16.030-16.040 Unified Engineering
Department of Aeronautics & Astronautics
Massachusetts Institute of Technology

Spring 2004

Systems Problem 2: Part II
System Requirements
&
Design, Build, Fly

Handed out:	Thursday, February 12, 2004
Answers due:	Thursday, February 26, 2004, 5:00 p.m. **(2 WEEKS)**

Learning Objectives

At the end of this systems problem you should be able to:

- Synthesize system functional requirements utilizing available resources.
- Articulate system functional requirements, development resources, and constraints.
- Organize system functional requirements in a systematic manner that will facilitate system development and analysis.
- Develop and document design ideas that are intended to achieve functional requirements.
- Use group consensus to develop group project documents.
- Within a group develop and setup design ideas for analysis.
- Create a work breakdown structure.
- Create a Gantt chart.
- Establish a framework for effective teamwork and communication.
- Build and fly a radio-controlled model aircraft.
- Develop a baseline *system* test.

This is a team assignment

Motivation

You are being charged with the task of developing a *system* that will participate in an aerial competition in late April 2004. At the competition you will have at your disposal a team of four (4) or five (5) personnel, a radio controlled model aircraft, and associated equipment. You will be given a baseline aircraft at the beginning of the semester. During the semester you have the opportunity to modify the aircraft and design and optimize a *system* that will win the competition. You will be assigned to a team of four (4) or five (5) individuals, and four (4) hours per week per team member has been allotted to activities related to this project. Various materials and resources will be made available to you to help you organize and manage your project, and to help you develop, analyze, and optimize your winning system.

At competition day your system must do the following: Take off carrying no payload and fly two (2) laps of a closed indoor circuit for speed. Land and load one (1) to four (4) eggs, which we will give you, as a payload. Then takeoff with the egg payload and fly for endurance (maximum time aloft) in any manner you want within the indoor track and land. You will be judged on your time to complete empty and loaded parts of the competition. You will be judged on the amount of time it takes to load your payload. Shorter times to complete the empty laps are better. Greater amounts of time in the air are better for the laps with the egg payload. And your time in the air with payload is multiplied by a factor proportional to the number of eggs that you carry. Shorter amounts of time loading the egg payload are better. Crack or break the egg handling, loading, or landing, and you are eliminated from the competition.

The approximate dimensions of the rectangular boundary of the indoor circuit are 185'x95'. Your system must be designed with the possibility that the competition may eventually take place outdoors.

The official competition objectives, scoring method, and constraints have been written by Col Young and appear in a separate document.

Good system design and development begins with a thorough understanding of system functional requirements. This is an exercise in understanding and articulating customer needs and specifying *what* needs to be accomplished. After *what* needs to be accomplished has been established then *design* and analysis lead to the development of a *system* (hardware, software, people, and procedures) that determines *how* customer needs are meet and functional requirements are achieved.

Good project resource and risk management leads to the *timely* development and delivery of the system. A thorough understanding of available resources and constraints will aid in both the development and timely delivery of they system.

Your team assignment in this system problem is to start doing excellent system design and development. You are to use available resources to assess and synthesize system functional requirements for the aerial competition. Then you are to articulate and document these functional

requirements in a brief system requirements document. You are also asked to document system resources and constraints. Next, you are asked to organize the system functional requirements in a manner that will facilitate design and analysis of your system, and management of your project. Finally, you are asked to develop a preliminary strategy and preliminary design ideas that realize your system requirements. Additionally, your group will need to develop a plan for designing, developing, implementing, testing, delivering, and operating your system for the competition. Your group is also required to build a baseline aircraft for the competition, and to perform some baseline flight tests.

Your group's system requirements, functional requirements and strategy will allow you to *design* a system that will achieve your desired goal – winning the competition. You will use Prof Slocum's FRDIARRC framework as a tool to document your *design ideas* and to manage your *design process* (analysis, tradeoffs, etc). (CD) You will need other tools and frameworks to manage the *timely* delivery of your system *within budget*. (IO). These tools will generally fall into the categories of either *teamwork* or *project management*.

Project Management:
With system requirements and strategy in hand, project deliverables (aircraft, wing, testing, competition procedure, trained pilot and pit crew) will become apparent. One key graphical tool for communicating and tracking project deliverables for your system is a work break down structure (WBS). Project deliverables then need to be *scheduled* for delivery within timeframe and budget. A Gantt chart is popular graphical tool for timeline display and tracking of project deliverables and tasks.

Teamwork:
Your established management plan, communication plan, and ground rules from System Problem 2: Part I will help you successfully complete this assignment on time and within the allotted time budget.

Assignment

This is a group assignment. Your group should meet and develop a group system requirements document with resource and constraint lists. Document your group's system requirements for design development using Prof Slocum's FRDIARRC table.

Develop a group strategy for your system and write a document explaining it. Your group should develop design ideas for *landing* and *laoding* of the aircraft, as these are two particularly challenging and problematic features of the aircraft. Develop your group design ideas using the FRDIARRC framework, and include sketches and brief documentation.

Utilize your group's strategy and functional requirements to develop a work breakdown structure (WBS). Use your WBS and resource budget to develop and preliminary schedule. Document your project schedule using a Gantt chart.

Assign and train at least one pilot for your group. Build your baseline aircraft. Separately estimate the number of hours it will take to construct the wing, body, and empennage of the aircraft, and installation of the propulsion and control system. Record the actual number of hours required to construct and install these subsystems.

Develop a baseline system test plan. It is important to note that a good test plan will include measurements of important aircraft performance parameters (i.e. thrust required, ground roll, etc.). Consult *Aircraft Performance and Design* (John D. Anderson) Chapters 5-6 or your TAs for more information.

Deliverables

1. Group systems requirement document in format shown in Charlie Boppe's "Satellite Sensor System Requirements" document with two additional sections: 4.0 Resources and 5.0 Constraints.
2. Group strategy document.
3. Group system functional requirements documented in a completed FRDIARRC table.
4. Completed FRDIARRC table, sketches and documentation of design ideas for
    a. Landing
    b. Loading Payload
5. Group WBS document and Gantt chart (schedule).
6. Baseline build report to include list of weights of components (motor, propeller, servos, wing, vertical stabilizer, horizontal stabilizer, etc). Treat the entire fuselage as a single component. The build report is also to include estimate and actual construction times for wing, body, and empennage, and installation time for the propulsion and control system. Pilot training report including time logged in simulation and flying.
7. Baseline test plan documenting what is to be measured during the baseline test.

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Group Number	
Name	**Time Spent**