Multidisciplinary Senior Design: Design Review Agenda

Land Vehicle for Education: P11211, P11212, P11213 – System Level Design

Meeting Purpose:

1. Overview of the Project
2. Confirm Engineering Specifications and Customer Needs
3. Review QFD and FMEA

Materials To Be Reviewed:

1. Overview
2. Project Summary
3. Mission Profile
4. System Architecture
5. Customer Needs
6. Engineering Specifications
7. Quality Function Deployment (QFD)
8. Functional Failure Modes and Effects Analysis (FMEA)
9. Interface Control Document
10. Project Schedule

Meeting Date: Friday January 14, 2011

Meeting Time: 9:30-11:00 am

Meeting Location: Xerox Auditorium

Senior Design Project Data Sheet

Project #	Project Name	Project Family
11211, 11212, 11213	Land Vehicle for Education (LVE)	Land Vehicle for Education (LVE)
Start Term	**Team Guides**	**Project Sponsor**
20101	Phil Bryan, Vince Burolla Leo Farnand	Dr. Hensel

Project Description

Project Background:

The Land Vehicle for Education, or LVE, is a vehicular robotic platform that has the capability of being connected with the Modular Student Attachment (MSA). This project was originally under the name of the Land Vehicle series but has since shifted focus onto developing an educational device for the Mechanical Engineering Freshmen of the incoming 2013 class. This project is designed to be used to teach Mechanical Engineering principles and design concepts to the students by having various components of the MSA they need to manufacture and put together themselves.

Problem Statement:

Create a vehicular robotic platform that can be attached to an MSA. The design must be cost effective and have the ability to be produced in large quantities. The MSA must also be developed to teach various aspects of the Mechanical Engineering. There are three groups to handle the LVE, MSA, and the controls for the entire system.

Objectives/Scope:

1. Create a vehicular robotic platform
2. Create an MSA that satisfies educational needs of incoming freshmen
3. Enable wireless transmission
4. Keep the design cost effective

Deliverables:

-Vehicular robotic platform that is remote controlled

-An MSA to attach to the platform

-Keep the project cost effective

Expected Project Benefits:

While there are many alternatives out there such as the Lego Mindstorm, the purpose of the project is to create a device that other departments and colleges will want to adapt or emulate. It will also provide a tangible example of college level projects for Mechanical Engineering Freshman to use.

Core Team Members:

Michael Deyhim

Megan Ott

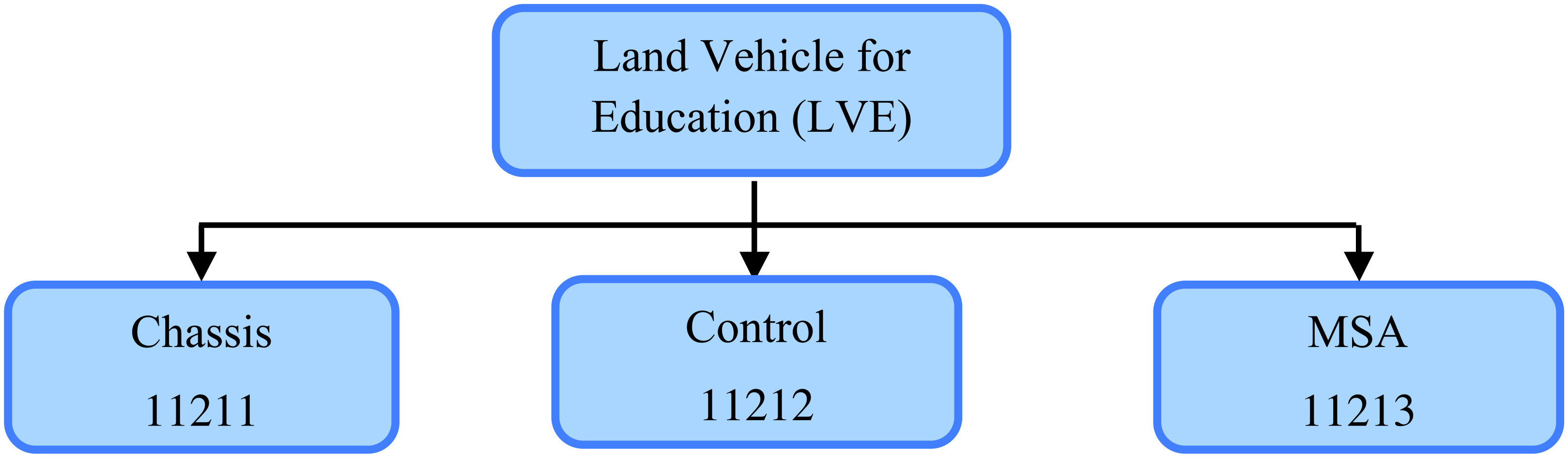
Assumptions & Constraints:

The team must obtain a well-rounded understanding of the past Land Vehicle projects in order to build off their work and improve upon it. The MSA must satisfy an educational objective, which is difficult to measure as a tangible product. The team is also limited by a budget of $500 for all three LVE components.

LVE: Mission Profile

1. LVE is removed from charging station fully charged
2. LVE travels approximately 25 ft on a carpeted floor
3. LVE makes approximately 5 turns
4. LVE grabs object (TBD)
5. LVE lifts item, weighing at most 1 lb
6. LVE travels approximately 25 ft on a carpeted floor while carrying object
7. LVE makes approximately 5 more turns
8. LVE lowers object
9. LVE releases object
10. Steps 2-8 may be repeated up to 5 times in a single class session
11. LVE is turned off and placed back in charging station

LVE System Architecture



- Power
- Frame
- Drive Train

- RF
- Control Board
- Programming (code)

- Education
- Motors/Mechanical
- Student Designed Parts

Customer Needs

CN #	Description
1.1	The driving factor of cost is the trade off between a few expensive robots, or many less expensive robots.
1.2	The economic value would allow the LVE to be successful in marketplace.
1.3	Costs related to manufacturing processes must be minimized.
1.4	Costs related to maintenance must be minimized.
2.1	The class would ideally include team projects, made up of groups of 3-6 members.
2.2	Competitions will be conducted in class, under proper restrictions.
2.3	The course content must keep students' attention.
2.4	Course content must stimulate interest in mechanical engineering.
2.5	Students will be expected to build off high school education.
2.6	The course must be challenging to students.
2.7	The course must include hands on activities.
2.8	Course projects must be related to students' interest.
2.9	The course must educate the students about mechanical engineering topics.
3.1	The LVE project must make up a major part of the class.
3.2	The LVE should be able to accommodate multiple competitions.
3.3	The LVE provides tangible example of engineering design processes.
3.4	The LVE projects must perform a quantifiable objective.
3.5	The LVE provides an introduction to future engineering topics.
3.6	The LVE represents college level engineering.
3.7	The LVE must be ready to support a class beginning fall semester 2013.

4.1	The LVE is safe for use by students and faculty.
4.2	The LVE design process must consider aspects of sustainability.
4.3	The LVE must be impressive so that other will want to emulate it.
4.4	The LVE must be easy to manufacture, maintain, and store.
4.5	The LVE must be made up of modular components.
4.6	The LVE must contain a platform for customizable attachments.
4.7	The LVE must utilize previous work from the Land Vehicle and Robotic Platform project families.
4.8	The LVE must be design to require the use of only a small selection of tools.
4.9	The LVE must look professional.
4.1	The LVE must be able to withstand multiple years of use and abuse.
4.11	The LVE must be designed for easy assembly and troubleshooting.
4.12	The LVE must be designed with reasonable and standard geometric dimensioning and tolerances.
5.1	The LVE is a reasonable size, so that several can be stored in a confined area.
5.2	LVE senior design teams must provide complete and up-to-date design and manufacturing documentation to maintenance staff.
6.1	The LVE must use off the shelf parts as often as possible.
6.2	Manufacturing of LVE components should utilize in house facilities as often as possible.
6.3	LVE design teams must provide clear manufacturing instructions.

Engineering Specifications

SS #	System Specification	Metric	Value	Test
General 1.0				
1.1	# of LVEs	Count	25-30	Cost per LVE to total budget
1.2	Cost Per Mass Production LVE	$	500	Cost of initial LVE
1.3	Cost for initial prototype	$	500	Cost of initial LVE with bulk discounts
1.4	Educational	Percentage of 5's	75%	Questionaire
1.5	Required machinable parts	Count	>3	Count done
1.6	Hand Tools Required by students	Count	<5	Count done
Chassis 2.0				
2.1	Weight of Chassis	lbs	<5	Weigh the LVE
2.2	Weight of Payload and MSA	lbs	<3	Place increasing weight on the LVE to see when it stops functioning
2.3	Speed of Fully Loaded LVE	mph	>2	Measure the speed of the LVE with 3 lbs on top of it
2.4	Turning Radius	in	<12	Measure
2.5	Height Chassis	in	<8	Measure
2.6	Base Area of Chassis	in^2	<144	Measure
2.7	Ability to travel up incline	Degrees	15	Test on a ramp
Power/Control 3.0				
3.1	Power Consumption	Watts		Use the battery life to determine power consumption
3.2	Battery Life At Full Load	Hours	>2	Run the LVE constantly while 3lbs on top of it
3.3	Recharge Time for Full Battery	Hours	<4	Measure
Safety 4.0				
4.1	Surface Temperature	Degrees F	<70	Measure
4.2	Number of Sharp Edges	Count	0	Rub paper against various parts to see if it tears/rips
4.3	Minimize Material Waste	lbs	<1	Measure
4.4	Lead time for OTS parts	Weeks	2	Measure
4.5	Time to construct LVE	Weeks	1	Measure based on work need to complete LVE
4.6	Drop Height	ft	3	Drop the LVE and test if it still functions
4.7	Machined Parts Per LVE	Count	<20	Count done
4.8	Custom Order Components	Count	0	Count done
Boolean 5.0				
5.1	Incorporates EDG Concepts	Boolean	Y	Parts to be drawn using CAD program
5.2	Incorporates Materials Processing Concepts	Boolean	Y	Part to be machined
5.3	Incorporates a design aspect	Boolean	Y	Parts to be designed by students
5.4	Enclosed Wiring	Boolean	Y	No wiring is visible in chassis
5.5	Complies with Regulations	Boolean	Y	Complies with RIT regulations
5.6	Uses standardized hardware	Boolean	Y	No specialized tools required for student assembly

Quality Function Deployment (QFD)

	Customer Needs	System Specs	Weighted Importance	# of LVEs	Cost Per Mass Production LVE	Cost for initial prototype	Educational	Required machinable parts	Hand Tools Required by students	Weight of Chassis	Weight of Payload and MSA	Speed of Fully Loaded LVE	Turning Radius	Height Chassis	Base Area of Chassis	Ability to travel up incline	Power Consumption	Battery Life At Full Load	Recharge Time for Full Battery	Surface Temperature	Number of Sharp Edges	Minimize Material Waste	Lead time for OTS parts	Time to construct LVE	Drop Height	Machined Parts Per LVE	Custom Order Components	Incorporates concepts from EDG	Incorporates concepts from Materials Processing	Incorporates a design aspect	Enclosed Wiring	Complies with Regulations	Used standardized hardware
1.1	The driving factor of cost is the trade off between a few expensive robots, or many less expensive robots		9	9	9	9																											
1.2	The economic value would allow the LVE to be successful in marketplace.		3	1	3	3																											
1.3	Costs related to manufacturing processes must be minimized.		9		3	3		3	3													3				3							
1.4	Costs related to maintenance must be minimized.		3		3	3																9											
2.1	The class would ideally include team projects, made up of groups of 3-6 members.		1	3				9																									
2.2	Competitions will be conducted in class, under proper restrictions.		1				3	3				3	3			3																	
2.3	The course content must keep students' attention.		1				3	9	3			3				1		3															
2.4	Course content must stimulate interest in mechanical engineering.		3				3	3	3			3				1												3	3	3			
2.5	Students will be expected to build off high school education.		1																									1	1	1			
2.6	The course must be challenging to students.		3				3	9	3																								
2.7	The course must include hands on activities.		9					9	3																								
2.8	Course projects must be related to students' interest.		3				3	3																									
2.9	The course must educate the students about mechanical engineering topics.		9				3	3																				9	9	3			
3.1	The LVE project must make up a major part of the class.		1	3																													
3.2	The LVE should be able to accommodate multiple competitions.		1	3								3				3		1															
3.3	The LVE provides tangible example of engineering design processes.		3					9																				3	3	3			
3.4	The LVE projects must perform a quantifiable objective.		3					9																									
3.5	The LVE provides an introduction to future engineering topics.		1					1																				3	3	3			
3.6	The LVE represents college level engineering.		3					3																				3	3	3			
3.7	The LVE must be ready to support a class beginning fall semester 2013.		9																				3	9									
3.8	The LVE must combine topics currently captured in Engineering Design Graphics and Materials Processing.		1																									3	9	3			
4.1	The LVE is safe for use by students and faculty.		3																	3	9											3	
4.2	The LVE design process must consider aspects of sustainability.		1																			9										1	
4.3	The LVE must be impressive so that other will want to emulate it.		3				3	3				3	1	1	1	1	1	3	3									1	1	1	3	1	3
4.4	The LVE must be easy to manufacture, maintain, and store.		3							3	3			3	3								3	3									
4.5	The LVE must be made up of modular components.		3					3			1																						
4.6	The LVE must contain a platform for customizable attachments.		9					9																									
4.7	The LVE must utilize previous work from the Land Vehicle and Robotic Platform project famlies.		3									1	1	1	1	1	1	1	1														
4.8	The LVE must be design to require the use of only a small selection of tools.		1					3	3																	3	9						
4.9	The LVE must look professional.		1				3	3				3	1	1	1	1	1	3	3									1	1	1	3	1	3
4.1	The LVE must be able to withstand multiple years of use and abuse.		3							3	3			3	3								1	1	9						1		
4.11	The LVE must be designed for easy assembly and troubleshooting.		3																				3	3		3							
4.12	The LVE must be designed with reasonable and standard geometric dimensioning and tolerances.		3					3														3				3							9
5.1	The LVE is a reasonable size, so that several can be stored in a confined area.		3							3	3			9	3																		
5.2	LVE senior design teams must provide complete and up-to-date design and manufacturing documentation to maintenance staff.		3																				3	3		3	3						
6.1	The LVE must use off the shelf parts as often as possible.		3																				3	3		3	9						
6.2	Manufacturing of LVE components should utilize in house facilities as often as possible.		3																					3		3	9						
6.3	LVE design teams must provide clear manufacturing instructions.		9																				3	9		3	3						3
				Count	$	$	% of 5's	Count	Count	lbs	lbs	mph	in	in	in^2	Degrees	Watts	Hours	Hours	Degrees F	Count	lbs	Weeks	Weeks	ft	Count	Count	Boolean	Boolean	Boolean	Boolean	Boolean	Boolean
	Raw Score			19	18	18	24	97	18	9	10	19	6	18	12	11	3	11	7	3	9	24	19	34	9	24	33	27	33	21	7	6	18
	Weighted Value			93	126	126	72	379	78	27	30	33	10	52	34	17	7	19	15	9	27	72	93	210	27	102	99	119	125	65	15	14	66

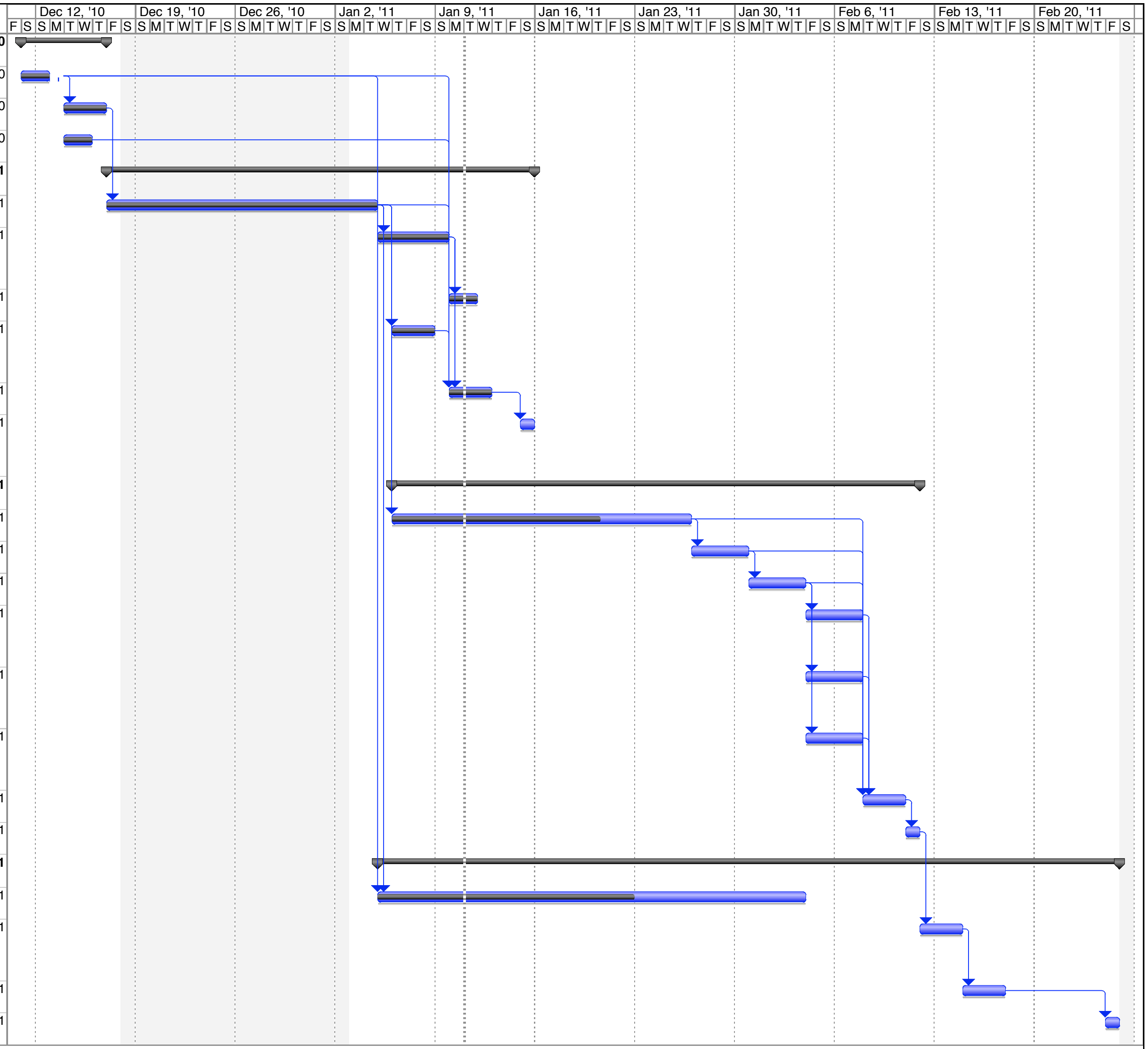
Functional FMEA

Sub-System	Function or Requirement	Potential Failure Modes	Potential Causes of Failure	Occurrence	End Effect on Product, User, Other Systems	Severity	Detection Method/ Current Controls	Detection	RPN	Actions Recommended to Reduce RPN	Action Item #
Chassis	Transports Vehicle	Does not move	Motors do not produce enough power	1	LVE will not be able to complete the assigned task and will fail to provide educational value to the students	3	ICD	2	6	Perform careful calculations / ICD meetings	1
			Does not read signal from controls	1		3	ICD	1	3	Open communication between chassis and controls teams / ICD meetings	2
			Not enough traction from wheels	2		2	Chassis Team	1	4	Careful Calculations / Account for use in field house	3
			Vehicle overheats	3		3	Chassis Team	1	9	Account for chassis cooling	4
		Does not turn	Wheels will not skid on floor surface	2		2	Chassis Team	1	4	Careful Calculations / Account for use in field house	5
									0		
	Supports MSA	Cannot support MSA load	Structure is too weak	2		3	ICD	1	6	Perform careful calculations / ICD meetings	6
			Structure is unbalanced	2		2	ICD/Chassis	1	4	Account for location and weight of load from MSA / ICD meetings	7
			Connectors do not match	1		1	ICD	1	1	ICD Meetings	8
									0		
		Does not provide power to the MSA	Battery is undersized	1		3	ICD	2	6	Perform careful calculations / ICD meetings	9
			Connectors do not match	1		1	ICD	1	1	ICD Meetings	10
Controls	Communicates with Chassis	Does not communicate with Chassis	WOCCS doesn’t function as intended	3	Will have to buy wireless device	3	None	1	9	Communicate with WOCCS team	11
									0		
	Communicates with MSA	Does not communicate with MSA	WOCCS doesn't function as intended	3		3	None	1	9	Communicate with WOCCS team	12
									0		
MSA	Educates Students	Does not educate students	Does not incorporate design aspect	1	Students will not benefit from this exercise	3	MSA Team	1	3	Provide components to be drawn by students using CAD	13
			Does not require hands on machining	1		3	MSA Team	1	3	Provide components to be machined by students	14
			Tasks are too simple	2		2	MSA Team	3	12	Account for multiple students working on each LVE over the course of several weeks	15
									0		
	Carries Object	Cannot grasp object	Not enough grip strength in claw	2	MSA will not be able to complete the task of moving an object	2	MSA Team	1	4	Account for the maximum possible load	16
			Claw is too small	1		2	MSA Team	1	2	Define object to be carried and design to maximum tolerances	17
									0		
		Cannot support object	Not enough power supporting the arm	2		2	ICD/MSA Team	2	8	Perform careful calculations / account for weight of arm as well as payload	18
			Mechanical structure of arm is too weak	2		2	MSA Team	1	4	Perform careful calculations / account for the maximum possible load	19
									0		
	Versitile	Does not support multiple competitions	Set of parts are too specific	2	ME department will only be able to use the MSA for one specific competition	3	MSA Team	2	12	Account for multiple configurations / test more than one possibility	20
									0		

Interfact Control Document

Interface Type	System 1	System 2	Value	Units	Interface #	Description
Power	Controls	Chassis	9.6	Voltage (V)	1	Power to control board
	Controls	Chassis	0.2+TBD	Current (A)	2	Power to control board
	Controls	Chassis		Connector	3	Power to control board
	Controls	Chassis		Wire Guage	4	Power to control board
	Controls	Chassis		Voltage (V)	5	Power to drive motors for operation
	Controls	Chassis		Current (A)	6	Power to drive motors for operation
	Controls	Chassis		Connector	7	Power to drive motors for operation
	Controls	Chassis		Wire Guage	8	Power to drive motors for operation
	MSA	Chassis	9.6	Voltage (V)	9	Power to MSA control board for controller operation
	MSA	Chassis	0.2	Current (A)	10	Power to MSA control board for controller operation
	MSA	Chassis	Bare Wire	Connector	11	Power to MSA control board for controller operation
	MSA	Chassis		Wire Guage	12	Power to MSA control board for controller operation
	MSA	Chassis	9.6	Voltage (V)	13	Power to MSA for motor actuation operation
	MSA	Chassis	2	Current (A)	14	Power to MSA for motor actuation operation
	MSA	Chassis	Bare Wire	Connector	15	Power to MSA for motor actuation operation
	MSA	Chassis		Wire Guage	16	Power to MSA for motor actuation operation
	Chassis	External	12	Voltage (V)	17	Power to recharge the battery
	Chassis	External	2	Current (A)	18	Power to recharge the battery
	Chassis	External		Connector	19	Power to recharge the battery
	Chassis	External		Wire Guage	20	Power to recharge the battery
	All Systems		Black (Power) and White (Neutral)	Color	21	Wire colors
	Controls	Chassis	Controls	Party Responsible	22	Signal conditioning responsibility
	MSA	Chassis	MSA	Party Responsible	23	Signal conditioning responsibility
	MSA	Controls	5	Voltage (V)	24	Controller shared regulator voltage
	MSA	Controls	MSA	Party Responsible	25	Voltage regulator mounting location
	External	Controls (RF)	12	Voltage (V)	26	Power to recharge the battery
	External	Controls (RF)	2	Current (A)	27	Power to recharge the battery
	External	Controls (RF)		Connector	28	Power to recharge the battery
Mounting	MSA	Chassis	11 x 11	Bolting Pattern (in)	29	Mounting surface for MSA components
	MSA	Chassis	1/4x20	Bolt Dimensions	30	Mounting surface for MSA components
	MSA	Chassis	3.5 x 2.5	Bolting Pattern (Sketch)	31	Mounting for microcontroller to chassis
	MSA	Chassis	1/4x20	Bolt Dimensions	32	Mounting for microcontroller to chassis
	MSA	Chassis	5 :)	Weight(lbs)	33	Max Weight of MSA
	Controls	Chassis		Bolting Pattern (Sketch)	34	Mounting for control board to chassis
	Controls	Chassis		Bolt Dimensions	35	Mounting for control board to chassis
	Controls	Chassis		Bolting Pattern (Sketch)	36	Mounting for RF device to chassis
	Controls	Chassis		Bolt Dimensions	37	Mounting for RF device to chassis
	Controls	Chassis		Bolting Pattern (Sketch)	38	RF Antenna mount to the chassis
	Controls	Chassis		Bolt Dimensions	39	RF Antenna mount to the chassis
	Controls	Chassis		Wiring Type	40	Wire gages, thicknesses, etc
	MSA	Chassis		Wiring Type	41	Wire gages, thicknesses, etc
	MSA	Chassis	6.5	Height (in)	42	Height of the mounting plate above ground
	MSA	Chassis	Dead Center	Location	43	Location of the I/O Ports on the top plate
	MSA	Chassis	Top, Dead Center and Offset	Location	44	Location of the MSA board within the chassis
	MSA	Chassis	Aluminum 2024	Material	45	Mounting surface material
	Controls	Chassis	0.2	Weight (lb)	46	Max Weight of the Controls System
	Controls	Chassis	Base, Dead Center	Location	47	Location of main control board within chassis system
	MSA	Chassis	Rectangular, 12 x 12	Dimensions (Area) (in)	48	Shape of top mounting surface.
Communication	MSA	Controls	USART	Signal Type (Serial)	49	Serial Protocol
	MSA	Controls	1	Number of Wires	50	Serial Protocol
	MSA	Controls	Molex 22-01-3027	Connector	51	Serial Protocol
	MSA	Controls		Wire Guage	52	Serial Protocol
	MSA	Controls	8	I/O Number of Ports	53	Number of ports and I/O's available
	External	Controls	4	Number of Wires	54	Connection to RF recieving device
	External	Controls		Wire Guage	55	Connection to RF recieving device
	External	Controls	USB	Connector	56	Connection to RF recieving device
	External	Controls	Custom C++ OR C#	Input Program	57	Input interface to RF transmitting device
Volume	MSA	Chassis	4 x 3 x 1	Dimensions (Volume) (in)	58	Allowed volume for the MSA microcontroller within chassis design
	MSA	Chassis	4 x 1	Dimensions (Volume) (in)	59	Opening in the top plate for control ports
	Controls	Chassis	X	Dimensions (Volume) (in)	60	Allowed volume for the controls microcontroller within chassis design
	Controls	Chassis	X	Dimensions (Volume) (in)	61	Allowed volume for each individual sensor for feedback
	Controls	Chassis	X	Dimensions (Volume) (in)	62	Allowed volume for the controls RF sensors within chassis design
	MSA	Chassis	0.5	Dimensions (Volume) (in)	63	Thickness of the top plate for ports
	MSA	External	1	Weight (lb)	64	Max Weight of an Object
	MSA	External	3 x 3 x 8	Dimensions (Volume) (in)	65	Max Size of an Object
	MSA	Chassis	5	Energy (W)	66	Allowable MSA internal heat generation
					67	Allowable surfaces for the LVE
	All Groups	External	10	Weight (lb)	68	Max weight of the LVE and MSA assembly
					69	Allowable Controls internal heat generation

ID	Task Name	Duration	Start	Finish
1	**Due Week 3**	**6 days**	**Sat 12/11/10**	**Thu 12/16/10**
2	Customer Needs	2 days	Sat 12/11/10	Mon 12/13/10
3	System Specifications	3 days	Tue 12/14/10	Thu 12/16/10
4	Project Plan	2 days	Tue 12/14/10	Wed 12/15/10
5	**Due Week 5**	**14 days**	**Fri 12/17/10**	**Sat 1/15/11**
6	Create Functional Specs	3 days	Fri 12/17/10	Tue 1/4/11
7	System Analysis	5 days	Wed 1/5/11	Sun 1/9/11
8	Mission Profile	2 days	Mon 1/10/11	Tue 1/11/11
9	System Design/Block Diagram	3 days	Thu 1/6/11	Sat 1/8/11
10	System Design Summary	3 days	Mon 1/10/11	Wed 1/12/11
11	System Design Review	1 day	Sat 1/15/11	Sat 1/15/11
12	**Due Week 9**	**37 days**	**Thu 1/6/11**	**Fri 2/11/11**
13	FMEA	21 days	Thu 1/6/11	Wed 1/26/11
14	Risk Analysis	4 days	Thu 1/27/11	Sun 1/30/11
15	Feasability Analysis	4 days	Mon 1/31/11	Thu 2/3/11
16	Updated Risk List with appropriate actions	4 days	Fri 2/4/11	Mon 2/7/11
17	Show customer needs are being met	4 days	Fri 2/4/11	Mon 2/7/11
18	Show engineering design specs are being met	4 days	Fri 2/4/11	Mon 2/7/11
19	System Design Summary 2	3 days	Tue 2/8/11	Thu 2/10/11
20	System Design Review 2	1 day	Fri 2/11/11	Fri 2/11/11
21	**Due Week 11**	**52 days**	**Wed 1/5/11**	**Fri 2/25/11**
22	QFD	30 days	Wed 1/5/11	Thu 2/3/11
23	Updated Risk List with appropriate actions	3 days	Sat 2/12/11	Mon 2/14/11
24	Part 1 Summary	3 days	Tue 2/15/11	Thu 2/17/11
25	Part 1 Presentation	1 day	Fri 2/25/11	Fri 2/25/11



Project: MSDGnatt
Date: Tue 1/11/11

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone