# Using a Product Engineering Process to Manage an Introductory Mechanical Engineering Program

by

Christina Marie Laskowski

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Signature of Author: ______________________________
Department of Mechanical Engineering
May 6, 2005

Certified by: ______________________________
Rohan Abeyaratne
Quentin Berg Professor of Mechanics
Thesis Supervisor

Accepted by: ______________________________
Ernest Cravalho
Professor of Mechanical Engineering
Undergraduate Officer

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ABSTRACT

"Discover Mechanical Engineering" (DME) is a student-run Freshman Pre-Orientation Program at the Massachusetts Institute of Technology which, in the time since its inception in 2002, has developed into a popular, professional, and well-organized pre-orientation program MIT. Yet despite its success, it routinely experiences difficulties with respect to personnel and timeframes, both of which continually threaten the well-being of the program. It appears, however, that such difficulties are not a result of the students' motivational level, since all of DME's student volunteers contribute a great deal of time to the program. Rather, the problem may be that DME student leaders (and their supporting volunteers) are attempting to run the program prior to having taken MIT's Product Engineering Process course (also known as 2.009), a required senior-year mechanical engineering course which is expressly designed to teach students how to manage projects similar to DME. This course teaches tools most useful for the management of personnel and of time – the very areas which DME seeks to improve – through the use of Gantt charts, delineation of the project's critical path, and sundry other methods. It is reasonable to believe that bringing a Product Engineering Process methodology to DME would help rectify existing problems, thereby benefiting the program as a whole. This thesis studies the DME program, examines PEP approaches as potential solutions to recurring problems, and suggests several areas for further improvement of DME as a whole.

Thesis Supervisor: Rohan Abeyaratne
Title: Quentin Berg Professor of Mechanics

Christina Marie Laskowski attended the Massachusetts Institute of Technology as an undergraduate student from August 2001 through June 2005, earning her Bachelor of Science degree on June 3, 2005. She is the former (Summer 2004) program head of the Discover Mechanical Engineering Pre-Orientation Program, the organization around which this thesis is based. An advocate of both design and education, she has assisted and taught a number of design-related classes and seminars at MIT, including: Design and Manufacturing, Undergraduate Assistant, Springs 2005 and 2004; Discover Mechanical Engineering Freshman Advising Seminar, Founder and Student Leader/Associate Advisor, Fall 2004; Culture & Technology Seminar, Instructor, Springs 2005 and 2004, Teaching Assistant, Spring 2003; Introduction to ANSYS seminar, Teaching Assistant, January 2004; Physics with Sports, Teaching Assistant, Fall 2003; in addition to several dozen assorted engineering outreach activities. She plans to begin graduate school immediately following graduation, at an as of yet undetermined university, and plans to pursue medical product design.

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*To Kate*

*And to future generations*
*of DME "froshlings"*

**Foreword: How to Read this Document**

This thesis has a twofold purpose: to address planning concerns of the Discover Mechanical Engineering Pre-Orientation Program as they pertain to the planning of mechanical engineering programs in general, and also to specifically provide a planning guide for the student leaders of future iterations of the Discover Mechanical Engineering Program.

For this reason, parts of this thesis will be a scholarly investigation of a mechanical engineering organization's proceedings, while other parts will persist in the style of a manual or handbook. This reflects the dual nature of the document – the lengthy textual portions are to be read carefully as one has time; when one lacks the time, one can refer to the timeline spreadsheets, other figures, and appendices, which reveal the program at a glance.

## Table of Contents

## 1.0 Introduction - History and Overview

Over the five year span from the beginning of the 1995 academic year to the end of the 2001 academic year, the mechanical engineering department faced a problem of decreasing enrollment. Gathering together students from Pi Tau Sigma (the Mechanical Engineering Honor Society), the department challenged students to create new ways to address this problem. Out of that challenge grew the Discover Mechanical Engineering program, which piloted in January of 2002 and has continued for every summer since as a pre-orientation program (a program for freshmen which runs the week preceding Freshmen Orientation).

Discover Mechanical Engineering is devoted to providing incoming freshmen an exciting hands-on introduction to mechanical engineering through construction of a soccer-playing robot (SoccerBot). During the week-long program, participants learn to use machine tools, construct SoccerBots, speak to professors and industry representatives in mechanical engineering, tour related companies and MIT labs, spend time with upperclassmen in the department, and much more. The program cumulates in a double-elimination robotic soccer tournament held at the Boston Museum of Science.

From its strong beginnings in 2002, DME has grown each subsequent year, and is currently respected as one of the most popular, professional, and well-organized of all the pre-orientation programs. It routinely receives 200 applications to fill 32 spaces in the program; the program receives unsolicited volunteerism from upperclassmen and freshmen both in the Mechanical Engineering Department and from other departments. DME volunteers have taken the program through enough iterations to understand the process, and a great deal of collective wisdom has accumulated through the years, passed down in a combination of official documents, oral format, and pure experience. Even in its most troubled times, DME still manages to produce a highly successful and well-liked program each year.

### 1.2 Contribution of the Thesis

Despite DME's tremendous success as a pre-orientation program, several key difficulties persist, two of the most important of which pertain to management of personnel and of time. On the personnel side, since virtually all the participating students are volunteers, there is difficulty in keeping everyone on task and productive when summer internships beckon. Small tasks are neglected here and there, requiring the student leader to complete these tasks herself and to therefore spend the entirety of the summer in a combination of planning, managing, and completing neglected tasks. Small overlooked tasks occasionally build up into larger crises, which may threaten the program as a whole if unchecked.

Time management causes even greater difficulties. Often, the volunteer nature of the program can create an environment of little accountability for one's actions, as there is no personal penalty to being late with one's assigned tasks. Progressively later deadlines mean that volunteers helping during or immediately before runtime face extraordinary pressure to complete an exhausting amount of work in little time. In its most severe form, procrastination has caused a multitude of exciting and complex activities to be scaled down or cut in their entirety when there is insufficient time to prepare for them. Furthermore, the timing of internships and job offers means that many students who volunteer to help the program over January break cannot participate in the same capacity over the summer, and vice-versa. This discontinuity in personnel negatively impacts each affected committee and likewise affects the continuity of the program progress as a whole.

It is important here to strongly emphasize that these failings are not for lack of motivation on the part of either the student leader or of the student volunteers involved in the program. In fact, most people involved in DME in any capacity are quite dedicated and loyal, taking large amounts of time out of both their term and summer schedules with no expectation of reward, simply because they believe in DME's cause. Many students volunteer to help DME each year, giving the program a very large amount of manpower at its disposal. Everyone involved in the program exerts a tremendous amount of effort and is generally quite tenacious in completing their tasks. Yet the program suffers regardless. Thus the problems rest not in the students themselves.

It is quite interesting here to note that – with the lone exception of the upcoming Summer 2005 leader – every DME student who has attempted to plan the program has done so without the benefit of having taken MIT's 2.009 Product Engineering Process (PEP) course. This all-encompassing course is offered senior year in part to help students understand the process behind producing a product. Run as small companies, groups of 16 students each progress from a concept for a device through an actual functional prototype, encountering everything from inventory control, to budgeting, to data collection, to interviews, to usability testing, to presentations, to the creation of posters and pamphlets, etc. In this manner, the processes involved within the 2.009 PEP course bear an uncanny resemblance to DME, which in turn means that previous DME leaders missed an opportunity to learn the intricacies of managing an engineering team from the 2.009 PEP course prior to managing the much larger DME organization.

While Discover Mechanical Engineering has encountered significant difficulties with respect to personnel and timeframes, the dedication and sheer number of students involved suggests that the difficulty lies not with the motivation of the students themselves. Instead, these students are currently attempting to develop DME without the guidance of the very course in Mechanical Engineering designed to address such projects. It is therefore believed that introducing the Product Engineering Process methodology into the planning of DME would remedy many of the program's persistent difficulties, especially those with respect to personnel and timelines. PEP methodology has a great deal of potential to improve DME as a whole.

### 1.3 Structure of this Document

The remainder of this document is composed of several different sections. Section 2 outlines the overarching goals of DME at large, defines the organization of the program, explains the constraints within which the program runs, and generally sets the stage for further discussion of the topic. Section 3 outlines a PEP methodology for achieving greater efficiency within DME via systematic elimination of its greatest difficulties. Section 4 lists several additional concerns which future leaders must keep in mind while applying the suggested methodology. were Finally, Section 5 brings the document to a close with suggestions for future work.

## 2.0 Program Goals, Organization, and Key Considerations

*"An organization is a set of roles tied together by communication."*

*- Kenneth Boulding,* *The Organizational Revolution*

In order to more fully understand the particulars of organizing the Discover Mechanical Engineering program, it is necessary to first understand the goals for which the program stands, its organizational structure, and several other key considerations necessary for planning purposes.

### 2.1 Program Goals

DME is officially both a teaching program and a recruitment tool. However, as many program upperclassmen can attest to, this program is also a great deal more. It is meant to give freshmen an enjoyable time while giving them an insider's look into mechanical engineering. By doing so, they can make an informed choice of major, since it is better to have a freshman who is happy in another department than one who is miserable in mechanical engineering. Beyond the freshmen, DME furthers the professional development of the mentors and staff as well. It is meant, in short, to fulfill a great number of roles at once, and DME rarely means the same exact thing to two different people.

Though opinions vary somewhat, it is widely understood that the main goals of DME are:

- Fun – The very reason for having robot building, social activities, and fun events afterwards are to give the freshmen wonderful experiences to remember, both in and out of lab.
- Professionalism – DME is a highly sophisticated program, arguably perhaps one of the most professional undergraduate-run programs at MIT. It entertains a number of important people, from department heads and emeritus professors, to representatives of professional organizations and industry leaders. Only the highest level of dignity and professionalism can sustain such a sophisticated program.
- Opportunity – DME is meant to give freshmen and upperclassmen a chance to begin exploring their new world of Mechanical Engineering at MIT, through structured activities they may not otherwise have access to, well before their MIT career even begins.
- Technical Training – DME provides freshmen with technical training valuable to their potential career as an engineer.
- Career Guidance – By providing such hands-on exposure to mechanical engineering, DME allows freshmen to discover their potential for a career in engineering.

### 2.2 Program Organization

DME embodies an organization all to its own in addition to fulfilling broader roles within the Mechanical Engineering Department and the Pre-Orientation Office. DME's internal structure can be seen in Figure 1.

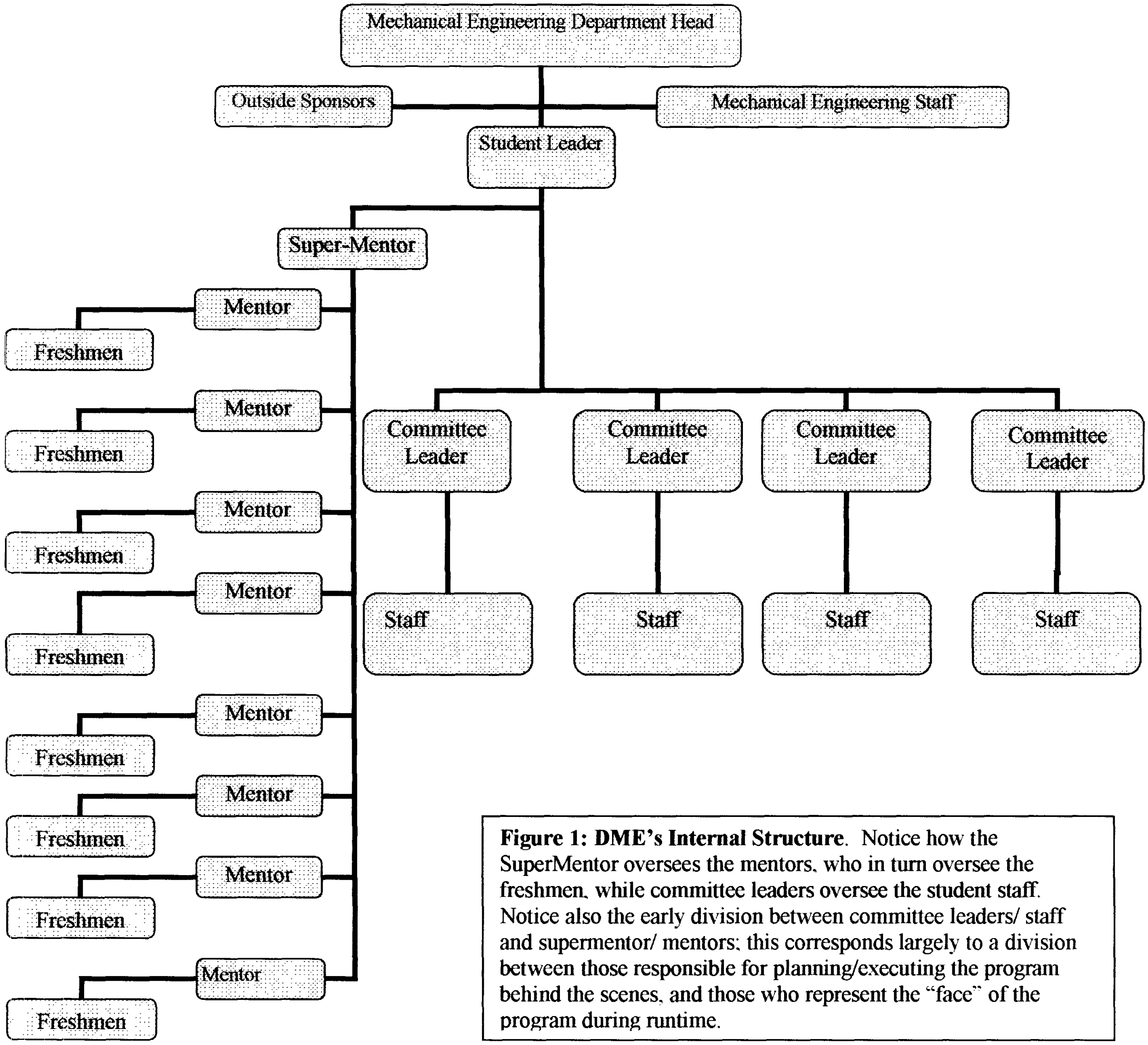


**Figure 1: DME's Internal Structure**. Notice how the SuperMentor oversees the mentors, who in turn oversee the freshmen, while committee leaders oversee the student staff. Notice also the early division between committee leaders/ staff and supermentor/ mentors; this corresponds largely to a division between those responsible for planning/executing the program behind the scenes, and those who represent the "face" of the program during runtime.

As shown here, the Department Head oversees DME and provides the highest-level support to the organization; the Outside Sponsors and Mechanical Engineering Staff provide an assisting level of support and overseeing capability. The person who most frequently interacts with these people is the student leader of DME, who comes next on the chart and who oversees the remaining body of the organization. The student leader manages and aids each of the committee leaders and staff, as well as the supermentor and mentors, thus interacting with each member of DME individually, despite the formalized hierarchy. The committee leaders and their assisting student staff are each responsible for bringing a particular aspect of the program to fruition. Meanwhile, The supermentor role is often designed as a "program-head-in-training" role, and allows a future leader to manage the mentors while still under the guidance of the student leader. The eight mentors, in turn, are in a position of prestige, interacting directly with the freshmen while overseeing and protecting them for 16 hours per day for each of the five days of DME.

These mentors usually become initially involved in the program as staff or as a committee leader and serve DME for a year or more before becoming a mentor. As need arises, though, leadership has the discretion to appoint and dismiss individuals as required. However, those who remain with DME through the years and rise through its ranks tend to adhere to the following progression:

Freshman ⇨ Staff ⇨ Committee Leader ⇨ Mentor ⇨ SuperMentor ⇨ Student Leader.

**2.3 Key Program Considerations**

There are several considerations considered key to the nature of the organization that must be kept paramount in mind when any measure of program planning occurs. Namely, these considerations include guardianship of the freshmen, providing autonomy, and organizational learning.

### 2.3.1 Protecting the Freshmen

DME is responsible for all of its freshmen from the time they arrive on campus until the time the program hands them over to Orientation. This means that if someone gets hurt in lab, the program is potentially liable; if someone sneaks out of an evening activity to become intoxicated, the program is potentially liable; if someone becomes lost while venturing off campus, the program is potentially liable; if someone falls into a depressive state and the program fails to find appropriate aid, the program is again potentially liable; etc. The lives of DME's 32 freshmen are quite literally DME's responsibility for an entire five days.

If any of these eventualities occur, they must be dealt with quickly and professionally, documenting whatever happened as soon as possible in case it comes up in the future. In case of serious incident, the FPOP office acting in concert with MIT and ME might be able to provide some degree of legal buffering to protect our people from lawsuits. However, the program should at all times endeavor to avoid potentially troublesome circumstances, so as to prevent these incidents before they can occur.

For this reason and others, DME's primary responsibility is to protect the freshmen at all costs. This protection comes in a myriad of forms, including but not limited to:

(a) Ensuring the SoccerBot design is free of defects that could cause harm in operation or in testing;

(b) Ensuring the SoccerBot assembly directions are free of ambiguities which could potentially lead to hazardous misunderstandings (ie, mis-marking the screwdriver casing and consequently sawing a battery in half);

(c) Training the freshmen in the use of all shop equipment; including potential safety concerns and what to do if something goes wrong; also ensuring that the mentors who actually perform said training are thoroughly informed, rehearsed, and otherwise prepared for said training;

(d) Providing continual supervision for freshmen every moment they are in lab, and non-stop attention (via "lab lifeguards") when they are utilizing any shop machine of any kind;

(e) Thoroughly testing each out-of-shop activity – including evening events, back-up events, and first-day activities – to quality-check for potential discomforts, sources of tension, etc; also to eliminate those which may provide potential discomfort;

(f) Streamlining all activities such that freshmen for the most part do not see the preparation work behind their day (the impression that everything is taken care of can be quite calming);

(g) Acting at all times in an entirely calm and wholly professional manner, including dealing with crises quickly and quietly;

(h) Charting and providing to each mentor a clear-cut, tested route to each locale, with instructions provided to eliminate ambiguity (ie, "at Park St, exit via the right side of the train, not the left") such that no mentor gets lost or strays from the rest of the group;

(i) Keeping track of all freshmen; both their progress in the machine shop as well as their physical location at all times; such that No Freshman Is Left Behind.

(j) Controlling all mentors and staff to ensure that each acts in the best interests of the freshmen, not of himself;

(k) Recognizing and eliminating any potential social and psychological sources of discomfort which may cause distress and hence negate the positive effects of the program, including: competition among groupmates, striations in initial machine shop know-how, fear of not completing the robot, failure to accommodate dietary needs, miscommunications over email, discomfort taking part in social activities, cultural differences, etc.

Of these, (k) is perhaps the most ambiguous, only because so many things could potentially cause such distress. Thus, this rule must be kept in mind throughout program planning and allowed to guide program decisions as necessary. The typical freshmen, in their first few fragile days at MIT, are already far enough outside their comfort zones as it is, and hence they should not be forced too strongly to take on more than they are prepared to handle.

### 2.3.2 Providing Autonomy

Despite the need to protect the freshmen, there is also a conflicting need – the need to treat the freshmen as adults. As of the writing of this document, law dictates that all college students are considered to be "emancipated minors," which enjoy the full privileges of adulthood, regardless of whether or not they are 18 years of age. Furthermore, sheltering the freshmen excessively is in direct conflict with the stated goal of allowing them to explore their surroundings.

Thus, a delicate balance is required – student leaders may need to be extraordinarily cautious about freshmen safety, but they must exercise such caution quietly. This balancing act is evident in letting freshmen make simple choices about their day while simultaneously keeping them occupied and present in the program for 12 to 16 hours out of the day. Simultaneously allowing choice and setting clear boundaries does much to soothe the mistrust/trust tension noted here.

This autonomy clause has direct relations to the machine shop, as well. True autonomy means knowing how to create something from basic parts with little help; in this spirit, DME allows each freshman to create her own robot, such that freshmen must rely upon their own efforts alone without depending upon those of a group mate. This also helps freshmen develop a sense of pride in their individual accomplishments. Likewise, the program provides minimal prefabrication of parts – since prefabrication reduces individual autonomy – and largely shuns the use of jigs on principle.

### 2.3.5 DME as a Case Study of Organizational Learning

One way to conceptualize the project management concerns that this thesis seeks to address is through consideration of problems of organizational learning. Organizational learning expresses the idea that every organization, as a whole, learns from each experience it encounters, with each member of the group retaining some knowledge from previous years, (Ackerman, Organizational Memory). Over time, this knowledge base – embodied fully not in any one individual but spread in parts across the organization – develops into a "collective wisdom" (or more professionally, "organizational memory,") that helps the organization's success. This arrangement evidently works best in low-turnover environments, since it is assumed that each learning individual will be around in the future when a familiar situation arises, although the distributed nature of the knowledge base does help provide some buffer to the loss of particular individuals (that is, more than one person is likely to know each of the various lessons of the past).

However, organizational memory has limits in a rapid-turnover organization. In a situation such as DME, for example, ¼ of the program's people are lost each year due to graduation and roughly another ¼ leave due to other factors. This suggests that in the absence of formalized documentation or training, close to 50% of the collective wisdom from each generation of the program must be re-learned each year. Quite a bit of this is unavoidable – i.e., one would expect a freshman to know significantly less about design than a graduating senior – and to a certain degree, some of this re-learning of knowledge helps nourish DME's reputation as a teaching tool for upperclassmen as well as freshmen. Additionally, the actions taken by individual upperclassmen to train their successors prior to graduation greatly reduce this percent lost. However, much of this re-learning could be significantly better facilitated with heavier use of written records. Owing to DME's high turnover and volunteer status, this task of insuring written records must fall largely on the shoulders of the student leaders: to note the processes involved with each committee and ensure that such memory is passed down to future years.

The effects of high turnover on organizational learning precipitate both beneficial and harmful effects. This is perhaps most highly evident through comparison of the DME program with one of DME's sister programs, Discover Ocean Engineering (DOE). DOE has a faculty member who largely takes the place of DME's student leader, and performs many of the same functions. Because of this, one would expect that the organizational learning inherent to both programs – which comes to an apex with DME's student leader and DOE's faculty leader – suffers fewer losses as a result of turnover at its head. Indeed, the DOE program has remained fairly steady and largely unchanged for several years now, whereas the DME program in many ways "reinvents itself" every year.

These differing arrangements lend benefits to both programs. DME has the organizational structure, manpower, and pure will to creatively react to arising situations, lending the program an advantage in dynamic environments. Considering that DME is entering its fourth year as a pre-orientation program, it has relied heavily upon this ability in the past, as particular conditions have changed every year. Additionally, since the SoccerBot assembly often requires the use of specialized parts (for example, the electric screwdriver motors we utilize to power our drive wheels), it comes as no large surprise when one or more parts are discontinued every year or so, prompting a re-design of the SoccerBot. Likewise, the program constantly strives for a more robust robot design – one that can be completed faster, survive stronger collisions, use cheaper materials, etc. These factors prompt a robot redesign each year, rendering it desirable to have a program organization of sufficient flexibility to handle such changes. Indeed, the high turnover rate and loss of organizational learning might here even be considered a benefit, as it promotes the influx of fresh ideas and prevents stagnation. Moreover, allowing DME to reinvent itself each year encourages individual student volunteers to innovate to the maximum extent, which benefits their futures endeavors. Thus the organizational structure and turnover rate of DME (which promote a loss of organizational learning) actually benefits DME to a great extent.

However, organizational learning also provides great benefit to DOE. Owing largely to its continuity of leadership over many years, much collective knowledge has accumulated in one person, so the transfer of leadership that is currently underway in the department means that all information from previous program iterations can stem from one person instead of several different people. When issues arise, DOE personnel can turn to a single all-knowing source whereas DME student leaders must gather information from a variety of resources, including prior leadership. Continuity of DOE's robot design and of many other program aspects allow for program details to be solidified earlier in the year, allowing more time to deal with any potential difficulties which develop. The planning period for DOE is shorter, DOE must expend less time and energy in development, and there is arguably less stress placed upon DOE volunteers. DOE is not necessarily better than DME, but it is – in every sense of the word – more consistent.

It must be noted, though, that DME's reinventing process is appropriate at this point in the program's development. In several committees – for example, the prototyping committee, which continually redevelops the SoccerBot based upon designs and experiences from previous years – the large number of changes desirable in this program in its early years made lack of continuity less of a detriment than one might expect. However, several of the other committees may no longer benefit from continually reinventing the wheel. For example, the food committee has in recent years largely borrowed their menus from previous iterations of the program, since there is little reason to change from trusted and tested suppliers. This suggests that DME should, as it matures, endeavor more and more to document its processes as each committee begins to settle down into a well-defined role, in order to minimize losses in organizational learning. The loss of organizational learning has provided little detriment to DME in the past (and by extension, other similar start-up organizations); however, without some measures to ensure the retention of organizational learning past this point in time, it will be impossible for DME to settle into the long-term, consistent state of develop that DOE currently enjoys. It is therefore now an appropriate time in DME's history to begin the heavy documentation process on a more formalized and more rigorous level than previously endeavored.

This thesis and its supporting text therefore comprise a first attempt to begin formal compilation of the collective knowledge of DME; it is desired that future student leaders will expand and update DME texts with their own information and experiences once their term is completed.

## 3.0 A Methodology for Greater Efficiency Via Improved Organization

As stated earlier, two of DME's largest difficulties have lain with personnel and with timeframes. Therefore, this section shall discuss in detail how a Product Engineering Process approach can be used to better organize and manage the program to alleviate both difficulties.

### 3.1 Prioritization of Committees

DME routinely organizes its 30 or so student volunteers into committees in order to more effectively complete their tasks. As is suggested by the command structure given in Figure 1, committees are often though of as equal in stature and priority. This is, of course, not true – there is naturally a hierarchy of sorts among the committees, with some tasks being supremely critical to the program, while others have less overall significance. It is therefore important to lay forth a prioritization of the various committees, as a preface to further discussion of program optimization. When allocating personnel, time, money, or other resources, the relative priority of each committee should be kept firmly in mind.

By utilizing as criteria prior experience as to how far behind each committee can become before exerting a strong deleterious effect on the program as a whole, the rough hierarchy of committees can be rationally determined as seen in Figure 2:

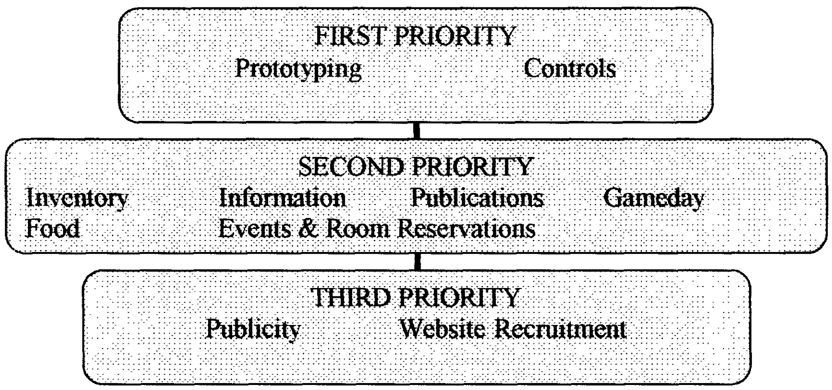


**Figure 2: Prioritization Hierarchy for DME Committees.** Notice how Prototyping and Controls occupy the highest level.

Prototyping and Controls occupy the first tier of the committee hierarchy, simply because they together form the foundation of the program. Without an accurate and robust prototype (irrespective of whether the prototype is an all-new design or simple changes from the previous year), control system, and set of directions, the program cannot run. These committees must be given first priority as to personnel and funding. When these high-priority committees interact with other committees for various tasks, those tasks must be similarly be given high priority.

Many of the remaining committees occupy the second tier of the committee hierarchy; these are committees which are required in some capacity for the program to run, but whose resources can be slashed in some manner or another without crippling the program (ie, the inventory listing can get slightly out-of-date, a previous year's publication could be used instead of updating it, or one of the social activities could be cut without irreversible harm to the program).

The third tier is comprised of publicity, website, and recruitment. While these items add an important polished flair to the program, in a crisis they could be largely neglected for some time without debilitating the program.

### 3.2 Implications of Prioritization

Now that the hierarchy among committees has been elucidated, the critical path of program development can be laid forth. A critical path is defined by Product Design and Development to be "the longest chain of dependent events... [such that] a delay in any of the associated critical tasks would result in an increase in project duration," (Urich & Eppinger, Product Design and Development). Because the prototyping and controls committees occupy the highest tier of the committee hierarchy and their tasks must largely be performed in a sequential manner riddled with hard deadlines, it is expected that the prototyping and controls committees largely define the critical path. In the interests of space the complete critical path of the program (which includes such aspects as food ordering, t-shirt design, etc) will not be developed in full in this text, but instead the Prototyping Committee shall be examined as a case study of one committee's critical path. The sections which follow in this chapter will delineate the precise tasks of the committee, a relative timeframe for each, and discuss how each committee's tasks are interrelated, which will in turn guide the division of personnel among committees.

### 3.1.2 Prototyping Committee Background

Prototyping shares equal status with controls as the most important committees of the entire program. DME can still exist (and has, in the past) with minimal publicity, a tiny website, and only a handful of dedicated student volunteers. However, without a robot the program cannot run. For this reason, prototyping and testing of the robot is paramount, along with the creation of the SoccerBot Assembly Book and obtaining of the relevant robot parts from the Inventory Committee.

Reflecting the nature of Prototyping's paramount status is the large level of responsibility placed upon it. It is to be noted that most of Prototyping's checkpoints are comprised of hard deadlines, with little to no margin for extensions. Since so many events must occur in rapid succession in order for the program to develop successfully, it is understood that this committee takes priority over nearly all other committees for the entirety of the planning period. It is likewise understood that the majority of headaches and angst stem from this committee.

It is not difficult for problems to occur within the prototyping group. A delay of two or three days due to backlogged parts is enough to put the program behind schedule. A person who promises a task and then disappears on vacation or with a company project would spell untold difficulty. Thus, it is of utmost importance that those working on the robot design are highly motivated, highly competent, and highly responsible. Though anyone can offer assistance – even freshmen – it is crucial that the finalized details are set forth and reviewed by the most experienced, trusted, and reliable mechanical engineers that DME has to offer. Given its high priority, the student leader should offer his/her unique blend of talents whenever humanly possible to ensure the robot is completed in time.

Once the robot is assembled, a book of instructions must be written. Since a comparatively small portion of the previous year's book tends to change from year to year, the prototyping committee usually begins by updating and correcting the previous year's manual rather than starting from scratch with a new book. These updates take a very, very long time – remarkably longer than most people assume. Student leaders should set aside roughly one-and-a half months exclusively for use in documentation, book updates, book testing, book revisions, and addendums.

In the past, DME has always utilized a professional technical editor for use in creating the SoccerBot Manual. This current technical editor put together the original version of the book four years ago and has been helping the program ever since; she does remarkable work in putting together a highly professional document that both the staff and freshmen can appreciate. However – as prototyping tends to push each and every one of its hard deadlines – the technical editor is often placed into an uncomfortable situation since revising is at the very end of the process. The student leader for DME should thus endeavor, whenever possible, to provide more time for book revisions rather than less.

It is also desirable to have a student volunteer assigned to help with the editing process. Student leaders must consider what a technical editor's time is worth, and it makes sense not to waste her time with simple revisions when she can instead focus upon the more difficult parts of text editing. Furthermore, the technical editor cannot be expected to know the full intricacies of a new prototype at a glance. Ideally, a knowledgeable representative from Prototyping should maintain full contact with the technical editor to ensure the veracity of her work. For this reason, a recommended schedule incorporates time for a student volunteer to learn to use Adobe FrameMaker, the program in which the existing text of the book currently resides. Since FrameMaker is a good program for any text with a large number of pictures or diagrams, someone with a large upcoming thesis might want to take the opportunity to learn and practice this program within the context of DME.

Upon reaching a first draft, the book should be tested by building a complete robot from the assembly instructions. Much more can be gleaned (regarding the quality and clarity of the text, timeframe of building, etc) by having two people test the book in this manner than by the entirety of DME's public email list reading the instructions at their computers for errors. Ideally, this tester should be someone soon to complete – or just completed – the freshman or sophomore year, and one previously uninvolved with the prototyping committee. This will prevent a person from making well educated guesses or assumptions about how the robot should look (as might a prototyping-savvy person) or from relying upon previous experience and making assumptions when the instructions are unclear (as would a senior), and instead testing the accuracy, clarity, and order of every single sentence of instruction in the book. Under some conditions, it might even be possible to obtain a pre-freshman to this task; this possibility is documented later in the text for further recommendation.

After the first draft is tested, a list of changes should be sent back to the technical editor and her assistant to be incorporated into the final copy of the book. When this is completed, the book can be sent off to print, even as the on-campus mentors build their robots, and in doing so, test the book one final time. If these mentors note any inaccuracies or confusions in the text (which has already been sent to print), these items should be typed up, photographed, and otherwise documented, in the same style as the text, in a document entitled "Addendum." Having a printed addendum and fully documented assembly instructions helps prevent freshman injury due to confusion, meanwhile reducing program liability in such case of freshman injury in the first place. This addendum should be distributed to all freshmen along with their SoccerBot manuals.

After this step is completed, the Prototyping Committee's tasks are completed, and the program can begin.

The first step to organizing people and their corresponding timeframes lies in setting forth a list of steps required for each committee. Through prior example, the required steps can be delineated and the time to complete each can be determined; also, the number of people required to effectively complete each task can also be determined. From this set of knowledge, a more detailed listing of personnel arrangements can begin to take form, as can a rigorous schedule embracing all program necessary tasks.

### 3.4 List of Required Prototyping Steps

The following steps, their relevant timeframes, and other information are taken from a combination of experience with prior examples and of interviews with involved DME personnel.

<u>Step 1: Identify Needed Improvement Areas From Last Year's Robot Design</u>

*Key People*: Prior year's freshmen & mentors, along with staff who were able to watch competition

*Prior Steps*: None

*Inputs*: None

*Outputs*: List of problem areas, potential areas to change

*Next Steps*: Develop Strategies, Concepts to Realize Said Improvements [Prototyping]

*Approx Time:* Several post-competition weeks of reflection

*Personnel:* As many as possible

*Deadlines*: Soft; complete before June

*Complexities*: Brainstorm anything and everything that could potentially help. Don't hold back at this step.

<u>Step 2: Develop Strategies, Concepts To Realize Said Improvements</u>

*Key People*: As many minds as possible, with plenty of insight from post-2.007 students.

*Prior Steps*: Brainstorming [Prototyping]

*Inputs*: Trouble Areas Brainstorming List

*Outputs*: Sketches, models, and other methods of communicating concepts

*Next Steps*: Select Preliminary Design [Prototyping]

*Approx Time:* Several post-competition weeks of reflection

*Personnel:* As many as possible

*Deadlines*: Soft; complete before June

*Complexities*: Keep ideas as simple as possible; mentors and staff should be able to complete bot building within 10 hours in order for freshmen to finish in 15-20. (This is otherwise known as the "Ten Hour Rule.")

Step 3: Select Preliminary Design

*Key People*: Post-2.007 students with as much design experience as possible

*Prior Steps*: Concept Development [Prototyping];

*Inputs*: Materials from brainstorming and concept development phases

*Outputs*: Preliminary design (sketches, explanations, models, etc); List of required parts submitted to Inventory; Notify student leader as to scope of changes

*Next Steps*: Begin Alpha Prototype [Prototyping]; Prototype Parts Order [Inventory]; Learn FrameMaker [Prototyping] (only if significant changes are to be made)

*Approx Time:* Under an hour for decision; several more hours for parts list

*Personnel:* As many as possible (send comments to public email list for feedback)

*Deadlines*: Soft: Complete w/ adequate time for remaining steps

*Complexities*: Remember 10-hour rule. Request extras of everything, as documentation will eat parts.

Step 4: Learn FrameMaker to Help Technical Editor With Book

*Key People*: Someone motivated to learn Adobe FrameMaker (perhaps someone with a long thesis in planning)

*Prior Steps*: none

*Inputs*: Adobe FrameMaker program; help guide

*Outputs*: FrameMaker savvy technical editor assistant; discuss progress with program head with respect to anticipated role of Professional Technical Editor: (a) PTE needs to do majority of editing; (b) PTE will be used primarily for finishing touches and polishing the final document, (c) PTE not necessary this year.

*Next Steps*: 1$^{st}$ Draft [Prototyping]

*Approx Time:* As much time as possible (at least one month for basics)

*Personnel:* 1-2

*Deadlines*: Hard Deadline: Must Be Done By 1$^{st}$ Round Documentation Completion (8 weeks to runtime)

*Complexities*: Spend enough time with the task to learn the program well. DME will rely upon your efficiency with the program later. Do NOT underestimate the value of a good technical editor; it is extremely likely you will need a PTE in some capacity if more than extremely modest changes are to be made.

Step 5: Alpha Prototype

*Key People*: Machine-Shop Certified Volunteers

*Prior Steps*: Preliminary Design Selected [Prototyping]; 1st Round Robot Parts Arrive [Inventory]

*Inputs*: Kit Parts, Preliminary Design

*Outputs*: Completed Alpha Prototype; Notes regarding changes to design.

*Next Steps*: Begin documentation [Prototyping]

*Approx Time:* 2 weeks

*Personnel:* 2-5 (at least two in the shop at a time; no more than 5 can work efficiently together)

*Deadlines*: Hard Deadline: Must be done before Documentation Draft begins (9 weeks before runtime)

*Complexities*: Do not worry about 10-hr rule here; prototyping always takes more time than optimized product.

Step 6: SoccerBot Testing

*Key People*: Same people who worked on Prototyping; perhaps a few new minds

*Prior Steps*: Alpha Prototype Complete [Prototyping Committee]

*Inputs*: Alpha Prototype

*Outputs*: Revised Design; Revised alpha prototype

*Next Steps*: Assembly Instructions Sent to public email list for san-checking [Prototyping]

*Approx Time:* 1 week for all tests & prototype revisions

*Personnel:* 2+ (one to work and one to be there so tester does not work alone in the shop)

*Deadlines*: Hard Deadline: 7 weeks to runtime

*Complexities*: Take turns with documentation for actual use of the alpha prototype. You'll have to share during this week, so schedule carefully. See how bot performs, both with control box and with the tether. Make any necessary changes immediately; if cannot be performed immediately, inform documentation which parts will be revised later so they can begin work on the finished pieces.

Step 7: Documentation Draft

*Key People*: Same people who helped with prototype; accompanied by others

*Prior Steps*: Alpha Prototype Completed [Prototyping Committee]

*Inputs*: Alpha Prototype; Original Design + Changes, Digital Camera; Machine Shop; Extra Parts, Digital camera; Dongle; Extra memory & batteries; Laptop; Pens & Paper

*Outputs*: Documentation draft (Typed-up sections to replace or add to sections in previous year's book); lots of photos of every intermediate step or potential point of confusion.

*Next Steps*: 1st Round Edits Sent to Technical Editor [Prototyping]; Revised Tool List Sent to Inventory [Prototyping]

*Approx Time:* 1 week

*Personnel:* 3-5 (Two to machine intermediate parts while another takes pictures & types; plus people to do Solidworks drawings. These can be the same people but it's much less work when it's shared.)

*Deadlines*: Hard Deadline: Must Be Done Before 1st Round Edits Given to Technical Editor (8 weeks to runtime)

*Complexities*: Be very careful in your wording. Freshmen tend to scrutinize wording and be very literal. Make certain that all safety considerations are properly noted. Get others who are not on original prototyping committee. If you weren't there to see the original being built, yet the instructions still make clear what was done, your instructions are clear. Beware of safety considerations. Use Fred Shop to let Courtney aid in documentation picture-taking after hours. Start off describing in words the list of steps which was done. Now turn each step into a paragraph or two, mentioning everything from where the item is marked prior to where the cuts are made with which tool, and how the thing is fixtured while cutting, and how not to kill yourself while using the tool, etc. Take pictures of everything with a digital camera. Note which tools are used on which parts. (Even down to the size and shape of the screwdriver head, type of Allen key, and size of drillbit!)

<u>Step 8: Identify Tools Required for SoccerBot</u>

*Key People*: Documentation Crew

*Prior Steps*: Begin Documentation [Prototyping Committee]

*Inputs*: Pile of tools set aside while documenting; Prototype Documentation Draft; Digital Camera

*Outputs*: Tool list

*Next Steps*: Revised Tool List Added to Documentation Draft [Prototyping]; Inventory Informed of Tool List 2nd Round Edits Sent to Technical Editor [Prototyping]; Revised Tool List Sent to Inventory [Prototyping]

*Approx Time:* 30 minutes

*Personnel:* 1

*Deadlines*: Hard Deadline: 7 weeks to runtime

*Complexities*: Take pictures of each tool. When list is completed, add tool list to beginning of documentation draft. Also send to Inventory so they can order necessary tools. If you only need an object for a short period of time (ie, crimper, drillbits, etc), let inventory know for how long it is needed so they can order just enough to be shared. If it's something everyone should have, note that, too. Finally, check the tool list against the composite list of tools made from each step. Find and correct any disparities.

Step 9: Assembly Instructions Review

*Key People*: Everyone on public email list

*Prior Steps*: Documentation Draft [Prototyping]; updating of public email list with new people [Information]

*Inputs*: Documentation Draft (posted online in both .doc and as .pdf formats)

*Outputs*: Revised Documentation Draft sent to Professional Technical Editor and assistant.

*Next Steps*: Book Edits incorporated into existing text [Prototyping];

*Approx Time:* 3 days

*Personnel:* As many as possible

*Deadlines*: Hard Deadline: 6.5 Weeks to runtime

*Complexities*: Be very careful in your wording. Freshmen tend to scrutinize wording and be very literal. Make certain that all safety considerations are properly noted. Review for clarity & safety. Prompt respondents to suggest a better/safer/more efficient way to do what is described.

Step 10: 1st Draft Assembly Book

*Key People*: Professional Technical Editor; Technical Editor Assistant

*Prior Steps*: Assembly Instructions Review [Prototyping]; Book Cover [Publicity]

*Inputs*: Revised Documentation Draft; all pictures, alpha prototype; assorted semi-completed parts & spares; book cover

*Outputs*: 1st Draft Assembly Book (fully formatted & edited)

*Next Steps*: 2nd Round Edits Sent to Technical Editor [Prototyping]; Revised Tool List Sent to Inventory [Prototyping]

*Approx Time:* 2-3 weeks

*Personnel:* 2 (one to work and one to be there so tester does not work alone in the shop)

*Deadlines*: Hard Deadline: 3.5 weeks to runtime

*Complexities*: Contact professional technical editor at least one month prior to completing this step to let her know what's going on. Assistant should make first attempt to update file (under direction from professional), to better save the professional's time.

Step 11: Book Fully Tested

*Key People*: Machine-Shop Certified Volunteers

*Prior Steps*: 1st Book Draft [Prototyping]; 2nd Round Robot Parts Arrive [Inventory]

*Inputs*: Kit Parts, SoccerBot Draft, Red Pens

*Outputs*: Completed Test Robot; Red-Pen Marked Book & List of Changes sent to technical editor & assistant

*Next Steps*: 2nd Round Edits Sent to Technical Editor [Prototyping]; Identify Tools Required for SoccerBot [Prototyping]

*Approx Time:* 1 week

*Personnel:* 2 (one to work and one to be there so tester does not work alone in the shop)

*Deadlines*: Hard Deadline: 2.5 weeks to runtime

*Complexities*: Be very careful in your wording. Freshmen tend to scrutinize wording and be very literal. Make certain that all safety considerations are properly noted. Keep track of which tools you use to revise tool section with (I suggest you just make one big pile of everything you use, and go through it at the end.) Check which tools are used on which parts, even down to the size and shape of screwdriver head, type of hex key, and size of drillbit! Ensure no technical or tool-based assumptions. Check all diagrams; scrutinize all wordings for ambiguities. Check each drillbit size and each part count. Notify Copytech of large impending order. Time how long to finish; if longer than 10 hours (not including text-based confusions & delays), notify inventory regarding degree to which pre-manufacturing is necessary.

Step 12: Check Tools Required for SoccerBot

*Key People*: Book Test Group

*Prior Steps*: Book Fully Tested [Prototyping Committee]

*Inputs*: Pile of tools set aside while testing; 1st Draft; Digital Camera

*Outputs*: Tool list

*Next Steps*: Revised Tool List Added to Documentation Draft [Prototyping]; Inventory Informed of Tool List 2nd Round Edits Sent to Technical Editor [Prototyping]; Revised Tool List Sent to Inventory [Prototyping]

*Approx Time:* 30 minutes

*Personnel:* 1

*Deadlines*: Hard Deadline: 2.5 weeks to runtime

*Complexities*: Take pictures of each tool. When list is completed, add tool list to beginning of documentation draft. Also send to Inventory so they can order necessary tools. If you only need an object for a short period of time (ie, crimper, drillbits, etc), let inventory know for how long it is needed so they can order just enough to be shared. If it's something everyone should have, note that, too. Finally, check the tool list against the composite list of tools made from each step. Find and correct any disparities.

Step 13: Finished Book

*Key People*: Professional Technical Editor & Assistant

*Prior Steps*: Book Tested [Prototyping];

*Inputs*: 1st Draft book (marked in red with list of changes)

*Outputs*: Final Book

*Next Steps*: Print Book [Prototyping]

*Approx Time:* 1.5 weeks

*Personnel:* 2

*Deadlines*: Hard Deadline: Must Be Done before book is printed (1 week to runtime)

*Complexities*: Make and keep it polished, as this draft will go to print.

Step 14: Book Goes to Print

*Key People*: CopyTech printing & binding department

*Prior Steps*: Finished Book [Prototyping]

*Inputs*: DME Account Number (obtain from Maureen); DME book on a CD or online as a .pdf.

*Outputs*: 50 SoccerBot Assembly Manuals bound with cloth tape or spiral binding with clear acetate cover

*Next Steps*: RUNTIME

*Approx Time:* 3 business days; more if backlogged

*Personnel:* 2 (one to work and one to be there so tester does not work alone in the shop)

*Deadlines*: Hard Deadline: 1 business day before program begins

*Complexities*:

Step 15: On-Campus Mentors Test Book Early

*Key People*: On-Campus Mentors

*Prior Steps*: Finished Book [Prototyping]; Mentor Kitting [Inventory]

*Inputs*: Print-out of completed book; Kit Parts, Red Pens

*Outputs*: Completed Test Robots; Red-Pen Marked Book & List of Changes

*Next Steps*: Type Addendum [Prototyping] (only if necessary changes found)

*Approx Time:* 2-3 days full time (depending upon frequency of interruptions/delays)

*Personnel:* 2+ (one to work and one to be there so tester does not work alone in the shop)

*Deadlines*: Hard Deadline: 1 day to runtime

*Complexities*: Anything further which needs changing required a printed addendum noting the change.

Step 16: Type Addendum

*Key People*: Mentor(s) who noticed directions problem, Prototype representative, documentation representative

*Prior Steps*: On-campus mentors test book [Prototyping]

*Inputs*: Marked-up mentor test books

*Outputs*: 50 Copies of typed, formatted, & spell-checked Addendum to instructions

*Next Steps*: RUNTIME

*Approx Time:* 3 hours

*Personnel:* 3

*Deadlines*: Hard Deadline: 1 day before runtime

*Complexities*: Remember this is our last chance to change the SoccerBot making process! Make absolutely certain that all addendums thoroughly cover safety considerations.

Step 17: Returning Mentors Build SoccerBot

*Key People*: Mentors who have not previously built current robot

*Prior Steps*: Finished Book [Prototyping]; Mentor Kitting [Inventory]

*Inputs*: Kit Parts, SoccerBot Assembly Book, Addendum (if existent)

*Outputs*: 8 Completed Mentor Robots; 8 SoccerBot savvy Mentors

*Next Steps*: RUNTIME

*Approx Time:* 2 days full time

*Personnel:* 2+ (one to work and one to be there so tester does not work alone in the shop)

*Deadlines*: Hard Deadline: RUNTIME

*Complexities*: Mentors should take care to understand the SoccerBot construction process as well as possible, for they will be responsible for overseeing freshmen.

### 3.5 Design Structure Matrix

Now that a list of steps has been delineated and each step has been defined, the dependencies of the various tasks can be diagrammed. Notice that our list of steps, earlier, included instructions on which steps must precede and succeed each listed step. Including this information on the list helps set the stage for creation of multiple such lists and further planning, which in turn set the stage for planning that includes the interplay among committees.

The aforementioned list of steps can be concisely summarized via the Prior Steps/Next Steps sections of said list into a Decision Structure Matrix, (Urich & Eppinger, Product Design and Development). This chart helps explain the interplay among the tasks of the prototyping committee. This graph is arranged such that each 'X' in a given row tells the reader which tasks, indicated by the vertical columns, that given task is dependent upon. For example, Prototype Testing (Step F) has a row occupied by X's in every column except D; this indicates that Step F is dependant upon every prior step except Step D, which can and should occur simultaneously with Step F.

This table serves to indicate, at a glance, which tasks of a given committee are dependant upon which other steps.

| Task | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Identification of Potenital Improvements | A | A | | | | | | | | | | | | | | | | |
| Develop Strategies & Concepts | B | X | B | | | | | | | | | | | | | | | |
| Preliminary Design Selection | C | X | X | C | | | | | | | | | | | | | | |
| FrameMaker Assistant Training | D | | | | D | | | | | | | | | | | | | |
| Alpha Prototype Completion | E | X | X | X | | E | | | | | | | | | | | | |
| Prototype Testing | F | X | X | X | | X | F | | | | | | | | | | | |
| Assembly Instruction Draft | G | X | X | X | | X | | G | | | | | | | | | | |
| Tool Identification | H | X | X | X | | X | | | H | | | | | | | | | |
| Instructions Review | I | X | X | X | | X | | X | X | I | | | | | | | | |
| Book 1st Draft | J | X | X | X | X | X | | X | X | X | J | | | | | | | |
| Book Tested | K | X | X | X | X | X | | X | X | X | X | K | | | | | | |
| Tool Confirmation | L | X | X | X | X | X | | X | X | X | X | X | L | | | | | |
| Book Finished | M | X | X | X | X | X | X | X | X | X | X | X | X | M | | | | |
| Book Printed | N | X | X | X | X | X | X | X | X | X | X | X | X | X | N | | | |
| Mentor Early Test | O | X | X | X | X | X | X | X | X | X | X | X | X | X | | O | | |
| Addendum Typed | P | X | X | X | X | X | X | X | X | X | X | X | X | X | | X | P | |
| Mentor Regular Test | Q | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | Q |

**Figure 3: Design Structure Matrix for the DME Prototyping Committee.**

### 3.1.5 Gantt Chart

The chart delineated in 3.1.4 can be combined with the information in section 3.1.2 regarding time to complete each task to produce a chart demonstrating both the relative timeframe of various tasks as well as the status of each task. This chart – referred to as a Gantt Chart – provides a graphical illustration of the timeliness of various tasks, information which would otherwise be time-intensive to manage, (Urich & Eppinger, Product Design and Development). With the aid of this Gantt chart, the student leader merely need shade in the corresponding box as each task is completed, thereby demonstrating how on-schedule the committee is as a whole. This provides a quick reference to each committee's progress.

In the following chart, for example, a vertical line is drawn representing a hypothetical present date, May 1st. Note that two shaded bars extend past that line – two of the committee's tasks are ahead of schedule. Also note that there are no unshaded bars to the left of the line – no tasks are presently behind schedule.

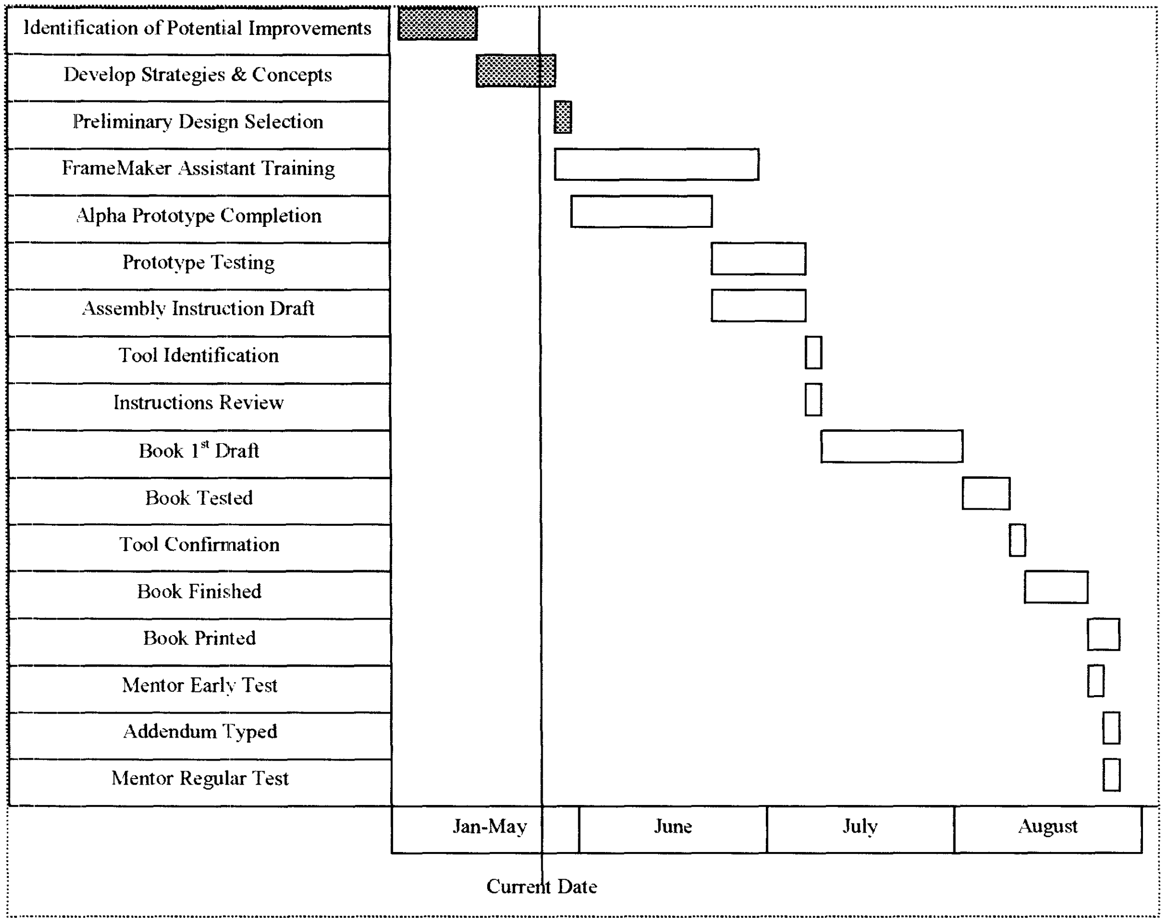


**Figure 4: Gantt Chart for the DME Prototyping Committee.** Two of the tasks listed here – "Develop Strategies & Concepts" and "Preliminary Design Selection" – are ahead of schedule.

Although it appears that this committee is well on its way to completing its task, note that a Gantt chart that indicates ahead-of-schedule progress does not necessarily guarantee that all will be well in the future. For example, if student leaders note that the committees are presently ahead of schedule and fail to push for progress in the next two weeks, the lack of progress will drive particular tasks behind schedule once again. The Gantt Chart indicates progress to date – in this case, that the committee is well on its way to completing its tasks and is currently ahead of schedule – but constant diligence is required to ensure that this temporary triumph evolves into a long-term success.

Since the Gantt Chart provides a readily-interpretable summary of each committee's progress, it is highly recommended that DME student leaders post Gantt charts for each committee in an area public to DME personnel. Doing so will eliminate the perpetual string of questions which leaders face in regard to how unassigned volunteers should be distributed. At present, student leaders survey each committee to find which tasks are behind and how many people are required for each and then relay this information to every volunteer who asks. However, this process can be nicely economized into referring the entire body of DME volunteers to the Gantt chart and asking each person to select a role which is either behind schedule or soon may be. This will also allow committees who are ahead of schedule to know when other committees are behind schedule, so as to render them able to reassign people to help the lagging committees.

There are two additional recommended Gantt chart additions which will help DME in specific and similar programs in general. First, the names of people responsible for each step should be listed, if not on the public version of the Gantt charts, then at least on the student leader's internal version. This will allow student leaders to anticipate when progress on a task is beginning to stagnate, so they can motivate the people involved or assign new people to the role. Likewise, when a committee is indeed ahead of schedule, publicly listing the names of people responsible for this success will bring a sense of pride to the committee, which will help motivate it to perform future work.

In addition to listing the names of student volunteers involved in each task, student leaders are encouraged to note the actual date that each task is accomplished, so as to record for future planning purposes the actual expected timeframe of each task. If a given task proves to be, over the years, consistently ahead of schedule while another task is consistently behind schedule, for example, the schedule should be revised to reflect these real-time values.

### 3.7 PERT Chart

Once the Gantt Chart has been developed, a PERT chart can be developed to more fully define the critical path for DME, (Urich & Eppinger, Product Design and Development). Earlier it was mentioned that the critical path revolves largely upon the prototyping and controls committee; in this step a more precisely defined series of tasks is delineated.

### 3.8 Summary Timeline

After the process delineated has been completed for each committee and the relevant timeframes of each step have been checked and confirmed by program veterans, a finalized planning schedule can be completed. This finalized schedule is obtained by listing the tasks required for each committee's success (as observed from prior iterations of the program) and by counting backward the weeks from the beginning of the pre-orientation period. This schedule takes into account the interaction of the various committees – for example, the fact that the SoccerBot assembly book cannot be published until the book cover is designed – and also adjusts the timeframes of tasks with otherwise ill-defined deadlines (eg., the obtaining of souvenirs) in order to minimize the minimum number of personnel needed at any given point in the program. This

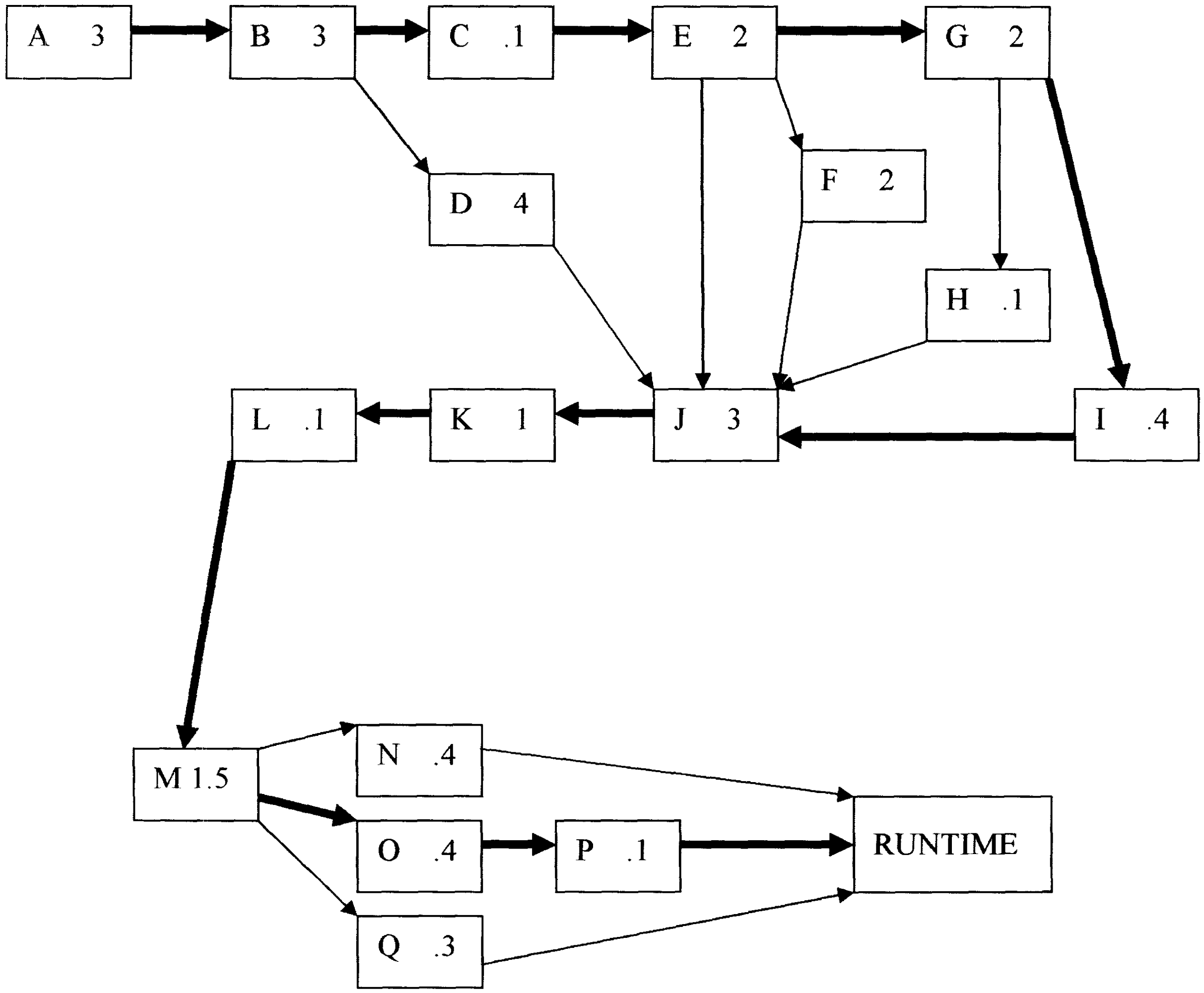


**Figure 5: PERT Chart for DME Prototyping Committee.** The letters indicate steps as delineated in Figure 4; the adjacent numbers indicate the time to complete each step, in weeks. The heavy black line indicates the critical path. Times of .1 week or under are rounded up to .1 for simplicity.

likewise gives committees who are not currently on the critical path a task to complete which they likely will not have time to complete later, which has the additional benefit of occupying committees with tasks not on the critical path as they wait for one of the core committees to complete critical-path tasks. This schedule is also slightly front-loaded, where possible, to take into account the tendency of program committees to procrastinate. The format of this schedule simultaneously shows each committee where it should be on a week-by-week basis as well as demonstrating to the student leader and others, at a glance, what is due on any given week.

| Prototyping & SoccerBot Manual | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | Identify Needed Improvement Areas from Last Year's Robot Design |
| February | 26 | Develop Strategies, Concepts to Implement Said Improvements; Select Preliminary Design; Begin Alpha Prototype |
| | 25 | Someone Begins Learning FrameMaker to help Technical Editor with Book |
| | 24 | |
| | 23 | |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | Detailed Prototype Design Complete; Alpha Prototype Complete; Begin Documentation; Begin Bot Testing (And Identification of Further Changes) |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | FrameMaker Person Reports on Progress; Decision is Made to Hire Professional Technical Editor or Not; Courtney is Contacted and Asked for Time Constraints |
| May | 14 | |
| | 13 | |
| | 12 | Identify All Tools Required for SoccerBot; Update Book & Inform Inventory |
| | 11 | 1st Round Documentation Complete; Edits Sent to Technical Editor |
| June | 10 | |
| | 9 | |
| | 8 | 1st Round Edits Returned |
| | 7 | Book is Tested |
| July | 6 | 2nd Round Edits Sent to Technical Editor; Revised Tool List Sent to Inventory |
| | 5 | |
| | 4 | |
| | 3 | 2nd Round Edits Returned; CopyTech is Notified of Large Impending Order; Get CopyTech Account # From Maureen |
| August | 2 | On-campus Mentors Test Book; Remaining Edits Typed into Addendum |
| | 1 | Book Goes to Print; Returning Mentors Build Bot; Book Picked Up From CopyTech |
| RUNTIME | 0 | |
| AFTERWARDS | | Speak to Maureen Regarding Setting up the Professional Technical Editor to Be Paid |

| Publicity | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | Begin Editing DME Video Footage from Prior Summer |
| | 25 | |
| | 24 | |
| | 23 | |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | Posters Requesting DME Volunteers are Posted in Key Locations |
| April | 18 | Reserve Drop Poster Space in Lobby 7 (and Student Center if Possible) for Gameday Poster Announcement |
| | 17 | |
| | 16 | |
| | 15 | Begin Taking Pictures of Mentors/Staff for Website; Begin Taking "Behind the Scenes" Developmental Video & Pictures for Posterity |
| May | 14 | |
| | 13 | Begin T-shirt Design |
| | 12 | Video Footage from Prior Summer Fully Edited; Completed Video Submitted to Website; Request Publication on Mechanical Engineering Video Board |
| | 11 | Complete T-shirt Design; Submit for Printing |
| June | 10 | Begin Designing Souvenirs; Begin Creating/Improving/Testing Childproof Robots for Museum of Science Interactive Display |
| | 9 | |
| | 8 | Finish Designing Souvenirs & Start Production |
| | 7 | Create MOS Publicity Posters; Learn About MOS Space Constraints for Publicity This Year; T-shirts Finalized; T-shirt Counts Received From Information; T-shirts Ordered |
| July | 6 | |
| | 5 | Finish Producing Souvenirs; Create MOS Publicity Brochures |
| | 4 | Begin Designing Drop Poster |
| | 3 | Complete Drop Poster; Laminate Drop Poster; Check Condition of Old DME Banner; Create & Laminate New Banners (If Necessary); Create & Make Copies of Small DME Gameday Posters for Infinite |
| August | 2 | Finish Work on MIT Museum Exhibit; Complete Childproof Robots |
| | 1 | Poster Hallways with Small DME Gameday Posters; Obtain Two Camcorders and Two Digital Cameras to Record Runtime |
| RUNTIME | 0 | Poster Hallways with More Small DME Gameday Posters; Create Promo CD's For Distribution at MOS (if time) |
| | | Submit Runtime Pictures to Website Committee; New Video Edited Into Presentable Piece; New Video Placed Upon ME Video Board. |

| Website | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | |
| | 25 | |
| | 24 | |
| | 23 | |
| March | 22 | |
| | 21 | Photographs of Mentors Submitted To Website |
| | 20 | |
| | 19 | |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | Pictures and Biographies Requested For All New Staff & Mentors |
| May | 14 | |
| | 13 | Update Website With Key Dates and Tentative Schedule |
| | 12 | Prior Year's Video Posted to Website |
| | 11 | Website Updated With All New Personnel (Pictures and Biographies); Website Updated With Tentative Schedule |
| June | 10 | |
| | 9 | |
| | 8 | |
| | 7 | Website Updated Again With New Schedule; Request an MIT Spotlight for Competition Weekend; Request ME Spotlight Link; Notify WebAdmins of the Outcome |
| July | 6 | |
| | 5 | |
| | 4 | |
| | 3 | Website Updated Again With Complete Finalized Schedule |
| August | 2 | MIT Spotlight Page Completed; ME Spotlight Page Created |
| | 1 | |
| RUNTIME | 0 | |
| | | New Video Posted to Website; Receive Runtime Pictures from Publicity & Post to Website |

| Personnel/ Recruitment | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | Initial New Staff Meeting; New Staff Added to public email list & Given Tasks |
| | 25 | |
| | 24 | |
| | 23 | Potential Mentors Identified & Contacted; Need for Early Returns Identified; Early Returns List Sent to Pre-Orientation Office, Information, and Administration; File for Early Returns with Housing Office; Photos Taken of New Mentors |
| March | 22 | |
| | 21 | Early Returns Submitted to Pre-Orientation Office & Housing Office |
| | 20 | |
| | 19 | Photos Taken of New Recruits |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | |
| May | 14 | |
| | 13 | |
| | 12 | |
| | 11 | Freshmen Applications Received from FPOP office; Freshmen Selected; Freshmen Information sent to Information & Administration |
| June | 10 | |
| | 9 | |
| | 8 | |
| | 7 | |
| July | 6 | |
| | 5 | |
| | 4 | |
| | 3 | |
| August | 2 | |
| | 1 | |
| RUNTIME | 0 | |

| Inventory | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | |
| | 25 | |
| | 24 | |
| | 23 | Complete Inventory of Current Parts; Order Parts As Needed For Alpha Prototype |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | Receive List of Problem Components from Prototyping; Order These Components |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | |
| May | 14 | |
| | 13 | |
| | 12 | Obtain Required Tool List From Prototyping; Compare With Current Inventory; Begin Identifying Cheap Sources of Good Tools |
| | 11 | |
| June | 10 | |
| | 9 | Enough Robot Parts are Ordered To Test the Book |
| | 8 | |
| | 7 | |
| July | 6 | Order Remaining Required Tools |
| | 5 | All Remaining Parts Ordered |
| | 4 | Tools Arrive; Put Kit #s on Everything (So All Toolkits Have Matching Tool #s) |
| | 3 | All Remaining Parts Arrive |
| August | 2 | Pre-Manufacturing Completed; Kitting (for Mentor Kits) |
| | 1 | Finish Kitting (for Freshmen Kits); Set Up Lab At Least 2 Business Days Before Freshmen Arrive |
| RUNTIME | 0 | |
| AFTERWARDS | | Run Full Inventory To Determine Remaining Parts |

| Publications | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | New Leadership Selected & Notified |
| February | 26 | New Leadership Installed; Leadership Guide Completed; New Head Begins Reading Book |
| | 25 | New Student Leader Finishes Reading Book |
| | 24 | |
| | 23 | |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | |
| May | 14 | |
| | 13 | Mentor Training Packet Revised; Edits Sent to Technical Editor & Assistant |
| | 12 | |
| | 11 | |
| June | 10 | |
| | 9 | |
| | 8 | |
| | 7 | |
| July | 6 | |
| | 5 | |
| | 4 | Mentor Training Packet Completed; Schedule Received From Events; Mentor Booklet Posted Online; All Mentors & Staff Read Booklet |
| | 3 | Obtain Mentor, Staff, Freshmen, and Team Information from the Information Committee; Incorporate Information and Schedule into InfoPak; MentorPak Goes To Print |
| August | 2 | InfoPak Goes To Print |
| | 1 | All Mentors On-Campus; Mentors Trained |
| RUNTIME | 0 | |
| AFTERWARDS | | Begin Updating Leadership Guide |

| Information | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | Start Updating FPOP Booklet Spread |
| | 25 | |
| | 24 | |
| | 23 | Staff/Mentor "Spreadsheet of Doom" Initiated, With Which Mentors Need Early Returns & How to Contact Them Over Summer |
| March | 22 | Finish Updating FPOP Spread & DME Application; FPOP Spread & Application Sent to FPOP Office |
| | 21 | |
| | 20 | |
| | 19 | |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | FPOP Booklets Mailed |
| May | 14 | |
| | 13 | |
| | 12 | |
| | 11 | |
| June | 10 | Receive Freshmen Information From Personnel |
| | 9 | dme-frosh-200X Mailing List Created |
| | 8 | FPOP Office Contacts Freshmen With Final Decision |
| | 7 | Email From Us Requesting Freshmen Info; Final Mentor/Staff Info Complete; Shirt Size Counts Given to Administration; Critical Cell Cards Begun |
| July | 6 | Repeat Freshmen Info Request Email |
| | 5 | Final Notice Freshmen Info Request; Critical Cell Cards Complete |
| | 4 | Freshmen Spreadsheet of Doom Completed; Critical Cell Cards Mailed; Freshmen Allergies Sent to Food Committee |
| | 3 | Freshmen Divided Into Mentor Teams (Preferably By Residence); Information Sent to InfoPak Group |
| August | 2 | Create Nametags for all Freshmen, Mentors, Staff, and Visitors |
| | 1 | Freshmen Doors are Postered With "Welcome to DME" Signs |
| RUNTIME | 0 | |
| AFTERWARDS | | Non-MIT emails are purged from freshmen list |

| Events & Room Reservations | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | Preliminary Idea of Budget |
| February | 26 | Talk to Dick Fenner RE: Using Pappalardo for DME; Reserve Space; Identify Good/Bad Aspects of Last Year's Schedule; Brainstorm Improvements |
| | 25 | |
| | 24 | Preliminary Decision of Activities; Schedule Sent to Information & Website |
| | 23 | |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | Determine Preliminary Social Activity Cost & Send To Administration |
| April | 18 | Budget Finalized; Social Activity Cost Approved; Modify Activity Plan to Meet Cost Target; Begin Semi-Finalizing Activities |
| | 17 | |
| | 16 | |
| | 15 | Remind Dick Fenner of DME Reservation |
| May | 14 | |
| | 13 | |
| | 12 | |
| | 11 | Schedule Semi-Finalized & Sent to Website; Key Challenges to Schedule Identified; Start Talking to Industries Re: Tours |
| June | 10 | |
| | 9 | All New Activities Tested |
| | 8 | |
| | 7 | Industry Tours Secured; Start Talking To Profs Re: Lab Tours |
| July | 6 | Reservations Complete; On-Campus Activities' (Including Meals') Room Reservation Forms Sent In; Inform Food Of Special Needs (Food to Go on Boat Dock, Delivery at a Different Time, Mentor Dinner Night, etc) |
| | 5 | |
| | 4 | All Paperwork and Payments In; All PO's Complete; Back-Up Plans Identified For All Activities; Schedule Finalized; Schedule Sent to Publications Committee |
| | 3 | Room Reservations Approved; Licenses Applied for (If Applicable, eg, for Harbor Islands); Travel Routes Identified, Printed Out, Tested, Hazards Identified (ie, Rush Hour, Multiple Exits, Confusing Pathways, etc); Faculty Invites Sent For Relevant Events; Staff Sign-Ups to Run Selected Activities |
| August | 2 | Lab Tours Finalized; Mentor Group Rotation Schedules Created (With Maps) |
| | 1 | Phone Calls To Confirm All Activities & Room Reservations (Check Again the Day Before Each Activity Is To Run); T-Tokens Bought; Tickets Picked Up |
| RUNTIME | 0 | Phone Calls To Confirm Activities & Room Reservations |

| Administration | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | Touch base with FPOP Office; determine dates for new FPOP |
| | 29 | |
| | 28 | |
| | 27 | Touch Base With Prof. Abeyaratne; Determine New Budget |
| February | 26 | |
| | 25 | Decide if DME Should Become ASA Recognized; If So, Begin Process |
| | 24 | Apply for DME Credit Card |
| | 23 | |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | Determination of ASA Recognition (If Applicable) Complete; Obtain International Orientation Schedule; Send to Events (& Keep Copy for Self); Request & Receive Cost Estimates From All Committees |
| April | 18 | Use Estimates from Various Committees to Determine Summer Budget |
| | 17 | |
| | 16 | |
| | 15 | |
| May | 14 | |
| | 13 | |
| | 12 | Write Freshmen Welcome Letter and Freshmen Rejection Letter |
| | 11 | Freshmen Welcome Letter sent to FPOP Office; Freshmen Rejection Letter Sent to Rejected Freshmen; T-Shirt Design Begun; Begin Obtaining Materials For Welcome Packet |
| June | 10 | Visit MOS & Scout Out Competition Arena; Determine MOS Gameday Space Constraints & Other Concerns; Determine Where DME Will Locate Repair Space, Competition Area, Publicity, & Spectators; Inform public email list of Findings |
| | 9 | |
| | 8 | Welcome Packs Complete |
| | 7 | |
| July | 6 | Find Non-Lab Storage Space for Drinks, Snacks, and Other Necessities; Begin Buying (if Desired) |
| | 5 | |
| | 4 | |
| | 3 | Revise, Finalize, & Photocopy Surveys; Obtain DME Cell Phones for Month of August (If Needed) |
| August | 2 | Update Vonnie & Invite to All Events; Send Out Press Releases |
| | 1 | Mentor Training; Poster Freshmen Doors with "Welcome to DME" Posters; Help Resolve Remaining Crises |
| RUNTIME | 0 | |

| Control System | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | |
| | 25 | |
| | 24 | |
| | 23 | |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | Find a Professional Capable of Fixing the Control System |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | |
| May | 14 | |
| | 13 | |
| | 12 | |
| | 11 | |
| June | 10 | |
| | 9 | |
| | 8 | |
| | 7 | Professional Completes Control System; Testing Ensues |
| July | 6 | |
| | 5 | |
| | 4 | |
| | 3 | |
| August | 2 | |
| | 1 | |
| RUNTIME | 0 | |

| Food | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | Begin Collecting Menus For Reference |
| | 25 | |
| | 24 | |
| | 23 | |
| March | 22 | |
| | 21 | |
| | 20 | |
| | 19 | |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | |
| May | 14 | |
| | 13 | |
| | 12 | Survey Sent on Previous Year's Food Likes/Dislikes sent to public email list |
| | 11 | Tentative Food Plan (16 Meals); Begin Testing Caterers if Necessary |
| June | 10 | |
| | 9 | |
| | 8 | |
| | 7 | |
| July | 6 | Special Events' Food Needs Received From Events; Caterers are Found to Accommodate Needs; Food Orders Changed to Accommodate |
| | 5 | Reserve/ Buy Coffeepot for Breakfasts |
| | 4 | Food Allergies & Restrictions Received From Information Committee; Remaining Food Restraints Accounted For |
| | 3 | Find 3 Car/Driver Pairs for BJ's Run; Begin Stockpiling Soda, Water, & Other Heavy Fluids (If 3 Drivers Cannot Be Found) |
| August | 2 | Food Orders Placed; Food Orders Confirmed; Confirm Shopping List for BJ's Run |
| | 1 | Conduct BJ's Run |
| RUNTIME | 0 | Confirm Food Orders the Day Before Each Order |

| Gameday | | |
|---|---|---|
| Month | Weeks Remaining | Actions & Deadlines |
| January | 30 | |
| | 29 | |
| | 28 | |
| | 27 | |
| February | 26 | |
| | 25 | |
| | 24 | |
| | 23 | Touch Base With MOS & Try to Reserve Competition Area; Else Look Into Alternatives |
| March | 22 | |
| | 21 | Reserve Mascot Costume |
| | 20 | |
| | 19 | |
| April | 18 | |
| | 17 | |
| | 16 | |
| | 15 | Find Volunteer Truck Driver For Competition Day; Rent 10-Foot U-Haul Truck |
| May | 14 | |
| | 13 | |
| | 12 | Reserve Large Space for Competition Floor Setup & Robot Practice |
| | 11 | |
| June | 10 | |
| | 9 | |
| | 8 | |
| | 7 | Test Build Competition Floor; Ensure No Missing Pieces; Order More Rubber Mallets or Floor Pieces As Needed |
| July | 6 | |
| | 5 | |
| | 4 | |
| | 3 | Gameday Sign-Up List Volunteer Request |
| August | 2 | |
| | 1 | Begin Charging Batteries |
| RUNTIME | 0 | Pick Up Mascot Costume (& Check All Parts Before Leaving CAC Office); Freeze Ice Packs; Practice Competition Floor Setup |

## 4.0 Detailed Planning Considerations

In addition to the PEP processes outlined for broad use in the DME program, there are many detail-level considerations that must be applied to any measure of planning. For example, one recurrent issue within the program is the debate over the permissibility of design components within the DME program, which otherwise focuses largely upon manufacturing from the freshman vantage point; the consideration of this issue requires the setting and evaluation of specific criteria. Another level of program considerations lies in finding unseen connections among committees or between committees and particular pieces of information; for example, the days of the week over which the program runs can significantly change the planning of the program. Finally, student leaders must also consider the ways in which the various committees interact, and deal with unfinished tasks. These three examples demonstrate further levels on which the PEP process is required for DME.

### 4.1 SoccerBot Customizations

Related to the scheduling of committee timeframes is a core issue pertinent to the development of the program. Namely, for many years now freshmen surveys have revealed a strong desire (or more formally, "company need") for design and/or customization to become a significant part of DME. However, each year problems pertinent to the completion of the program have prevented customization and design initiatives from taking place.

In the future, student leaders may in fact decide to pursue a design activity during the course of DME. However, any attempts to do so must be in full agreement with the stated and unstated goals of the program, and thus must address a set of specifications inherent to such an activity. Namely, any design or robot customization activities must at a minimum fulfill the following activity specifications:

1. Ensure freshmen safety at all times (including being watched and having the people who are watching them know what they're doing at all times);
2. Give all freshmen fair and equal access to materials;
3. Avoid taking materials unfairly away from other limited resources (i.e., asking the machine shop for extra screws);
4. Allow the freshmen themselves to do the customization (i.e., will not consist of an upperclassman making changes for the freshmen);
5. Allow freshmen who are striving solely for completion of the robot to take priority over those engaged in customization activities (Remember, the number of machines available for freshman use, along with the number of staff around to supervise their use, together comprise the one of the largest time-sinks of freshmen manufacturing) ;
6. Ensure all changes are documented and have been reviewed by an upperclassman before machining begins. We can't expect a freshman to know the consequences of using a band saw with a course blade to cut steel, drilling a light piece without a clamp, or even hammering a tiny piece without adequately protecting the tabletop or her fingers.
7. Modifications should not overwhelmingly unbalance the final competition. Minor improvements in performance are allowed but radical alterations of the SoccerBot's abilities should not be allowed for regulation play.

It is primarily for these last three reasons that customization has been largely excluded from the program, year after year. Customization takes an enormous quantity of time – to think through, to obtain materials for, to document, and to thoroughly review instructions for. Furthermore, students who struggle just to complete the standard design should not be overtly penalized. When program planning ventures near crunch time towards the end of the summer, there will be no time at all left for customization unless it is thought through early – that is, fully developed and tested by mid July or earlier, in order to avoid the documentation rush.

A few ideas which student leaders might consider if they decide to attempt customization (in order of increasing difficulty):

1) K'Nex. The pilot program did in fact have a customization unit - contestants were asked to build K'Nex modules to place on the front of their robot, and the most interesting one won a prize. This could easily be done again.

2) Unrelated design competition. In Summer of 2003, DME attempted to have a design competition unrelated to the SoccerBot – design of mousetrap-powered racecars, for example. (Google will provide many good sets of competition rules for reference.) This design competition was cut from the program plan at the last moment to make time to resolve other crises, but is another potential design component that satisfies all the above criteria. (In particular, ASME hosts a Student Design Competition, and the MIT division is eager for a partnership with DME. Since DME freshmen get first year in ASME free, this would be a fun way to get them involved in a lasting project for Mechanical Engineering, earn some notoriety,

and enjoy a design component.)

3) Customized, Fully-Documented SoccerBots. Another idea once expressed was to create several different versions of the SoccerBot, then allow each freshman to choose which of three components he would like to make. For example, perhaps the team's goalie robot would have a different flipper than the defensive or offensive ones. This would allow for decision-making and customization on the part of the freshmen, yet would still allow each part of the process to be fully documented. This would have the drawback of greater complexity on the part of the program and of documentation, but is one of the most professional ways to incorporate customization into DME.

### 4.2 Weekend Considerations

Likewise, special considerations must be made if the program dates for DME incorporate a weekend:

- **Shortened Assembly Time** – Immediately preceding competition day, there will be no regular access to machine shop for assembly. This means that the time which freshmen are allocated for SoccerBot construction is cut from 16-20 hours to 12-16 hours. This requires either substantial redesign of the robot or substantial accommodation from the events committee. In the absence of either of these factors, an alternate assembly location must be obtained for freshmen use in completing wiring and other final robot assembly steps.

- **No Weekend Access to Machine Shop** – Having no access to the machine shop for the weekend means that DME cannot load/unload robots and other items to be transported to the MOS competition day; thus it must arrange for storage of all program materials for the weekend in a location outside of the machine shop; likewise, checklists must be developed and confirmed to ensure that no program materials are left behind.

- **MOS Opens Late & Closes Early** – In the early days of DME, on competition day staff would frequently be awake and preparing for the competition as early as 6am. By 8AM, the materials had already been taken to the MOS and people were busy setting up such that the competition was fully prepared by 9AM. However, on years during which DME holds its competition on a Sunday, this routine must change. On Sundays the MOS does not open until 9AM; to further complicate things, the exhibit hall which DME frequents must be returned to its prior state by 5PM, which means DME needs be fully out of the area by 4:30. This squeezes the already taxed competition schedule to the point where efficiency and being exactly on time are singularly critical. Therefore, in years during which this timeframe is the case, it is worth considering making the competition single-elimination instead of double-elimination. (This shift, however, will itself require a series of changes – updating the tournament progression sheet in the InfoBook, the handouts for the MOS, and the large tournament progression poster for comp day.)

- **One of UHaul's Busiest Days** – Since Sunday is one of the most popular moving dates, hosting the DME competition on a Sunday makes it difficult to obtain a UHaul truck or van for use in transporting competition materials. One must therefore be requested as early as possible.

- **Religious resources** – A myriad of people will need to worship over the weekend, and their needs will have to be addressed by DME staff.

- **Parents** – Many parents will attempt to visit their children over the weekend; contingency plans should be made to accommodate them.

Please note that this myriad of considerations is simply in response to a change in program date. It is expected that any myriad of eventualities will force the program to adapt in unique ways. It is therefore in the best interests of the program as a whole to remain vigilant for potential program interactions, to alert the relevant committees as to their repercussions, and to use the PEP process to ensure a fluid program development.

## 5.0 Conclusions & Recommendations

With the understanding derived from MIT's 2.009 Product Engineering Processes (PEP) course, one can readily decipher numerous instances where such a process will facilitate smoother operation of the program as a whole. In particular, the PEP process can be utilized to better organize personnel and timeframes, and therefore to help eradicate the difficulties associated with each. By delineating the committees necessary to run DME, stating the hierarchy of tasks therein, listing the tasks associated with each committee and their corresponding timeframes, developing Design Structure Matrices alongside Gantt and PERT charts, and thereafter remaining vigilant in pursuit of the critical path, many of DME's most persistent difficulties can be eliminated.

It is highly recommended that future program leaders adapt the PEP methodology for use in future iterations of the program and then report on their observations; this would benefit DME both in terms of documentation (ie, retention of organizational learning), but also in terms of furthering understanding of PEP's interaction with DME as a whole.

## Appendices List

# Appendix 1a: Initial DME Email to Freshmen

**Subject:** Welcome to DME!

Hello MIT Freshmen!

Greetings from Discover Mechanical Engineering! I am the one of the project coordinators in charge of making sure the week of August 17-22 is one of the best times of your lives!

In order to streamline the process, we at DME would appreciate the following information, to supplement the info you already sent us:

* Dorm at which you will be staying (preferably including room number so we can find you in an emergency)
* Dorm Phone Number
* Cell Phone (if applicable)
* Are you arriving with anyone? If so, what are their names?
* Allergies
* Dietary/religious/medical restrictions
* Anything else that would be helpful to know

Please understand that any information sent to us will be released only to the staff of students running the program, and will be kept in the strictest confidence unless you tell us otherwise.

In addition, we are planning to compile a short list of the DME freshmen. Since you will be working in teams during this program, it presumably would be helpful for the other members of your team to know how to find you. So, if you wish to have your dorm and contact info included in this list, please confirm that you give permission for your name, email, phone, and dorm to be printed in the list.

If you do not wish to be included on the list, please indicate that choice via reply.

Please reply as soon as possible, but before August 10th.

Thank you and have a great remainder of the summer!

Sincerely,
Christina Laskowski
DME Secretary
cmlaskow@mit.edu

# Appendix 1b: Staff Info-Collection Email

**Subject:** URGENT - DME INFO NEEDED

DME Mentors, Helpers, and Staff: Lend me your ears.

IMPORTANT! I need a list of all people participating in any capacity with DME this year. If you are participating in DME in any capacity, then I need an email within the next 48 hours containing the following:

Part 1 - Address (because Athena's finger info is slow to update and often lacking...)
* Current Dorm/FSILG/or Address (preferably including room number so we can find you)
* Dorm/FSILG/Address During the Program (include room #)
* Fall Dorm/FSILG/Address (if known - include room #)
* When you're moving from Current to Program to Fall Address (i.e., Are you moving before, after, or during the program?)

Part 2 - Phone #s
* Cell Phone (if applicable)
* Current Phone Number
* Program Phone Number
* Fall Phone Number
(If you don't know the phone number corresponding to your Program or Fall room, please try to find out.)

Part 3 - Availability
* What dates and times during the week of and week before the program you absolutely cannot make
* What dates and times during the week of and week before the program you know you'll be free
* What types of evening/ first day activities you'd like to help with
* Are you on campus now? If not, when do you get back?

Part 4 - Other
* During the week of the program - what is the best way to reach you during which parts of the day (i.e., "Email me between 9 and 5; otherwise, call my cell." In other words, if there is an emergency for which we need to reach you immediately, how do we get to you?)
* Course Year (and if by some error in judgment you're not course 2, let me know that, too...)
* Dietary restrictions
* Allergies
* Any religious considerations that might affect the program (i.e., you are not allowed to play with bots on Saturdays)
* Anything else I probably should know but was afraid to ask...

I really need to know all of this (or at least as much as you can possibly find out) as soon as possible - the sooner the better.

Thanks!

~ Christina

# Appendix 2: Example Information Spreadsheet

| Last Name | First Name | Middle Nar | Street | City | State | Country | Zip Code | Phone |
|---|---|---|---|---|---|---|---|---|
| Cannon | Justin | M. | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Collins | Kimberlee | Chiyoko | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Fan | Irene | R. | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Gelb | Benjamin | Steel | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Green | Forrest | O. | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Gu | Yingdan | | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Gu | Fangli (Clare) | | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Jennings, I | Edward | B. | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Jeon | Jessie | S. | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |
| Kao | Kalvin | Dar-Chih | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXXX | XXXXX |

| E-mail | MIT E-mai | Gender | Date of Bir | Allow Infor | Dorm | Dorm Phor | Cell Phone | Date of Arr |
|---|---|---|---|---|---|---|---|---|
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |

| Time of Ar | Transporta | Emergency | Phone1 | Phone2 | T-shirt size | People | Allergies | Dietary | Comments |
|---|---|---|---|---|---|---|---|---|---|
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |

## Appendix 3a: MentorPak Contents

- ❑ Mentor Training Booklet
- ❑ Mentor Training Addendum
- ❑ SoccerBot Instruction Booklet
- ❑ Bot Parts Kit
- ❑ Freshman Facebook
- ❑ Copy of Spreadsheet of Doom
- ❑ Critical Cell Card (with staff info)
- ❑ Copy of Internal/ Private Schedule
- ❑ Copy (physical or discussed in mentor training) of Pappalardo Layout (i.e., where stuff is)
- ❑ Copy of IO Schedule (for mentors of International Freshmen)
- ❑ Folder to put everything into
- ❑ Pen to take notes
- ❑ MIT lab rotation schedule (distributed again on day of MIT lab tours for those who lose it)
- ❑ Anything else you can think of:
    - ❑ Item 1
    - ❑ Item 2
    - ❑ Item 3

**Appendix 3b: Freshmen WelcomePak Contents**

- ❑ Folder to contain everything
- ❑ InfoPak Booklet (contains group listings & important general info)
- ❑ Critical Cell Card (in case freshmen lost it since summer)
- ❑ Updated copy of schedule, including times and locations
- ❑ Small map of MIT Campus (available from CopyTech), with DME-critical locations highlighted
- ❑ Large Map of MIT Campus, no highlighting (available from MIT Information Office in Lobby 7)
- ❑ "Call 100" brochures (available from MIT police)
- ❑ Emergency phone number stickers (also available from MIT police)
- ❑ Updated SafeRide Schedules (Cambridge, Boston, & Tech Shuttle, available at MIT Card Office)
- ❑ Athena email checking instructions
- ❑ MIT Postcard so they can write home
- ❑ Small notepad (available free from Copytech)
- ❑ Pen so they can take notes

## Appendix 4a: Notes on Food

### Special Diets

1. Vegetarian - usually not a difficulty for most restaurants/caterers; plan for several vegetarian options as a typical courtesy at all meals (if not for the freshmen, then for the staff & visiting professors).
2. Lactose Intolerant - one or two DME people each year is lactose intolerant. Plan on one or two options, also as a courtesy at all meals. (Most places have milk-less options; even pizza can be made without the cheese, or else can be delivered with side salads, chicken fingers, etc...)
3. Kosher - Immediately contact the freshmen and ask for clarification. More than once, a freshman has indicated "kosher" when she really means "I only eat meat that is killed humanely," which translates neatly and easily to "vegetarian" with no significant problems. Other times the freshmen will keep some Kosher rules but not all. Once DME had a fully devout Orthodox. Regardless, the only way to know for sure is to ask directly. Then, talk to Hillel for guidance. Read their webpage on the Kosher kitchen (available at http://web.mit.edu/hillel/www/kashrut/) for more guidance regarding practices. Meal planning is an absolute necessity here, as eating meat for lunch often prevents a strict Orthodox Jew from eating dairy during dinner. Learn to recognize hechsherim on food packaging, and ensure there are sufficient snack and drink options marked with the appropriate symbols (full list available at http://web.mit.edu/hillel/www/kashrut/hechsherim.html). Be prepared to spend significantly more money anywhere you eat out. If possible, assign someone who keeps

Kosher himself to the task of feeding both himself and any relevant freshmen, as this will avoid unintentional snafus.

4. Wheat Allergy - Read up on the situation as much as possible. Contact the freshmen to find out how sensitive they are and if they are allergic to anything else. Often, wheat allergies translate into a week of varied salads; however, if the freshmen can tolerate minute quantities of wheat, meal planning becomes an order of magnitude easier. Learn to recognize indications of food allergies, just in case.
5. Nuts, Seafood, Mushrooms, etc - certain other diets may exclude one or another of particular items, but as long as you keep people's reported food allergies in the back of your mind while meal planning, you're unlikely to meet with extreme difficulty.

## Appendix 4b: Sample Shopping List for BJ's Run

*(Note: To buy everything at once will take 3 cars; plan accordingly!!!)*

- ❑ 10 Cases of Water (27 bottles/case)
- ❑ 16 Flats of Soda (24 cans/flat)
- ❑ 8 Big Jugs Orange Juice (for breakfast)
- ❑ 3 Big Jugs Apple Juice (for breakfast)
- ❑ 4-5 Varieties of Snacks (50-count of each; all small & individually wrapped!):
  - ❑ Pretzels
  - ❑ Chips
  - ❑ Cookies
  - ❑
  - ❑
  - ❑
  - ❑
  - ❑
- ❑ Food for Welcome Lounge
  - ❑ Bread
  - ❑ Peanut Butter
  - ❑ Jelly
  - ❑ Cheese
  - ❑ Crackers
  - ❑ Pastries
  - ❑ Muffins

- ❑ Fruit
- ❑ Cookies
- ❑ Ice (to keep fruit, etc cold)
- ❑

*(Note: Most days, you will not have time to deal with large-scale prep of food, which is why we get the majority of our food catered. On Welcome Day, however, you're going to have several staff sitting in a lounge all day. There's no reason they can't wash and cut a bit of fruit, cheese, etc for a few minutes somewhere therein)*

- ❑ Sheet Cake (50-serving size, use full sheet size or larger)

*(Either for the welcome dinner or for final day of program; recommended for final day, but watch you don't run out of time to shop during program)*

- ❑ Ice Cream (if you choose to buy in bulk rather than let the freshmen pick flavors at Star)
- ❑ Ice Cream Toppings
- ❑ Cereal (~ 24 single servings)
- ❑ Milk (1-2 gallons)
- ❑ Cups (capable of hot AND cold)
- ❑ 750 Plates
- ❑ 900 Spoons (the extra 100 is for cereal, coffee, and ice cream)
- ❑ 750 Forks
- ❑ 750 Knives
- ❑ 1000-pk Napkins (not everyone will use them, but they're very useful if someone suddenly spills something)
- ❑ 100-pk Bowls (for ice-cream sundaes and for cereal at breakfasts)
- ❑ 8 Sponges (for cleaning meal tables)

- ❑ 3-pk Clorox Bleach Wipes (for cleaning meal tables)
- ❑ 10-pk Serving Utensils (for all food)
- ❑ 2-3 Coffeemakers (One for coffee; one or two for hot water [tea & hot chocolate])

  *(Note: If you ask nicely, you might be able to buy the industrial-sized ones from Tech Catholic Community, who only use theirs between 9 and 11 on Sunday morning. Ask before you buy.)*
- ❑ Coffee filters (if using little coffeemaker instead of coffee urn)
- ❑ Coffee Grinds (150-serving size, just in case)
- ❑ Stir Sticks (~ 200)
- ❑ Creamer (~ 200 servings)
- ❑ Sugar Packets (~ 300)
- ❑ Tea (~ 50 teabags)
- ❑ Hot Chocolate (~ 30 servings)

*You will likely not need 100% of all the coffee/tea/hot chocolate supplies; however, for the extra dollar or two that it takes to buy the next largest size, it is worth it to risk overbuying in order to keep people happy.*

*Note also that exact counts of utensil requirements will depend upon how many times you eat off campus and how often caterers supply their own utensils. Given here is a rough estimate which should cover your needs; if you feel like scrimping, you are welcome to recalculate a more precise number based upon your program configuration.*

## Appendix 5: Sample Checklist for MOS/Weekend Packing

- ❑ UHaul
- ❑ Handtruck or two *(If you don't have them, you can order smallish ones [18'X24"] from harborfreight.com, or borrow larger ones from Pappalardo. If neither of these options are available, you can rent them from the UHaul dealer.)*
- ❑ 32 Robots, 2 to a bin
- ❑ 8 Mentor Bots (and any other backup bots you may have)
- ❑ All Control Boxes
- ❑ All Transmitters
- ❑ 5 or more freshmen toolkits, with complete set of tools
- ❑ 15 (or so) safety goggles
- ❑ Mentor Tool Kits (with any tools which the freshmen had access to but were not in their kits)
- ❑ 3 Multimeters
- ❑ 2 Dremmels (w/ attachments)
- ❑ Several rolls electrical tape
- ❑ 5 (or more) soldering irons
- ❑ 5 Rolls Solder
- ❑ 2 Desoldering Pumps
- ❑ 5 Rolls Desoldering Braid
- ❑ Wire (1 roll each type & color)
- ❑ Replacement bot parts (for all bot parts that can easily be replaced (i.e., screws, not

baseplates)

- ❑ Part 1
- ❑ Part 2
- ❑ Part 3
- ❑ Part 4
- ❑ Part 5
- ❑ Part 6
- ❑ Part 7
- ❑ Part 8
- ❑ Part 9
- ❑ Part 10
- ❑ Part 11
- ❑ Part 12
- ❑ Part 13
- ❑ Part 14
- ❑ Part 15
- ❑ Part 16
- ❑ Part 17
- ❑ Part 18
- ❑ Part 19
- ❑ Part 20
- ❑ Part 21
- ❑ Part 22
- ❑ Part 23
- ❑ Part 24
- ❑ Part 25
- ❑ Part 26
- ❑ Part 27
- ❑ Part 28
- ❑ Part 29
- ❑ Part 30

- ❑ Freshmen Prizes/ Souvenirs
- ❑ "Discover Mechanical Engineering" Banner
- ❑ The means by which to affix said manner to MOS wall, neatly and non-destructively (no duct tape)
- ❑ Poster of tournament progression
- ❑ Publicity Posters
- ❑ Stands for Publicity Posters & Tournament Progression, if not provided by MOS
- ❑ Scoreboard (borrow from Zeisiger, if possible)
- ❑ Tables for Publicity Land & for Repair Area, if not provided by MOS
- ❑ 200 Publicity brochures
- ❑ Competition Ball
- ❑ Back-up Competition Ball

- ❑ Goalie Uniform
- ❑ Publicity CDs (if existent)
- ❑ Child-proof Bots (2)
- ❑ Thank-you gift for Sponsors (if they're coming)
- ❑ Charged batteries (all of them)
- ❑ Battery chargers (all of them)
- ❑ Power Strips (all of them)
- ❑ Beaver Suit (including all parts + charged battery for fan)
- ❑ Ice packs for Beaver Suit (all of them, frozen overnight)
- ❑ Cooler for Ice Packs
- ❑ DME T-shirts
- ❑ Competition Floor (all pieces, count & check them)
- ❑ Competition Walls (all pieces, count & check them)
- ❑ Competition Wall Supports (all pieces, count & check them)
- ❑ 60 copies of competition rules (for freshmen, mentors, staff, & passer-by who care)
- ❑ Several SoccerBot Instruction Books (for repairs)
- ❑ Video camcorder (2 if possible)
- ❑ Back-up camcorder battery
- ❑ Extra camcorder tapes
- ❑ Good Digital Camera (2 if possible)
- ❑ Extra batteries for cameras
- ❑ Laptop *(to dump pics onto; to record notes; to lookup stuff in case of emergencies, etc)*
- ❑ MOS Contact information

- ❑ Cell phone numbers for all mentors/staff
- ❑ Several copies of team listings (i.e., which freshmen are in which mentor group)
- ❑ Drinks for MOS lunch (if catered pizza outside)
- ❑ Cups, plates, utensils, napkins, etc for MOS lunch (if catered pizza outside)
- ❑ Big envelope to collect lunch receipts (if small groups go to museum for lunch)
- ❑ Spraypaint (for customization, if you can find a place to legally spraypaint over weekend)
- ❑ Tarp for spraypaint
- ❑ Anything else you might need for weekend activities

| | | |
|---|---|---|
| ❑ Item 1 | ❑ Item 6 | ❑ Item 11 |
| ❑ Item 2 | ❑ Item 7 | ❑ Item 12 |
| ❑ Item 3 | ❑ Item 8 | ❑ Item 13 |
| ❑ Item 4 | ❑ Item 9 | ❑ Item 14 |
| ❑ Item 5 | ❑ Item 10 | ❑ Item 15 |

NOTE: TEST ALL THE BATTERIES WELL IN ADVANCE OF RUNTIME TO INSURE THEY HOLD A CHARGE. REPLACE AS NEEDED. CHARGE THEM ALL, EARLY IN RUNTIME WEEK.

## References


Ackerman, Mark S. "Organizational Memory." 2005. University of California, Irvine. 01 May 2005 < http://www.ics.uci.edu/~ackerman/om.html>

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