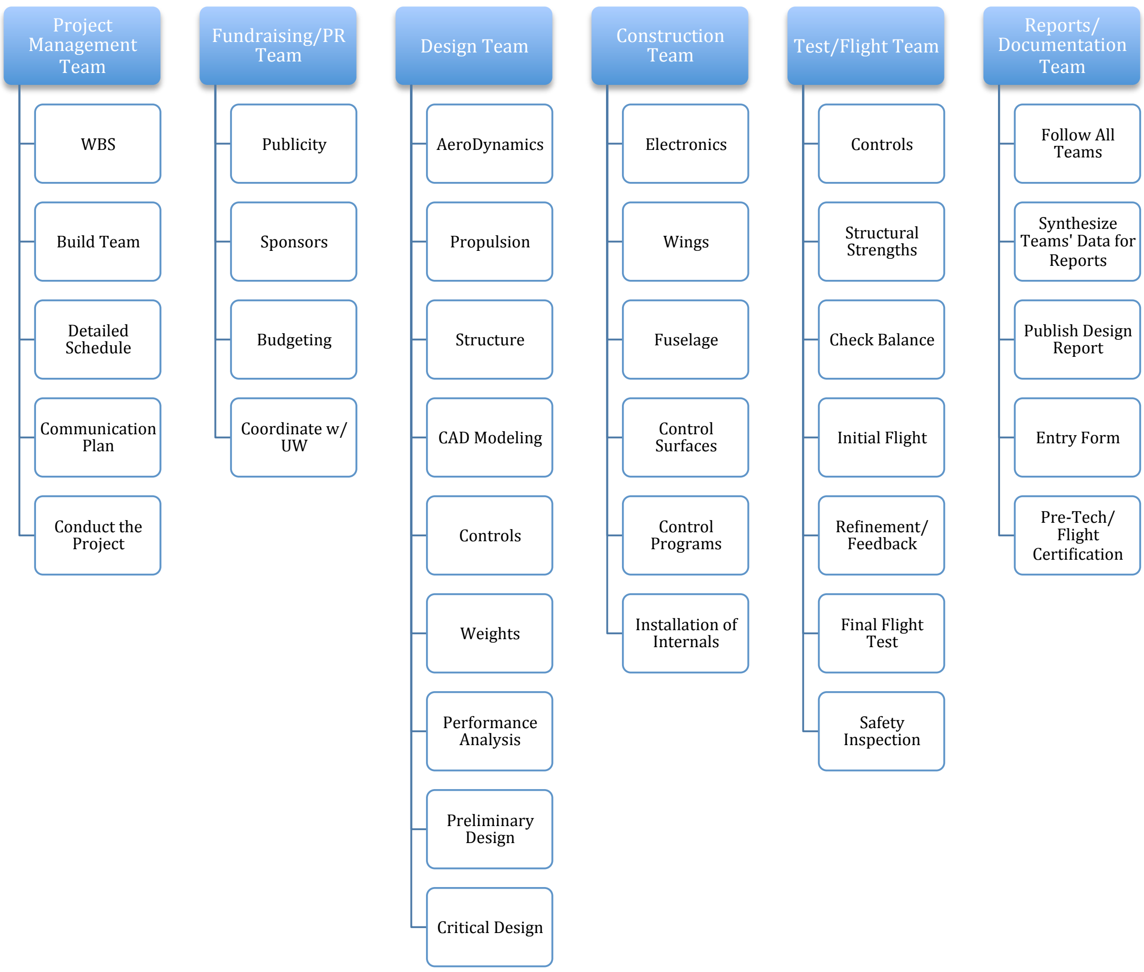

Fig. 1.1: Work Breakdown Structure

1.2 Categories of Work

For each category of work, there is a statement describing the goals and tasks under each main category that the project has been split up into. This helps the teams working under each category follow a plan and goal for their job.

1.2.1 Project Management Team

The Project Management team is responsible for the overall success of the DBF project. Project Management (PM) oversees the entire project, ensuring the team stays on schedule and focused. PM is tasked with developing the work breakdown structure (WBS), assembling the team, creating a detailed project schedule, facilitating team communication, and conducting the project from inception to completion. The WBS defines the roles and responsibilities for each sub team, allocates resources effectively, and allows each team to focus on details without forgetting other components of the project. The WBS will assist the PM in assembling the correct team members for the DBF project. A detailed project schedule will specify when work should start and finish to meet project milestones. It will present an efficient timeline to ensure sequential tasks are completed timely and in the correct order. Good communication amongst team members ensures time and energy are well used, while reducing confusion and dysfunction. Finally, monitoring and facilitating overall team progress is necessary to a successful project.

1.2.2 Fundraising / PR Team

The Fundraising and PR team will serve as the interface between the project, its sponsors, and the public. They will work closely with the Project Manager.

The first and most-important sponsor is the University itself. This team will work with the University administration to secure financial, logistical and administrative support for the project. The team will seek additional assets from groups outside the University. The team will pursue sponsorships from businesses and raise community support for the DBF project.

The support sought will not necessarily be monetary, though they should focus on acquiring tangible assets. The Fundraising and PR group will also be responsible for creating a fiscal forecast to aid in determining a budget for the project. This will set the maximum acceptable projected cost and recommend an ideal value.

1.2.3 Design Team

The Design Team's primary task is to design the plane. The task begins with a preliminary performance analysis to determine the required thrust to weight ratio, likely aircraft size and lift to drag. The design team will be composed of several smaller groups. The team responsible for aerodynamics will determine an appropriate design for the wings and fuselage. A weight analysis team will be responsible for distributing components in the airplane and ensuring a stable center of gravity. The teams will report their findings at the end of the preliminary analysis, and their results will be used to direct follow on trade studies. The trade studies will provide refined preliminary designs for the subsystems of the plane. The structures team will design the wings and fuselage, selecting their shape and materials based on the preliminary analysis. The propulsion team will, naturally, design the propulsion system, selecting the motor, battery, and propeller shape. The controls team will design the electronic control system and begin considering what programming will be necessary for it. The structures and controls teams will work together to design the plane's control surfaces. Ultimately, these teams will be expected to create CAD models of their respective parts and to begin prototyping and testing their ideas. Ultimately the trade studies will all be examined at the Preliminary Design Review. If the results are found to be satisfactory, they will proceed ahead to detailed design.

1.2.4 Construction Team

This group's primary task will be to assemble the plane once it is designed. Multiple different sub-tasks will be involved in this process, each oriented towards completing a subsystem. The wing is arguably the plane's most-important piece; careful machining will be required to build it. The fuselage, while also important, will probably have a less-complex shape, making it easier to construct. The smaller subsystems will be constructed in parallel with the two major pieces. The control surfaces are similar to small–scale wings, and thus will need even greater care to build properly. Similar special attention will have to be given to the last two subsystems, the plane's electronics and its software. Not all students in the Aeronautics and Astronautics department are skilled with electronics and programming. Ideally, recruiting will target people who have some experience in these fields. Finally, once the subsystems are assembled they will have to be put together to create the final system, the airplane.

1.2.5 Test / Flight Team

The Test/Flight working group handles the optimization, testing, approval and verification processes. One early optimization task, controls trimming, is essential for a good flight performance, as it facilitates a safe and accurate maneuvering of the plane, especially in aerodynamically challenging parts of the flight envelope such as low speed, high angle of attack and landing approach. The aircraft should be able to recover from instabilities induced by the loading and adverse conditions such as cross winds etc. The balance of the airplane is crucial to a stable flight, particularly since the three missions are executed with different loading configurations. The structural strength of the different components as well as the quality of assembly is another field of interest for this working group. The wings have to withstand a certain load during maneuvers as well as during the landing, especially if the approach is too steep. During the landing maneuver, the landing gears are highly stressed, but need to function well as only a mission with a successful landing will count towards the final score. The initial flight is one of the most important milestones of the project. First, a flight capable plane has to be produced before the documentation deadline (in-flight photography is a requirement). Moreover, the maiden flight provides the first real indication if the design and construction work as expected. Normally, a number of adjustments or redesigns has to be done after the flight, leading to an improvement cycle and further refinements. Test flights simulating the missions can also be used to optimize several parameters to assure the best possible score in the contest. The final flight test should provide a last assessment of the airplane's performance and perform during a self-made scoring run. The score should at least match the targets set in the trade studies. Last, but not least, this group must prepare the plane for the safety inspection taking place at the start of the contest.

1.2.6 Reports/Documentation Team

The report is an important part of the contest and its score plays the role as a scaling parameter of the total score. The working group should follow the different other teams (design, construction, test/flight, project management and funding/PR) to monitor their activities and put their activities to paper. They are responsible for converting the raw data of the more hands-on teams into a tangible and manageable format for the report and presentations. The primary objective of this working group is to produce a Design Report that scores as high as possible. This includes proper formatting and making sure all the required information is included and clearly presented. If done well, the good score from this team's report will give the overall team a head-start in the competition.

2 Objectives

These objectives help the team understand the primary goals of the project and what all teams strive to achieve. All team tasks and schedules come from these primary objectives. The success of the project will be based on if and how well the objectives were met and completed.

In the tables 2.1, 2.2 and 2.3 , we'll show that the SMART (specific, measurable, attainable, relevant, timely) characteristics apply to our objectives.

Tab. 2.1: Objectives - part 1

Objective	Specific	Measurable	Attainable	Relevant	Timely
Produce a design report that fulfills all report requirements outlined in the DBF rules by 24 February 2014.	Yes, the requirements for each section of the document are laid out clearly in the contest rules.	Yes, the report will be reviewed and given a score. If the score is average or better, this objective will have been achieved.	Yes.	Yes. In addition to being a scored part of the contest, having a well-documented project will aid future projects.	Yes, the full report must be submitted by February 24, 2014
Manage the entire project so that critical deadlines and major milestones are completed and total expenditures meet or stay below total projected amounts.	Yes. It addresses the two clear points and gives a metric for each	Yes. There are large milestones imposed in the rules. Additionally, the team will have smaller milestones and a projected budget. Actual progress can be compared to the initial schedule and budget.	Yes.	Yes. Fulfilling this objective helps ensure the overall success of the team in the competition. Falling behind schedule or over budget will make completing other project objectives more difficult.	Yes. Contest rules mandate several critical milestones.
Complete all tasks in adherence to schedule requirements	Yes. The time schedule mandated by the contest rules. The tasks that have to be completed are determined at the project start.	Yes, by a schedule drawn up at the project start with deadlines/milestones	Yes, if the project groups stick to the schedule, project management is adequate	Yes. Inobservance of the schedule/deadlines will cause elimination from the contest.	Yes

Tab. 2.2: Objectives - part 2

Objective	Specific	Measurable	Attainable	Relevant	Timely
Build plane that outperforms 80% of the competition	Yes, building a plane to the standard of the top 3 of last year's competition, with improvements for this year's missions, will result in the best possible starting position	Yes. It uses the final competition results.	Yes, if trade study goals are met and the budget is assured	Yes. As a public-oriented event, it is an opportunity to demonstrate the UW's excellent reputation.	Yes, the time schedule is mandated by the contest rules.
Secure funding to provide 115% of projected cost	Yes. The projected cost is based on the critical design review, with a maximum set earlier by the fundraising forecast.	Yes. A goal, the projected cost, will be set during the design phase of the project, and the final fundraising will be compared to that goal. If the fundraising exceeded the projected cost by 15%, it will be viewed as a success.	Yes, if the projected cost is not set to too high a value. A forecast of fundraising potential will be used to determine the maximum reasonable projected cost.	Yes. This project cannot be done without sufficient funds. The additional 15% will be valuable for handling unforeseen expenses.	Fundraising should begin before the goal is even set. This will not only aid in creating the aforementioned forecast, but will also give the fundraising team more time to achieve their goal. Furthermore, it will decrease the likelihood of budget shortfalls delaying construction.

Tab. 2.3: Objectives - part 3

Objective	Specific	Measurable	Attainable	Relevant	Timely
Build plane that meets or exceeds stated safety requirements	Yes. Requirements to pass the safety inspection include “an expanded First-Flight requirement, a demonstration of a complete flight including take-off, flying a minimum flight pattern, and landing in a pre-designated location without damage to the aircraft” (AIAA Rules). Three other major inspections will be a part of the pre-tech inspection; a physical inspection, a structural verification, and a radio fail-safe check.	Yes. This objective can be measured simply by being able to present a signed Pre-Tech and First-Flight Certification. The Pre-Tech must be conducted by, and signed off by, a non team member RC pilot or the team faculty advisor.	Yes. Every team is expected to meet these requirements, and most teams have presumably met these or similar requirements in the past. Hence, there is no reason to assume this goal to be unattainable.	Yes. If we do not meet the safety requirements, we will not be able to fly at the competition. Hence, meeting this objective is vital to participating in the competition.	Yes. The Pre-Tech and First Flight inspection must be completed before the competition in April of 2014. The certification must be completed and signed before the safety inspection that will be held on-site at the competition (the first step done at competition). Therefore, the certification has a set due date for its completion. The inspection and completion of the certification itself should not take any longer than one day.

3 Team Structure

The team structure displays how the project is categorized and the “hierarchy” of the team. This helps the entire DBF team know who to communicate with and where their work is going. This structure gives a clear picture of the different parts of the project.

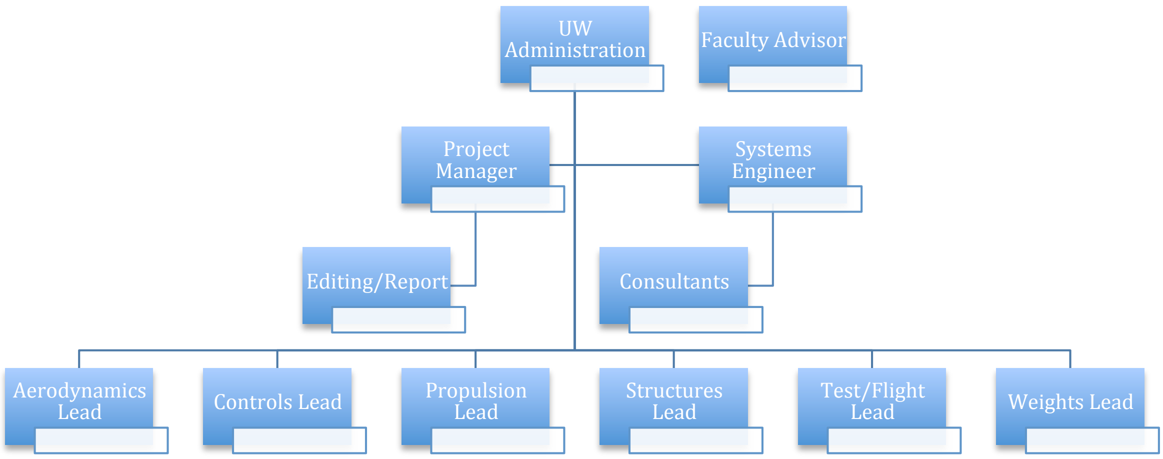

Fig. 3.1: Team Structure Diagram

3.1 Faculty Advisor

- Advocate project with university
- Advice teams on how best to accomplish their tasks
- Provide oversight to ensure that University policies are followed
- Perform Pre-Tech and First flight Certification if possible

3.2 Project Manager

- Create WBS and detailed project schedule
- Assign members to teams
- Conduct the project
- Facilitate inter-team communication

- Ensure project stays on schedule

3.3 Systems Engineer

- Oversee technical aspects of plane design and construction
- Create high level specifications for plane
- Provide technical interpretation and recommendations for PM and administration
- Define necessary system interfaces
- Ensure interface between subsystems

3.4 Editing/Report

- Submit required documents on time
- Work with Fundraising team to produce flyers and communications
- Make sure all contracts/certifications are correctly signed off
- Oversee all teams to gather and edit reports in order to be able to create a full design report

3.5 Consultants

- Provide information and experiences from past DBF competition
- Provide guidance and advice to each team on an as-needed basis.
- Communicate with Systems Engineer to help resolve technical issues

3.6 Aerodynamics Team

- Trade study: selecting the optimal airfoils for best mission performance: high lift for takeoff, low drag for fast lap times
- Predict aerodynamic performance for mission performance estimates
- Calculation of aerodynamic forces: crucial data for structures team
- Simulation: CFD analysis for wings and body of the airplane support structures team in aerodynamic design of the fuselage

3.7 Controls Team

- Design, build, and integrate electronic control systems
- Work with structures team to build and integrate control surfaces
- Program control system

3.8 Propulsion Team

- Selecting motor: unmodified over-the-counter model (from rules set)
- Trade study: motor with best thrust-to-weight ratio, high top speed, small installation space
- Selecting propeller: commercially produced propeller/blades (from rules)
- Ppropulsion unit testing: validate takeoff time and distance

3.9 Structures Team

- Design and build wings and fuselage
- Work with controls team to build control surfaces
- Test materials to ensure the plane will be structurally sound

3.10 Test / Flight Team

- Perform pre-flight safety inspection and approve plane for flight testing
- Test overall plane functionality and ensure plane meets design specifications and performance specifications
- optimize performance of plane control/handling through test iterations
- Perform test/practice flights for each mission to develop familiarity with the plane

3.11 Weights Team

- Monitor positioning of parts to ensure center of mass is correctly positioned
- Ensure that the vehicle's weight is low enough to allow it to fly
- Report issues in above bullets to appropriate teams with suggestions for improvement

4 Assumptions

These assumptions are identified so that each part of the team can start and complete their work. It is necessary to identify these assumptions so that the team knows that the completion of the project is attainable.

4.1 We will get the necessary funding

We will assume the success of our fundraising team. Otherwise, the project cannot continue.

4.2 The plane design will work - it will fly

This is a necessary assumption, as we cannot compete if the plane can't fly. It relies on the design team in performing adequately.

4.3 All materials will arrive on time

This assumption relies upon the work of the PM Team doing proper time scheduling, accounting for material shipment in the schedule, so that construction can continue in a timely manner.

4.4 Most group members will complete the project

We must assume that we will have a full team at competition, for there are team requirements that must always be met. It will be the PM's job to recruit and, if necessary, replace personnel.

5 Constraints

We have identified several constriants which might limit the DBF project and have developed workarounds for each.

5.1 Budget

All projects are constrained by the size of their budget, but this project also faces the challenge of not knowing what its total budget will be until construction acquisition begins.

Workarounds

Fundraising Forecasting: An estimate of total fundraising success must be created no later than PDR. The fundraising team will create a forecast for how much money they believe they can collect based on initial interest and the median sponsorship amount. The design team will have to keep their projected cost below the fundraising forecast to provide a safety margin against uncertainty. Cost-Effective Alternatives: Until the fundraising forecast is created, the design team will have to seek cost-effective alternatives for every part to ensure that they'll be able to build the best plane possible with their final budget.

5.2 Schedule

This project has the following firm deadlines that must be met: the deadline for entry (10/21/13), the deadline for the design report (2/24/13), and the date the contest begins, which is effectively the deadline for plane delivery (4/11/13).

Workarounds

Good Scheduling: On the project level, a realistic schedule which meets all of the deadlines must be created. Each team will also have to schedule their sub-tasks in such a way that their assigned tasks will be completed by the deadlines listed in the project's overarching schedule.

5.3 Rules and Regulations

The rules and regulations of the competition must be followed so that we'll be able to participate in the competition.

Workarounds

Awareness and Oversight: All team members will be required to familiarize themselves with the rules. The project leaders, including the Project Manager, Systems Engineer, and Team Leads will be responsible for making sure that the rules are followed.

6 Issues

Several known issues have been identified and addressed with action plans below.

6.1 Knowledge base

As at least one third of the team members have to be Freshmen, Sophomores or Juniors, it is necessary to establish a common knowledge base, so that the new members can start contributing to the project as fast as possible.

Action Plan

A first possibility is target recruiting on students with possible prior knowledge (model builders, airplane enthusiasts etc.). The DBF problem statement is likely to attract students with at least a strong interest in the field of aeronautics. Furthermore, the lessons learned documents of the last years teams should be distributed among the new team members for individual study to give a general overview of the challenges that the team might face. Veterans of previous years' teams and/or senior or graduate aeronautics students could be invited as guest speakers or consultants. They can play a mentor role, educating the new team members about the optimal approaches for tackling the different project tasks

6.2 Facilities Availability

The team needs meeting rooms, a workshop space, wind tunnel test time, storage space etc.

Action Plan

The project management team must get support from the university and/or the department as soon as possible to reserve usage of these facilities. In the best-case scenario, the structures from last years' teams are still intact and can be used. Meeting room booking is the responsibility of the project management team. The structures team could maybe include a research engineer with connections to the university's workshop facilities managers to play the role of supervisor for the work taking place there. Wind tunnel test time is free for students, they just have to fit in the free slots between commercial testing. Therefore, to ensure a good degree of capacity utilization, the aerodynamics and structures teams should always have ready models for testing on short notice. A room to serve as team headquarters could be obtained in collaboration with the university facility management and the student union.

6.3 Meeting scheduling

The different teams have to meet up to discuss current affairs, problems etc. As students often have differing schedules, time windows have to be found where everyone is available.

Action Plan

This issue has to be addressed by the project management team. They can use tools like Doodle, Microsoft Outlook Calendar etc. to aid in scheduling. One possibility is to counter this issue is to have each team have its own meetings, so that only the leads of the different teams have to attend the top level meetings. Meeting notes should be sent out to every team member,to keep them informed even if they can't attend the meeting in person. The different team leads can spread the information received on the top level meetings at their team's meetings.

7 Risks

Identification of risks and creation of mitigation plans help to organize and focus limited manpower. Mitigations plans decrease the probability and severity of risks. The following are several potential risks, with a mitigation plan for each.

7.1 Plane is destroyed or damaged during testing or transit

It is possible the plane will be damaged or destroyed during testing or while in transit to the competition.

Mitigation plan

Damage during testing is likely. To mitigate the severity of these events, the plane will be designed with part interchangeability in mind. A modular system limits repair downtime and allows for field repairs. Initial test flights will also be conducted in Dempsey Hall until pilots are familiar with the aircraft.

To protect the plane during shipment, a case will be built or purchased. The case will need to be tested prior to usage to ensure it can adequately protect the plane. Additionally, spare parts can be packed with the plane or brought separately and can be swapped in should the plane arrive damaged. Finally, the team (or a contingent) can arrive before the competition. This small window provides the opportunity to complete any repairs or adjustments which might be necessary. As a last resort, the plane can be driven by the team to the competition site.

7.2 Problems within the team

Team members may not do assigned work, leave the team without prior notice, or have the required 1:3 ratio of underclassmen

Mitigation plan

Ensuring good morale and camaraderie amongst team members is important to prevent negative feelings. Keeping good communication within teams and sub-teams will help identify when work is not being completed, so follow-up can occur. To ensure the proper ratio of students, heavy emphasis on initial recruitment is important to attract the largest number of underclassmen. The team can also continue recruitment efforts throughout the school year, as student schedules change. Finally, as a last resort, senior students may need to leave the team to maintain the regulation ratio.

7.3 Cannot meet hard deadlines

The team may fall too far behind schedule and miss competition deadlines.

Mitigation plan

Having an active and experienced project management team is the first defense against missing deadlines. Tasks identified as part of the critical path must be placed into the project plan and scheduled. If equipment needs to be reserved for tests and analysis, it will be done as early as possible using information based on previous projects' experience. Buffer time will be included to allow for some overflow of tasks without endangering the overall schedule.

7.4 UW emergency

Adverse conditions may cause the UW to shut down or limit operations. Possible events include power outages, snow closures, broken pipes/flooding, etc.)

Mitigation plan

First, the Project management team will include buffer time in the project schedule. Action plans for the most likely scenarios will be created. Work may not be affected, or workarounds may be possible (e.g. work remotely). The team can also work to foster a good relationship with key administration and maintenance crews to try to get issues resolved faster.

8 List of Tasks

8.1 Tabulated List of Tasks

The table below lists major tasks for the project. Milestones are in bold typeface.

Task	Duration	Start	Finish	Pred.	Resource
1) *Recruiting and Team Organisation*	4 wks	Mon 9/30/13	Fri 10/2513	-	Faculty Advisor, PM
2) *Entry Form Submission*	**1 day**	**Mon 10/7/13**	**Mon 10/7/13**	**6**	**Editing/ Report**
3) *Fund-raising - PR/ Outreach*	2 mons	Fri 11/4/13	Thu 1/23/14	4, 5	Fundraising Team, PM
4) *Establish Schedule*	1 wk	Mon 10/28/13	Fri 11/1/13	1	All
5) *Establish Initial Budget*	1 wk	Mon 10/28/13	Fri 11/1/13	1	All
6) *Get Support from UW*	1 wk	Mon 9/30/13	Fri 10/4/13	–	Faculty Advisor, PM
7) *Preliminary Analysis*	3 wks	Tue 10/29/13	Mon 11/18/13	9	Design Team
8) *Trade Studies*	3 wks	Tue 11/19/13	Mon 12/9/13	7	Design Team
9) *System Requirements and Specs*	1 day	Mon 10/28/13	Mon 10/28/13	1,2	Design Team, SE

Task	Duration	Start	Finish	Pred.	Resource
10) *Final Budget*	1 wk	Thu 1/23/14	Wed 1/29/14	14,27	Design Team, PM, SE
11) *Preliminary Design Review*	**1 day**	**Tue 12/10/13**	**Tue 12/10/13**	**8**	**Design Lead, SE, PM, Faculty Advisor**
12) *Subsystem Design*	3 wks	Wed 12/11/13	Tue 12/31/13	11,5	Design Team
13) *Design Integration*	1 wk	Wed 1/22/14	Tue 1/28/14	12,15	Design Team
14) *Critical Design Review*	**1 day**	**Wed 1/22/14**	**Wed 1/22/14**	**15**	**Design Lead**
15) *Prototyping and Testing*	3 wks	Wed 1/1/14	Tue 1/21/14	12	Construction Team
16) *Maiden Flight*	**1 day**	**Mon 3/3/14**	**Mon 3/3/14**	**25**	**Construction Team**
17) *Structural Construction*	4 wks	Fri 1/24/14	Thu 2/20/14	14,3	Structures Team
18) *Electric Construction and Programming*	4 wks	Thu 1/23/14	Wed 2/19/14	14	Controls Team, Construction Team
19) *Modeling and Simulation*	2 wks	Wed 12/11/13	Tue 12/24/13	11	Construction Team
20) *Integration*	1 wk	Fri 2/21/14	Thu 2/27/14	17,18	Construction Team
21) *Optimization*	2 wks T	Tue 3/4/14	Mon 3/17/14	16,32	Construction Team
22) *QA Check*	5 wks	Thu 1/23/14	Wed 2/26/14	14	Construction Team
23) *Practice Flights*	2 wks	Tue 3/4/14	Mon 3/17/14	16,32	Construction Team
24) *Final Test Flight*	**1 day**	**Tue 3/18/14**	**Tue 3/18/14**	**23**	**Construction Team**

Task	Duration	Start	Finish	Pred.	Resource
25) *Public Display/ Roll Out*	1 day	Fri 2/28/14	Fri 2/28/14	20	PM, Construction Team
26) *Competition*	**1 wk**	**Tue 3/18/14**	**Mon 3/24/14**	**24, 27**	**All**
27) *Transport Design*	1 wk	Wed 12/11/13	Tue 12/17/13	11	PM, Design Team, SE
28) *Close Out Meeting*	1 day	Tue 3/25/14	Tue 3/25/14	26	All
29) *Clean Up and Storage*	3 days	Tue 3/25/14	Thu 3/27/14	26	All
30) *Lessons Learned*	1 day	Tue 3/25/14	Tue 3/25/14	26	PM, SE, Team Leads
31) *Design Report*	**1 wk**	**Thu 1/23/14**	**Wed 1/29/14**	**14**	**Design Lead, SE**

8.2 Critical Path

The Critical Path of the DBF project is outlined in the Activity-on-Node diagram below.

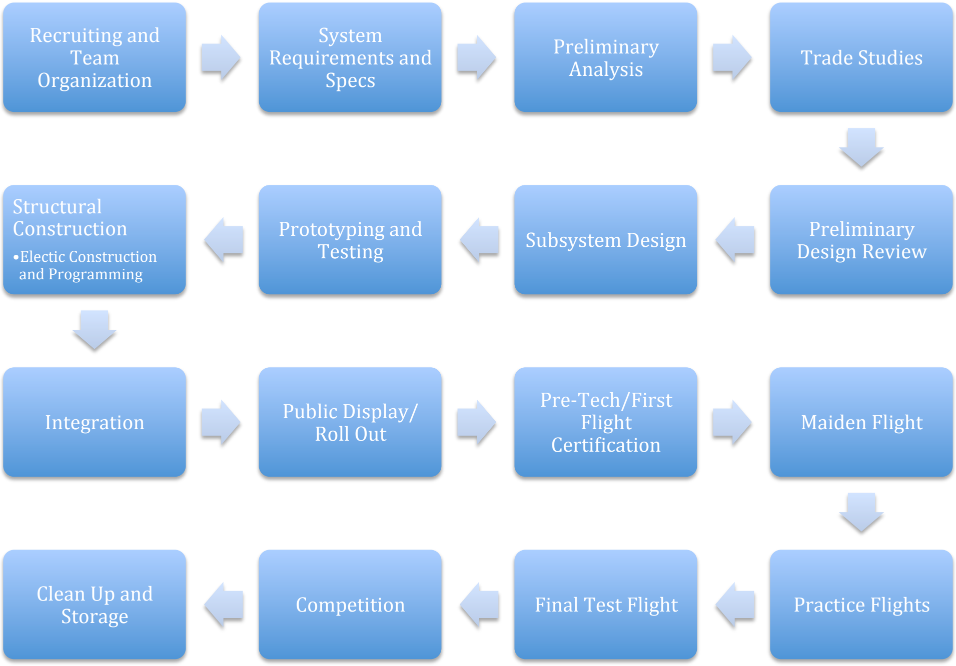

Fig. 8.1: Critical Path

9 Lessons Learned

While we had no major problems, there were still some things which we needed to improve. Firstly, we did suffer from some communication problems early in the project. As a result, we set a policy that all documents needed by more than one person must be sent out promptly to avoid bottlenecks. We also suffered from occasional confusion over revised documents not being marked; from now on, we'll make sure to clearly label revisions made to new versions of documents. We also realized early on that sharing files through email can be a disorganized, messy process, and thus we set up a single Dropbox to store all of our shared files. A final mistake which we ultimately corrected was not creating a good schedule for this project right away. Next time, we will be sure to set up deadlines for completion of the parts of our next assignment.

There also were many lessons which we learned from what we did well. Firstly, we quickly decided to make the Engineering Library our central meeting area. Having a single, central meeting location allowed us to coordinate easier. Additionally, we also found that the idea of everyone having a single document for their work to be surprisingly effective. It kept things organized, and at the end, we simply assembled the final document from those parts.