Team2228 Design Process Handbook

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REVISION HISTORY

DATE	DESCRIPTION OF CHANGE
V211130	RJV-Revised Decision matrix
V191018	RJV-Revised instruction sheets
V190327	RJV-Revised design process flow chart block diagram
V180105	RJV-updated game analysis work sheet
V170715	RJV-updated SWOT table questions
V161228	RJV-updated kickoff/game analysis worksheet
V160711	RJV-Updated from lessons learned in 2015-2016
V151223	RJV-Revised before build season
V151024	RJV-Revised after review
V150608	RJV-Original draft

1 INTRODUCTION

1.1 Purpose

The purpose of this document is to provide a detailed description of CougarTech's Team 2228 design process.

1.2 Scope

The scope of this document covers the FIRST robot design process for developing a game strategy and robot concept.

1.3 Audience

The intended audience is the Technical/Business for game strategy development and Technical for concept development..

1.4 References

Team 2228 - 2007, 2012, 2013 Design Process

Andy Baker, How to win in FIRST Robotics, AndyMark

Using the Engineering Design Process for Design of a Competition Robot By: John V-Neun

Team 2337 - 2013 kickoff

Team 234: Design Process Continuous Improvement

Memphis FIRST Teams - Winning Strategies for FRC

Team 1114 - Effective FIRST strategies for Design and Competition, YouTube: Simbot Seminar Series, simbotics.org/resources

Team 45: FIRST Robot Design: A Team Based Process

WPI: Strategy and Brainstorming, 2006,2007, 2008, Workshops and conference presentations

Chief Delphi: FRC role playing

Team 1511: penfieldrobotics.com/resources, wiki

Team 359: Behind the Lines episode 1: Things Every team Should Know

Team 358: Team358.org/Team Resources

Team 2228 Mechanical Handbook

Team 2228 Electrical Handbook

Team 2228 Software Handbook

Team 2228 Competition(Scouting/Drive Team) Handbook

Team2228 Team Handbook

1.4.1 Abbreviations

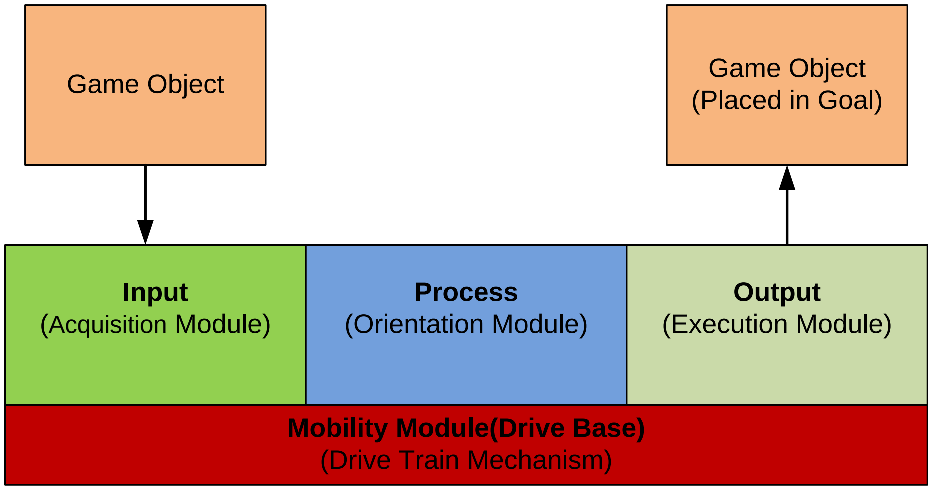
CAD	Computer Aided Design
CCWM	Calculated Contribution to Winning Margin
COT	Commercial Off the Shelf
e.g.	For example
FIRST	For Inspiration and Recognition of Science and Technology
FRC	FIRST Robotics Competition
HFL	Honeoye Fall Lima High School
ICD	Interface Control Document
IDE	Interface Development Environment
i.e.	That is
I/O	Input/Output
KOP	Kit Of Parts
KPP	Key Performance Parameters
OPR	Offensive Power Rating (this is an estimated contribution)
PO	Purchase Order
PoP	Proof of Principle
PWM	Pulse Width Modulation
QFD	Quality Function Deployment
SOP	Standard Operating Procedure
STEM	Science-Technology-Engineering-Math
SWOT	Strengths, Weakness, Opportunities, Threats
UL	Underwriters Laboratory
UML	Universal Modeling Language
WBS	Work Breakdown Structure (see section "Project Planning" for detailed description)

1.5 Definitions

1.5.1 Robot Model

The following is a generic model of the robot with typical functions that include:

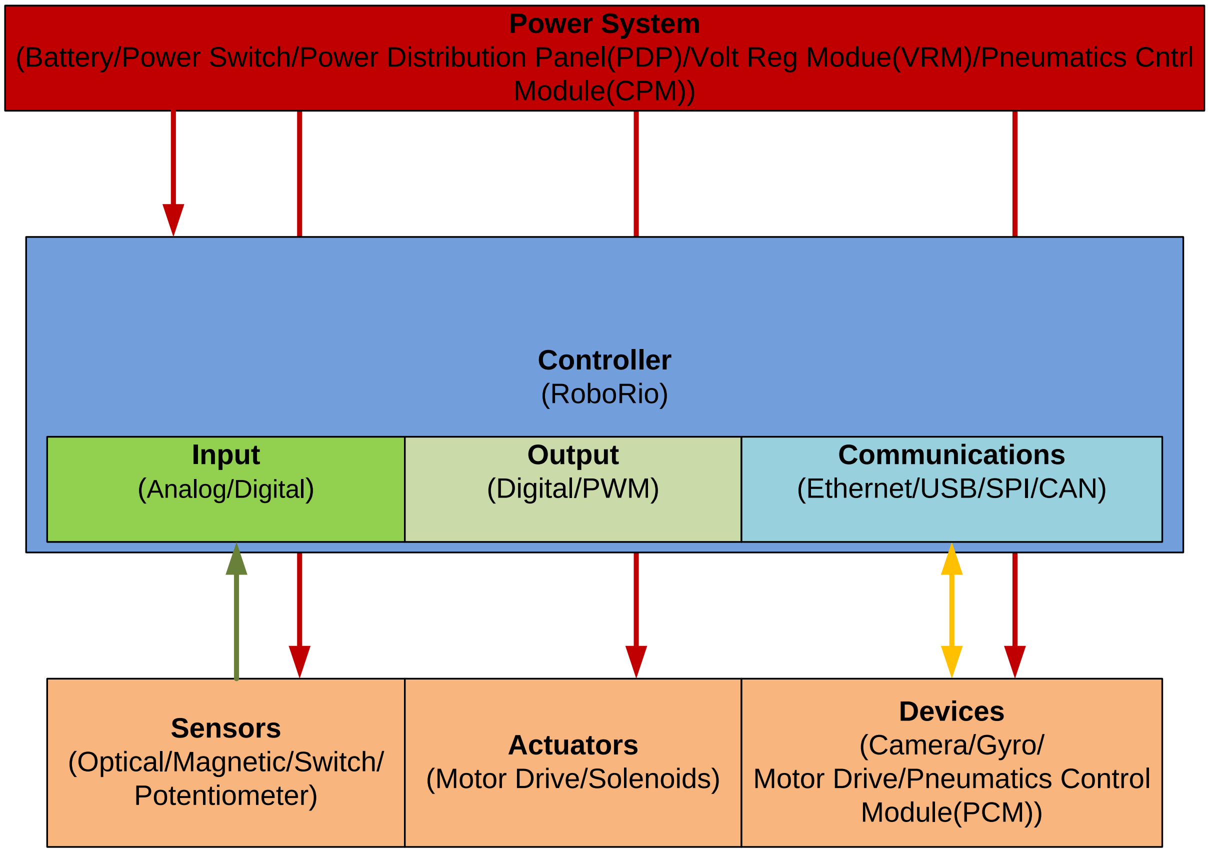
1) Acquisition Modules: claw, sweeper, roller pusher
2) Orientation Module: conveyor, elevator, scissors jack
3) Execution Module: thrower, pusher
4) Mobility Module: drive train(tank drive, mecanum drive, omni drive)



Game Object
Game Object
(Placed in Goal)
Input
(Acquisition Module)
Process
(Orientation Module)
Output
(Execution Module)
Mobility Module(Drive Base)
(Drive Train Mechanism)

1.5.2 Control Model

The control system consists of the following sections: power system, robot controller, and I/O devices.



1.5.3 Convergent Thinking

Convergent thinking is a problem solving thought process that uses the available information and technology in logical steps to develop a solution to a problem. In FIRST, a robot solution with respect to the game rules and FIRST constraints is bounded by the following tools and materials:

- Mechanical parts available
- Control modules available
- Sensors available
- Types of mechanisms we can build
- Types of drives we can build
- Software we can create

The task is to use the available tools and materials to build mechanisms and controls so that the robot can play the game. Engineering creativity comes into play with a design that is simple, low weight, fast, elegant in appearance, and reliable.

1.5.4 SWOT Analysis

SWOT is an evaluation tool to assess a design concept. SWOT is an acronym for:

S – Strengths
W – Weaknesses
O – Opportunities (How do mechanisms do multiple tasks)
T – Threats (Robot - How can the mechanism fail)

This analysis process was developed in the 1960’s at Stanford university as a structured appraisal process for business planning. Robot concept development extends this structured process to evaluate robot concepts.

2 OVERVIEW

2.1 Description

2.1.1 What is Engineering

Engineering is a practical blend of science, math and art. An engineer uses natural resources and converts energy to build products, structures and machines to benefit mankind.

2.1.2 The design process Product

The robotics Team 2228, CougarTech, develops a robot product based on the FIRST game challenge to compete in robotic competitions.

FIRST presents a problem to solve in the form of a game. In the Kickoff presentation, an animation is provide along with a game and robot manual. The challenge to all the participating teams is to effectively design and build a robot to play the game.

The intention of this document is to document a team standard for FIRST robot design that embraces the concepts of STEM:

1) Develop a critical thinking process
2) Embrace collaboration
3) Engage in hands-on, open-ended participation
4) Engage students in personally relevant projects

This document also supports the athletic "Play Like a Champion Today" winning philosophy "GROW": Goals + Relationships + Ownership = Winning.

2.2 Instruction sheets

To provide a consistent approach by all team members, there are five instruction sheets for the first few days of the build season:

1) Kickoff
2) Game analysis, Robot game strategy
3) Game simulation
4) Robot Functional description
5) Robot concept design

The work sheets provide a plan to develop a robot and have fun doing it.

3 DESIGN PROCESS

3.1 Design Process steps

The design process sequences through the following steps:

1) **Requirements Capture** (Understand "WHAT")
    a) Go to kickoff and obtain game/robot manuals
    b) Develop a strategy to play the game
    c) From the game strategy develop the functions the robot has to perform to play the game.
    d) Build the field - simulate the game
    e) Understand design constraints from FIRST(FIRST robot rules)
    f) Design Review - Team 2228 to agree on strategy
    g) Update the project Engineering Notebook with the strategy and functional requirements.
2) **Concept Development**("Think "it" through - Develop "HOW")
    a) Develop possible solutions through convergent thinking. This process entails research, possible previous solutions, math calculations, process physics
    b) Review Kit of Parts (KOP)
    c) Articulate the possible solutions in two and three dimensions(sketch it)
    d) Learn what you do not know - develop Proof of Principle Prototype designs in wood or other simple materials to see if concepts work. This is only done for the best concepts. (Concepts with the maximum strengths and least amount of issues)
    e) Refine possible solutions - integrate robot functions into one mechanism if possible
    f) Select best solution
    g) Design Review - Technical team to agree on concept
    h) Update project Engineering Notebook with documentation on the robot concept development
3) **Preliminary Design*("original CAD tool - Your brain/pencil and paper: Sketch it-try it-Improve it ")***
    a) Per module specification order mechanical parts
    b) Develop preliminary CAD drawings of modules
    c) Per module specification and functional specification develop electrical architecture / order parts
    d) Develop prelim electrical layout
    e) Define I/O for control system software - ICD document
    f) Define control software structure / software modules UML class and object models
    g) Design review - Technical sub-teams to review deliverables and start detail design
    h) Update project Engineering Notebook with sub-team documentation on deliverables
4) **Detailed Design*("The devil is in the details")***
    a) Develop CAD drawings / BOM / BOM weight per Mechanical handbook
    b) Develop electrical schematics / BOM / BOM weight per electrical handbook
    c) Develop control software per software handbook

   d) Design review - Sub-teams to review detailed work and start robot part fabrication
   e) Update project Engineering Notebook with detailed design documentation

5) **Fabrication*("Measure twice - cut once")***
   a) Mechanically build robot modules per mechanical handbook best practices
   b) Electrically build complete controls per electrical handbook best practices
6) **Module Integration*(Assembly)***
   a) Integrate mechanical modules to mobility module
   b) Integrate electrical modules to robot modules / wire sensors-actuators to control sub-systems
7) **Test and Evaluation**
   a) Test robot to functional / design specification
   b) Test drive robot
   c) Update project Engineering Notebook with test documentation
8) **Competition**
   a) Adjust, re-design or improve robot design/performance
   b) Update project Engineering Notebook with re-design documentation
9) **Lessons learned**

a) Technical sub-teams to review work done during robot build season vs team handbooks and update handbooks per lessons learned. This should be completed before new sub-team leaders are selected.

4 PRE-KICKOFF PREPARATION

4.1 Game Analysis-Game Strategy Training

Before the FIRST Robot kickoff meeting everyone on the team should have training that includes but not limited to:

1. Understand the FIRST robot organization model
2. Understand what game analysis and game strategy mean
3. Understand how the game analysis process is done. And how to use the instruction sheets.
4. Understand how the game strategy process is done, how to use the instruction sheets.

4.2 Concept Training

In the fall robot season technical sub-teams should have training that includes but not limited to:

1. Training in mechanical/control/software components
2. Training in electrical/software FIRST architecture
3. Training in mechanical structures
4. Training in mechanical mechanisms
5. Training in drive trains / power transmission
6. Training in energy sources
7. Train in tool usage - Mechanical / Electrical
8. Training in concept development process

4.3 Game Analysis-Strategy Team Member Organization

In order to have everyone participate effectively the team will be split in half. One half the RED Alliance and the other half will be the BLUE Alliance. Within each Alliance three Alliance teams will be created. The Team228 Captain and Team 2228 Vice Captain are the alliance leads and will develop a RED/Blue Alliance member list.

4.4 Kickoff preparation team

Some students and mentors along with alumni will prepare HFL for game analysis and game strategy development for returning students from the kickoff presentation. The kickoff preparation team will perform the following tasks:

1. Print out the game and robot manuals
2. Print out instruction sheets
3. Setup the overhead projectors to replay the kickoff video
4. Tape out a half size field in front of Gym A and build game objects

4.5 First Week of Build Season

Build season is the most intense part of FIRST Robotics. The first week also determines the robot character and the amount of work needed to develop the robot. To improve the success of the robot, a structured approach is used which includes the following steps:

1) (Sat) Kickoff meeting - introduction to the game
2) (Sat) Analysis of the rules and how points are gained
3) (Sat) Development of a team robot strategy(What the robot does during a match)
4) (Sun) Complete robot functional specification
5) (Mon) Organize robot functions with respect to robot model modules. Complete robot design specification
6) (Tue-Thru) Concept Development - mechanical/electrical/software architecture
7) (Fri) Concept Design selection - best solution to fit the defined robot strategy
8) (Sat) Start drive base design, start Proof Of Principle prototypes

5 KICKOFF-BUS TO HFL

5.1 Kickoff Meeting

When watching the game animation, consider the following and write responses in your notebook:

1) What ways can you score?
   a) Point values for each possible action?
      1. Autonomous
         Ex. Scoring into top basket for 2x points [2012-Rebound Rumble]
      2. Tele-Op
         Ex. Scoring Frisbees into the middle goal [2013-Ultimate Ascent]
      3. Endgame
         Ex. Mini bot racing up pole [2011-Logo Motion]
   b) Risks involved?
      1. *Ex. Potential damage from trying to climb the pyramid* [2013-Ultimate Ascent]

2) What important rules were mentioned in the game animation?
   a) *Ex. No pinning (contact for excess of 5 seconds)* [2012-Rebound Rumble]

3) Were there any implied or explicitly stated suggestions? If so, what were they?
   a) *Ex. Robot that shoots baskets* [2012-Rebound Rumble]
   b) *Ex. "… wise teams will design robots that can right themselves in case this happens…" (referring to flipping over when crossing the barrier)* [Breakaway]

4) Did the animation mention any important features? If so, what?
   a) Ex. Massive barrier dividing field [Breakaway]

5.2 Bus Trip to HFL

On the way back to HFL consider the following and enter them into your notebook:

1) Do not panic that you do not have the foggiest idea how the robot can be built.
2) Review the kickoff questions with others on the bus.
3) Think of ways you would play the game as if you were the robot

Back at HFL we will be having a working lunch by watching the video again in our alliance groups/teams that were defined before the kickoff meeting. This organization will be determined by the team captains.

6 GAME ANALYSIS - TEAM GAME STRATEGY

6.1 Game Strategy Development Sequence

1) Team Captain and Vice Captain are the Red and Blue Alliance leaders
2) Before kickoff team members are assigned to Red and Blue alliance teams
3) With game strategy instruction sheet Red/Blue teams do a score analysis
4) With game strategy instruction sheet Red/Blue teams develop a game scoring strategy
5) The Red/Blue teams will then gather and develop a team game scoring strategy

6.2 Robot Game Strategy Introduction

Designing and building a cool robot is a lot of fun and one that does well in competition is even more fun. However, we should be wary of the cool factor. You have to understand "WHAT" you want to do before you can figure out "HOW" to do it.

Robot strategic analysis is an important part of the robot design. This is accomplished in the following manner:

1) Game analysis: Understand game play / rules
2) Scoring analysis
3) Strategy development (i.e "WHAT" does the robot have to do to play the game?) [note: strategy dictates robot design]
4) Review Red/Blue team game strategies

The end result of this exercise is to document scoring analysis and game strategy(functions that robot has to perform to play the game).

6.3 Robot Game Strategy Schedule

7:00AM	Leave HFL for Kickoff meeting
12:00PM	Leave kickoff for HFL
1:00PM	Get lunch(working lunch), Divide into alliances, watch game video, read game manual/robot manual and execute game analysis
1:45PM	Develop game strategy / Prepare for game simulation
3:00PM	Gather to Review Red/Blue team game strategies
3:50PM	Clean up
4:00PM	Leave for the day

6.4 Materials needed

The following materials are needed to develop the robot strategy.

1) Notebooks or notebook with loose leaf paper
2) Dry erase makers / dry eraser
3) Laptop computer / tablets to obtain rules
4) Overhead projector
5) Camera to record white boards

6.5 Robot Game Strategy Development Teams

There will be two Robot game strategy development teams, the Team 2228 Red Alliance and the Team 2228 Blue Alliance. Members will be assigned before kickoff day and consist of team members from all disciplines (Technical/Operations) with experienced/non-experienced members. The leaders of these teams will be the Team Captain/Mentor and the Team Vice-Captain/Mentor respectively.

6.6 Game Analysis

6.6.1 Scoring Analysis

Each Alliance should develop a scoring dictionary. The scoring dictionary should contain the following items:

1. Examine every possible way to score points, no matter how obscure
2. List all scoring sequences (*For example in the 2015 game RECYLE RUSH game there was a combination of totes and a can that gave different scores.)*
3. What is the maximum score that can be attained by an alliance.
4. List all ways an opponent Alliance team could be prevented an opponent robot from scoring points.
5. List actions that will cause fouls
6. For an alliance what would the theoretical maximum score that could be attained with the game objects available

6.6.2 Time Analysis

Define a match time allocation for autonomous, tele-operation and endgame.

6.6.3 Game Object Analysis

The following items should be compiled:

1. Are there multiple types of game pieces?
2. How many?
3. Where are the game objects located?
4. How many can each team possess?
5. How many can each Alliance possess?

Develop a "Parking Lot" list of items you do not understand or have questions about.

6.7 Team Strategy Development Process

Strategy is "WHAT" the robot does during a match. The goal of the strategy process is to develop a game plan that develops the maximum number of points for an alliance team.

The Red/Blue alliances will break up into alliance teams(3) with a driver, coach and team scouts. The coach will be the team leader. Mentors will also join an alliance team. The teams will separate to different locations in the building to develop their team strategy.

In describing your strategy:
Use words(VERBS) that could translate to mechanism functions (e.g. Raise/Lower, throw, pick up, climb, draw in, push/retract, catch, etc)

6.7.1 Types of Game Play

Autonomous:

A certain amount of time is allotted during a match for the robot to execute a task by itself with no human interaction.

Tele-Operation:

The main part of the match is controlled by human interaction by providing commands to the robot to control mechanisms.

End Game:

The end game is an allotted amount of time at the end of the game to perform a special task with its own scoring values.

6.7.2 Types of Strategies

Offensively focused:

An offensive robot concentrates on making points with the game objects with regard to the game rules for scoring. The robot design would have to have mechanisms to gather the game objects and execute actions with the game objects to score points.

Ex. Collect balls from the floor and move them across the field (with the ability to cross the bridge), score in the middle basket (also have ability to score in either middle level basket or the lowest basket if necessary), and balance on the bridge at endgame (potentially with other robots) [Rebound Rumble]

Defensively focused:

A defensive robot stops opponent alliance robots from scoring. Preventing an opponent from scoring is as effective as scoring. A defensive strategy can be accomplished in the following manner:

1. Use of the drive train to block an opponent
2. The use of a specific mechanism to block the game object from an opponent robot
3. Remove game objects that opponent teams could use to score.

The risk of defensive strategies is the potential of accumulating penalty points.

6.7.3 Scoring Cycle Action Plan

Each alliance team will develop and document a robot play strategy for autonomous / teleop / end game that are defined by the rules. Make a sequence list of robot play action.

Make a list of all action steps need to execute the offensive game plan. For each action record the amount of time needed to do the action. The work sheet gives typical action times. Added up the times to develop a cycle time and determine the score developed for the number of cycles that can be completed in a match. Remember travel plan and time.

Review offensive game plan and adjust for the highest scoring scenario.

The scoring cycle action plan is organized in the following manner:

Step number / Step Task time / Step Task description

6.8 Team Game Strategy Analysis Process

In the strategy analysis the following questions should be asked:

1) What strategy obtained the most points?
2) What driver operations were needed to play the game?
3) How many cycles did the robot do during the game time?

4) How long did take to do the robot operations?
5) What worked best: defense / offense , combination?
6) What functions have to be very robust(*e.g.([Areial Assist] capture ball quickly within a large range*)?

Make a "Parking Lot" list of items you do not understand or have questions about.

6.8.1 Scoring Cost-Benefit Analysis

For each task you must compare the difficulty of accomplishment to the reward for doing so. This is where the strategic value vs. coolness factor decision often pops up. The best tasks to perform are those which are relatively easy, yet provide big points. Also, remember denying your opponents points makes your alliance points more valuable.

6.8.2 Strategy Failure Analysis

After combining strategy ideas look for any flaws in your strategies. The questions to ask include:

a) Does this strategy make sense?
b) Is the strategy legal with respect to FIRST Game/Robot rules?
c) Is it feasible?
d) Do you think the team could build this kind of robot?
e) Does the team have the technology to build this robot?

Develop a "Parking Lot" list of items you do not understand or have questions about.

7 ROBOT FUNCTIONAL SPECIFICATION

7.1 Robot Functional Specification Introduction

At this point the team members have a better understanding of the game and how it is played. The task at hand is to complete the robot functional specification. The robot functional specification will be the basis for the robot concept and design. The process converges all the strategies into one team strategy along with all the functions the robot has to do to execute the strategy.

7.2 Robot Functional Specification Schedule

1:00PM	Team completes development of team game strategy
1:30PM	Technical team develops game strategy functional sequence
3:00PM	Team develops Acquisition-Action module function list and complexity
3:30PM	Team starts on defining drive base foot print
3:45PM	Assign team members to concept teams for Monday
4:00PM	Technical team to start thinking about the "HOW".

7.3 Robot Functional Specification Materials needed

The following materials are needed to develop the robot requirements.

1) Notebooks or notebook with loose leaf paper
2) Dry erase makers / dry eraser
3) Laptop computer / tablets to obtain rules
4) Overhead projector
5) Camera to record white boards

7.4 Game Strategy Functional Sequence List

For each game strategy a functional sequence list will be developed that inculde a step number with a function that the robot has to do to match the strategy.

Note: use words(VERBS) that translate to mechanism functions (e.g. Raise/Lower, throw, pick up, climb, draw in, push/retract, catch, etc)

This should be completed for autonomous, TelOp, and End Game

7.5 Robot Module Functional Specification Convergence Process

The robot requirements convergence process consists of the following steps:

1. The robot sequence functionality lists are compared, duplicate items are combined, and one robot functionality list should result.
2. Robot functions will then be assigned to a acquisition, Action Module or Mobility Module.
3. Functions within the module should be ranked by complexity
4. Reality Check: The team needs to do a strategy failure analysis described in the next section.

7.6 Team Strategy Failure Analysis

The following questions should be asked with regard to the team game strategy::

a) Does this strategy make sense?
b) Is the strategy legal with respect to FIRST Game/Robot rules?
c) Do you think the team could build this kind of robot?

7.7 Homework

1) The technical team members should start to think about what kind of mechanisms can be made to perform the robot function required.
2) The technical team members should understand the concept process instructions.

8 ROBOT CONCEPT DEVELOPMENT

8.1 Robot Concept Design Introduction

The robot design concept process translates robot functionality into robot mechanisms. There are many solutions to a problem*. (Engineering is the iterative process to find an optimal solution to a problem taking into consideration cost, functions, time, technology, and reliability.)*

The process to develop concepts is based on convergent thinking where sub-teams use research, evaluation of previous work, engineering calculations, and process physics to develop an optimal design.

(It has been documented that concepts developed first by individuals and then refined by a team is more effective than a team starting with a blank paper and brainstorming ideas [e.g. FIRST, Microsoft, Facebook, Apple, Web browser, Ethernet[Xerox], however, NOTE that their concepts/ideas were based on the previous work of many individuals. Each of these inventions were based on needs of customers]).

In the design of the robot the requirements is divided into two sections:

1) Functional Requirements: On our first day of the design season the team worked on the functional requirements of the robot with respect to the robot strategy to play the game
2) Design Constraints - limitations imposed by FIRST on the robot design (e.g. weight, size, control components, etc). These constraints are listed in the robot manual.

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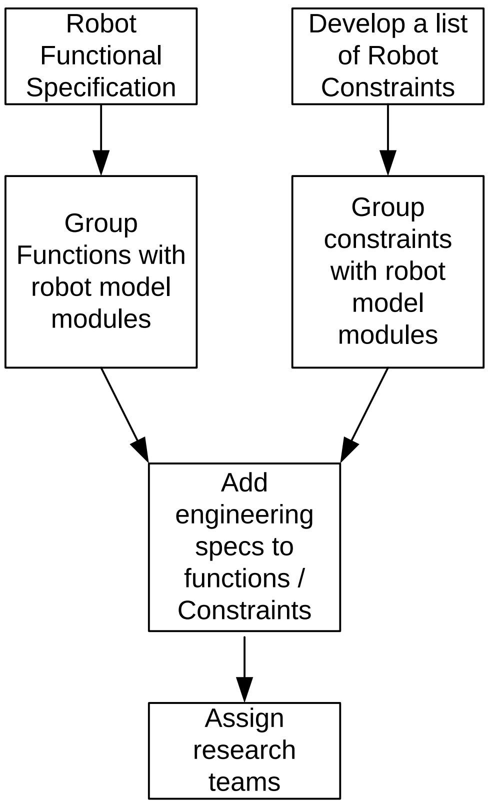
The concept team should then with "Gracious Professionalism" review each concept and try to improve it. The assessment process will eliminate concepts that cannot be used and converge to the best concept.

8.2 Design Specification Process Flow Chart



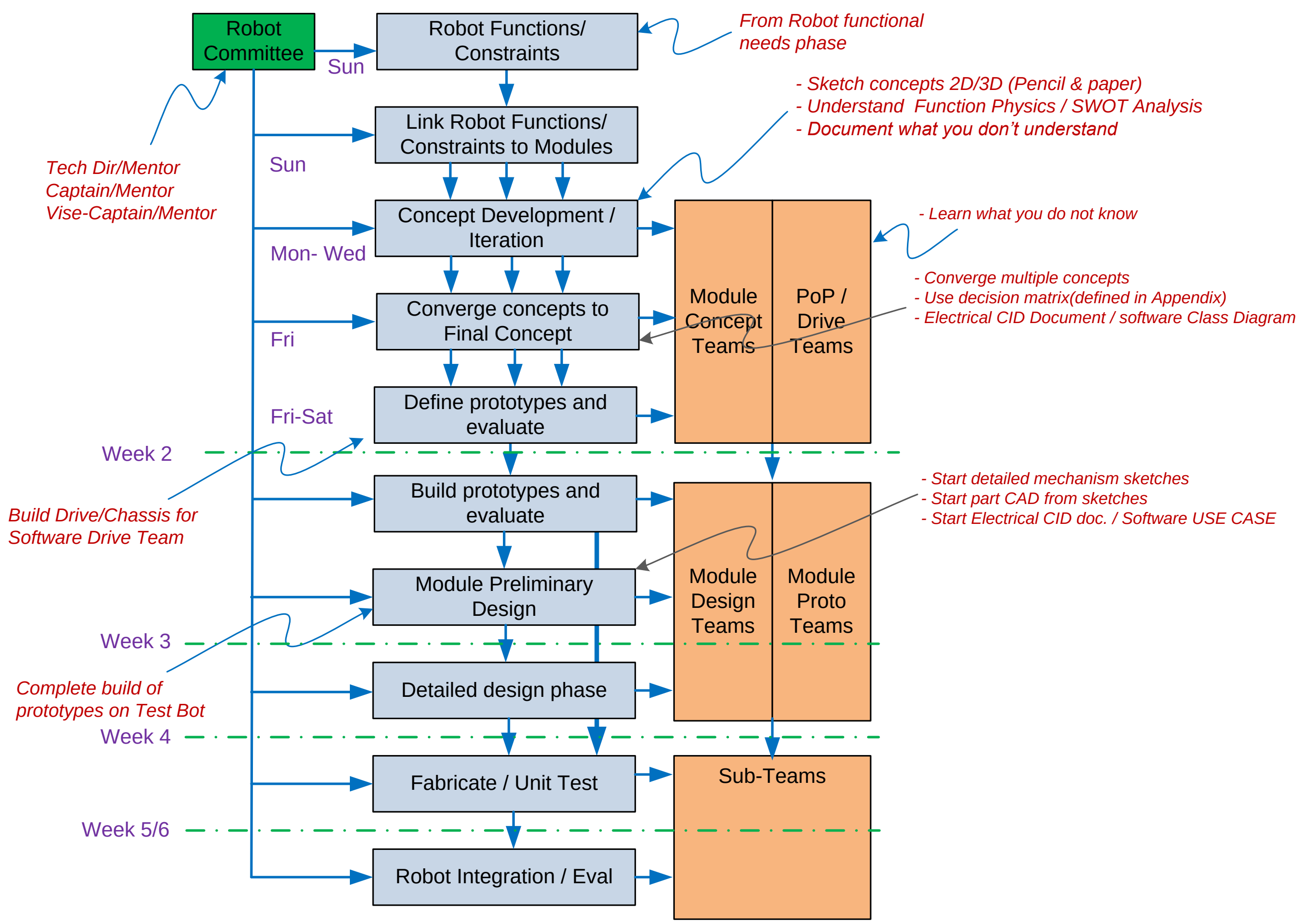
-Re-read the "FIRST Robot Manual"
-List all constraints (i.e. size, weight, etc)

- Group functions / constraints into robot model modules
- Create new modules if required
- "NAME" robot modules

-Add engineering specs to functions
e.g. How fast movements have to be
How much weight has to be lifted

-Learn what you do not know
-Search for:
"Has this been done before?"

8.3 Concept Development to Prelim Design Process Flow Chart



8.4 Concept Development Schedule

8.4.1 First Week

Monday	Organize functional requirements to link with robot module model and develop design specification; assign robot module research teams
Tuesday	Mobility module team / robot module teams start robot module concept research
Wednesday	Develop module concepts and do SWOT analysis
Thursday	Develop module concepts and do SWOT analysis
Friday	Convergence of concept strategy; Use of decision matrix if necessary; Definitions of Proof Of Principle prototypes and expected results; Mobility module design review
Saturday	Start prototype design-kit prototype material-start prototype fabrication / build drive chassis / add controls to test bot / start prelim design

8.4.2 Second Week

Monday	Continue prototyping fabrication / test test bot

Tuesday	Prototyping testing-redesign to improve
Wednesday	Prototype testing-redesign to improve
Thursday	Prelim design review/release for detailed design
Friday	Complete robot concept / assign prelim design teams
Saturday	Complete prelim design

8.5 Concept Development Materials needed

The following materials are needed to develop the robot requirements.

1) Notebooks or notebook with loose leaf paper
2) Dry erase makers / dry eraser
3) Laptop computer / tablets to obtain rules
4) Overhead projector
5) Camera to record white boards
6) Robot Functional specification

8.6 Robot Concept Design Roles and Responsibilities

Concept team leader: The concept team leader for each module is responsible for overseeing the concept development process using the concept process and concept process tools.

Concept team members: Module concept team members are responsible for providing the concept content by doing research, evaluating previous robot concepts, doing engineering calculations, finding physics that pertains to the concepts.

Technical Director: The technical director is responsible collecting concept documentation for the project engineering notebook. This documentation includes, but not limited to:

1) Engineering calculations
2) Concepts developed
3) Decisions developed
4) Proof Of Principle criteria, design, and results

8.7 Robot Concept Design Process

8.7.1 Robot Design Specification

The robot design is bounded by two factors: Functions required to play the game and constraints on material, size, cost, weight and time imposed by FIRST.

The robot functions determined by the team should be organized with a first cut version respect to the four main modules of the robot model. (i.e. Mobility module, Acquisition / Orientation module, Execution module).

To improve the concept process there should be engineering specifications for each function. For example: Function: low speed force for defending and high speed to access goals. The engineering specification would be 1) load speed: 2ft/sec, 2) high speed: 18ft/sec. The first engineering spec is the time required to accomplish the function.

Determine the key performance parameters(KPP) of the robot (e.g. speed, weight, turn, push, range)

8.7.1.1 Robot Constraint Analysis

The following steps should be completed to acquire all the robot constraints specified by FIRST

1) Read the robot manual
2) Record all robot constraints with respect to material, weight, size, operating environment

8.7.2 Module Concept Development Process

1. Split the technical team into three or four research groups with respect to the 4 main modules on the robot (i.e. Chassis module, Acquisition / Orientation module, Execution module).
2. STUDY THE GAME OBJECT for characteristics that can be used to constrain the game object in acquiring, orienting and perform actions on the game object. (It's all about the game object!!!)
3. Each research member should develop a concept on paper. The concept includes: 1) The module function, 2) A SKETCH, and 3) A concept assessment - SWOT analysis.
4. Review all concepts.

8.7.2.1 Concept Convergent Thinking

In developing a complete concept the following items should be considered:

1) Walk through the function requirement. Look for key words that translate to mechanism functions (e.g. Raise/Lower, throw, pick up, climb, draw in, push/retract, catch, etc)
2) In developing a concept, understanding the parts you have in our inventory and parts in the Kit Of Parts. These will be the basic components to build the robot mechanisms based on the requirements.
3) Think of the energy tools you have at hand: Motors, springs, pneumatics
4) DO NOT REINVENT THE WHEEL - have you seen mechanisms before that address the function. Remember that there are only six simple machines: incline plane, wheel/axle, lever, pulley, screw.
5) MAKE A SKETCH of your concept (Pictures are worth a thousand words). ***Use "The first CAD tool": your brain, pencil and paper***
6) Research the physics needed - do some calculations
7) Do a concept assessment of every concept – SWOT Analysis *(Failure analysis; note that finding failure early saves time, cost and effort)*
8) Define mechanical module interfaces
9) Make a "Parking Lot List" of what you do not understand
10) Define power/actuation strategies (motors, actuators, sensors…). This will be the basis for the electrical and software design.

Are their clues in the Kit Of Parts? Review the KOP. Parts provided may provide some information on what the game designers were thinking of for a robot design.

8.7.2.2 Module Concept Assessment (SWOT Analysis)

Before proceeding with concept refinement and validation it is advisable to do a concept evaluation of each concept.

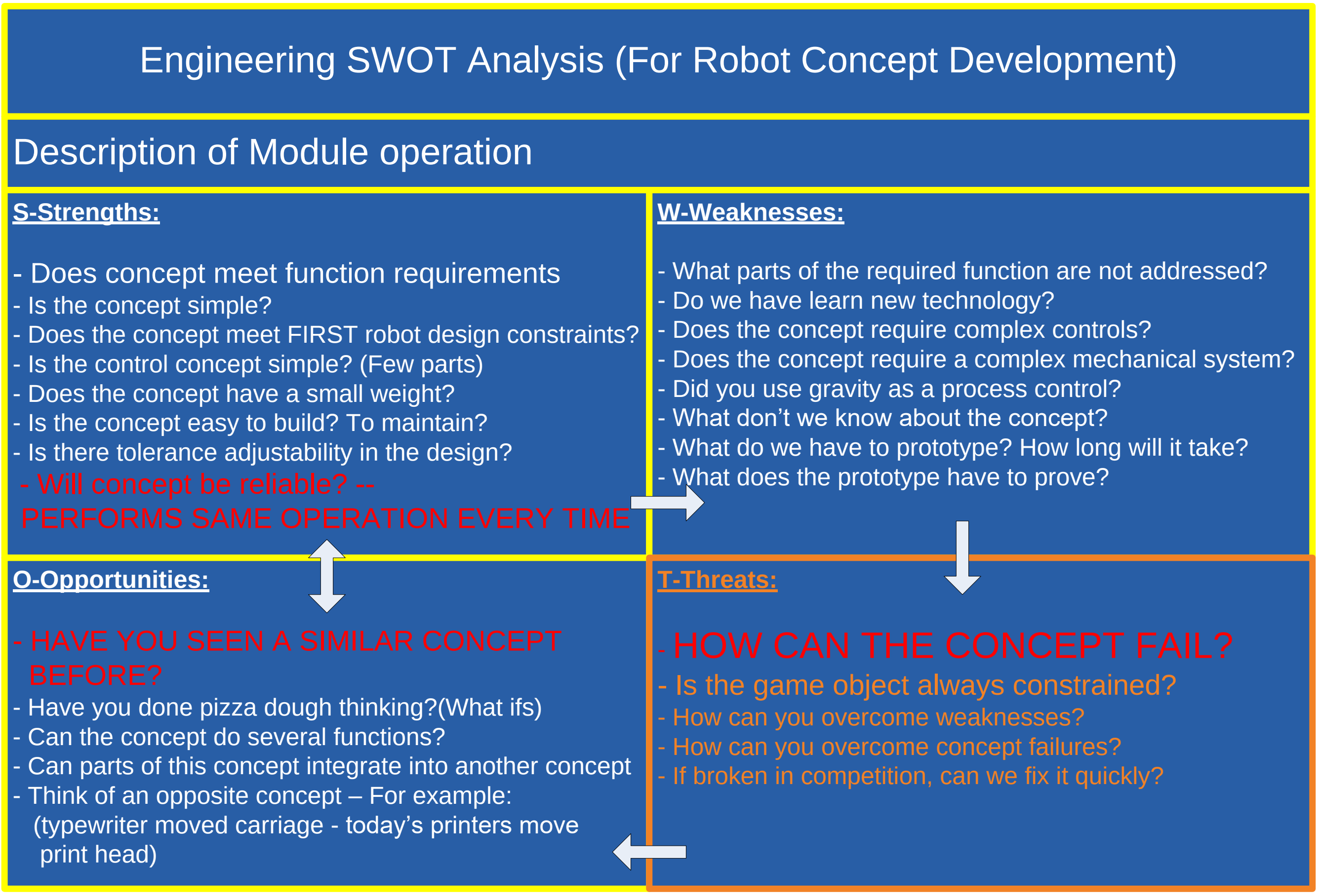
An Engineering SWOT analysis should be done for every concept:

S-Strengths:	Does concept meet the address the needs of the function? Are the constraints of the function addressed?
W-Weaknesses:	What are the limitations of the concept?
O-Opportunities:	Can the concept do more than one function?
T-Threats:	How can the concept fail? - Can you overcome the failure? Weaknesses – can you overcome weaknesses in the design?

Part of the concept evaluation the following items should be considered. The basic questions to ask, but not limited to, include:

1) Does the module concept satisfy the robot function definition?
2) Does the module concept meet the design constraints defined by the robot rules?
3) Do you have the technology to build the module concept?
4) Is the concept complex? *You only have three weeks to design it and build it.* (*Remember K.I.S.S(Keep It Simple Students)- Precision and complexity cost design time, cost, fabrication effort, spare parts, and maintenance. Look at your resources, budget, and team member experience.* **Golden Rule of FIRST: *Always build within your team's limits. Teams who try to do more than they're capable of tend to fail*.**
5) ***IS THE GAME OBJECT CONSTRAINED AND ORIENTED*** for the next robot operation on the game object? (For example: 2015 Recyled-Rush: At the player station when the tote falls to the ground, it needed to be oriented for the elevator to capture the tote with respect to the tote's features for a successful lift and orientation to the tote stack)
6) Does the concept interfere with another robot function and require more complexity to implement?
7) Did you use gravity as a process control? ***(Note: Gravity in robot design is not your friend)***
8) Does the concept require complex controls (electrical/software)?
9) What would cause this concept to fail? (e.g. not enough energy to make mechanism work, mechanism misalignment, mechanism does not constrain game object, physics works against you-[e.g.: human player throws ball to robot and ball bounces out of robot], counting on gravity to do useful work, etc)

The following is block diagram of the SWOT process:



8.8 Concept Presentation

Concept presentation shall be electronic and provide the following information:

1) Hand sketch of the concept
2) Concept assessment analysis (SWOT)

8.8.1 Module Concept Proof-Of-Principle

In the development of concepts, the concept design teams may find that a concept has merit, however, there is a lack of confidence in the concept. Proof Of Principle prototypes are developed to verify concepts.

There should always be a list of what information / performance the Proof-Of-Principle prototype will provide.

Every module concept SHOULD NOT BE prototyped. From analysis the best concept/concepts should be prototyped and evaluated.

8.8.2 Module Concept Refinement

Concept refinement is an iterative process to improve the concept (this is the fun part). Think of the following questions:

1) How do I make the concept:
    a) Lighter? / Faster?
    b) More robust
    c) Simpler
    d) Cheaper
    e) More efficient
    f) Easier to construct, assemble, repair
    g) How do I combine robot functions into one mechanism

8.8.3 Module Concept Selection

Concept selection shall be based on data. The use of a decision matrix shall be used. Refer to the decision process section of this document.*(Note that making the right choices based on your analysis will determine the fate of your season.)*

8.9 Final Robot Concept Convergence

8.9.1 Final Robot Concept Convergence Process

The final robot concept is an iterative process based on the sum of parts. For each module the best concept was developed with considerable detail. The final robot concept is an integration of those concepts.

The technical teams as group should go through refinement process asking the following questions:

1) How do I make the robot concept:
    a) Lighter? / Faster?
    b) More robust
    c) Simpler
    d) Cheaper
    e) More efficient
    f) Easier to construct, assemble, repair
    g) How do I combine robot functions into one mechanism (e.g. 2014 Aerial Assault: shooting mechanism was also game object acquisition mechanism)

Note that making the right choices based on your analysis will determine the fate of your season.

8.10 Prelim Design / Prototyping

8.10.1 Drive Base Prelim Design

The prelim design of the drive base should use final materials and mechanisms. The drive base is the first module that should be completed in the second week for testing and a second competition drive base should be started.

The electrical/software teams should develop controls and software to control the drive base in the second week of the build season.

8.10.2 Module Prototyping

The following are items to consider in developing module prototypes:

1. A prototype of the execution module should be prototyped. The prototype should be close to a design that could be used on the robot.
2. It should take into consideration robot functions, constraints, and control functions. This requires some sketches, and calculations - USE YOUR ENGINEERING NOTEBOOKS.
3. A statement of what the prototype should accomplish. Data should be put into YOUR ENGINEERING NOTEBOOKS.
4. The use of motor and pneumatic test boxes should be used to exercise the prototype

Rapid Prototyping methods and materials is coved in the Mechanical Handbook.

8.10.3 Electrical / Software Prelim design

Electrical and software prelim design is covered in the electrical and software handbooks.

8.11 Detailed Design / Fabrication / Testing

Detailed Design, Fabrication, and Testing are coved in the Mechanical, Electrical and Software Handbooks.

9 APPENDIX A: DECISION MATRIX

9.1 CONCEPT DECISION PROCESS

9.2 Concept Controlled Convergence

There are many solutions to a problem. The concept selection process goal is to decide on the best solution.

Think of selection as "controlled convergence" (Pugh, 1981), that is you are doing a multi-step process to narrow down the choices. The first round in a decision process is not the last round. Your decision process may show that after each selection stage, combine and strengthen existing concepts and use the selection results to generate new, stronger concepts for the next selection round. Often, more info must be gathered before the next selection round is possible.

The decision matrix (see appendix on decision matrix instructions) should be used to select and document team decisions. The rating process is accomplished by consensus. Consensus is everyone agreeing with a rating of a concept against a criteria item with the rating values provided. Math will determine the final decision.

Democracy should ensue… but a monarchy may come about during an impasse. The Technical Mentors shall make the decision.

9.3 When to Use a Decision Matrix

The concept team using concept convergent process and SWOT analysis may come to a consensus on a concept. A decision matrix is used when there are several concepts that meet the functional requirements and a consensus on a concept is not reached. A consensus on a concept should never be accomplished by voting. This is an opinion process. A decision matrix translates decision criteria verses concepts to a numeric formula that develops a decision based on data not opinion.

9.4 Decision Matrix Process

The following steps should be used in developing a decision matrix:

1) Develop decision criteria
2) Develop a weight for each criteria
3) Present concepts
4) Rate concepts to criteria
5) Calculate decision

9.5 Decision Matrix Layout

Structured selection is generally best done in a matrix format (Most common tool - Excel spreadsheet or a table format on a whiteboard). Selection criteria are listed down left column, concepts listed along top row.

If the matrix is overwhelming, generally it means the problem was not well divided into subtopics, or that decisions at the systems level are being driven by the detail level. The following is an example of a decision matrix.

		Concept 1		Concept 2	
Criteria	Weight	Ranking	Ranking result	Ranking	Ranking result
Team Experience(done this before)	4	3	12	3	12
Robot Functions meet(cons>weaknesses)	5	3	15	3	15
Concept Weakness(can we solve it)	5	5	25	3	15
Competition Robot Constraints meet	5	3	15	3	15
Mechanical Complexity(number of parts)	3	3	9	5	15
Controls Complexity(can we control it)	3	5	15	3	9
Manufacturablity(can we make it)	3	3	9	1	3
Reliability(not break in competition)	4	5	20	3	12
Maintainability(can we fix it)	4	1	4	3	12
Number Energy Devices	3	1	3	3	9
Cost(fit in budget)	1	3	3	3	3
Resources(number of team members)	2		0	3	6
Total:			130		126
	Weight = Importance(1-5)				
		[need to use all [1-5]			
	Ranking				
	1	doen't meet Criteria		ok	
	3	meets Criteria		Better	
	5	Exceeds Criteria		Best	
	Ranking result = Weight * Ranking				

9.6 Decision Matrix Criteria

The team must determine the selection criteria. A good definition should accompany the criteria name. These are the specific measures that the concepts will be judged on. The criteria should be developed by consensus of the team.

The core criteria should include, but not limited to:

1) **Team Experience**
   Has the team built a mechanism like this before?
2) **Robot Functions meet**
   Does the mechanism meet the requirements for the functions required?
3) **Concept Weaknesses**
   Can the team solve the weaknesses of the concept in the time allotted?
4) **Competition Robot Constraints meet**
   Does the concept satisfy the game constraints?

5) **Mechanical Complexity**
   Complexity is a measure of how many mechanisms, metal cuts, number of gears, belts, number of fashioners, etc. Complexity relates the time to design, fabricate, assembly and test. The goal is to minimize the complexity. "Keep it simple"
6) **Controls Complexity**
   Does the team have electrical devices for the concept? Can software control the mechanism?
7) **Manufacturability**
   Technology is a criteria that is a measure of fabrication processes available to the team (e.g. sheet metal processing, laser cutting, welding, 3D printing, etc). The goal is to manufacture a robot with the simplest methods and fewest parts. "Build within Your capabilities"
8) **Reliability**
   Reliability is a criteria that is a measure of how robust the design is (e.g will the robot withstand being hit by another robot and not have any of its mechanisms damaged or are the motors sized correctly so that they do not over heat, etc)
9) **Maintainability**
   Can we fix the mechanism easily in competition?
10) **Number Energy Devices**
   This criteria is a measure of how energy is used. The work the robot has to do will be the same, however, how the energy is used will be different. The goal is to minimize electrical energy to develop mechanical potential energy (e.g. The use of mechanical advantage[gearing/levers], potential energy devices[springs] and compressed air. Note that high energy should be developed through mechanical advantage into springs or rotating masses.)
11) **Cost**
   The cost criteria is a measure of complexity with respect to the robot budget. The goal is to minimize the cost.
12) **Resources**
   Does the team have the member resources/skills to complete the tasks. ("Build within Your capabilities")

9.6.1 Mobility Module

The mobility module is a distinct module of the robot that is a major factor in the performance of the robot and should be addressed by itself. For a the mobility module, criteria should include, but not limited to:

1) **Maneuverability**
   This criteria defines how the robot needs to move in the game.
2) **Speed/Torque**
   This criteria specifies the speeds and torques required for the game.
3) **Traction**
   This criteria specifies the game playing field surface and the robot wheel interaction.

9.7 Criteria Weight Options

9.7.1 Method 1

Weight options include magnitude range or a normalized range. The magnitude range would rank the attributes from 1 to 5 with 5 being the most important. Multiple criteria's can have the same weight. All the weight values(1 through 5) have to be used. Everyone has to agree on the value. This could take a long time to get everyone to agree.

9.7.2 Method 2

Another method is use a normalized range. Every team member ranking the criteria's from 1 to N(the number of attributes) with N being the most important. Put the results in columns with respect to their criteria item and then sum up each criteria row. Sum the resulting column and divide each row sum by this number. This will give a normalized value such that all weights will add up to "1".

The normalized range translates opinions into a math equation.

For example:

	Team Member weight values	
1 criteria #1	3 2 3 3 = 11	=>11/24= 0.46
2 Criteria#2	1 1 1 2 = 5	=>5/24= 0.21
3 Criteria#3	2 3 2 1 = 8	=>8/24= 0.33
Column Sum	24	

9.8 Ranking Options

The original Pugh decision matrix would rank other concepts with respect to a baseline concept. Seeing we do not have a baseline we need to just rate each concept on how well the concept meet the attribute. The rating value is typically 1-5 with 5 being the best. Everyone has to agree on the value.

There are only 4 distinct values to use:

1) 0 - Does not meet Criteria
2) 1 - Meets criteria somewhat
3) 3 - Meets criteria
4) 5 or 9 - Exceeds criteria.
    a) Using 9 for this value will result in a larger distance between the best concept and the rest of the concepts
    b) Or using 9 should be used by the one concept that accomplishes the criteria the best.

9.9 Decision Matrix Concept Presentation

All concept should be presented at approximately the same level of detail. The concepts should also be in the same level of scope. Concept presentations should include, but not limited to:

1) A sketch of the concept
2) A verbal description of the concept reviewing the sketch
3) SWOT analysis.

9.10 Decision Matrix Criteria vs Concept Ranking Process

The following steps should be followed in developing a decision score:

1) Rate each concept to a criteria with the ranking values agreed on.
2) Develop a sum of products rating for each criteria. This is the column sum of: all criteria importance multiplied by the concept rating the team has given for each criteria.

Rating each criteria should be done by consensus. Consensus means that all agree within the bounds of the criteria, not if they like the concept or not! Remember that this is not a personal competition.

If there is an impasse, the technical mentors of the rating exercise will make the final decision.

At this point we have a selection, however, we are not finished yet. We need to iterate the concept selected and ask the following questions:

1) Can we combine best designs of another concept with the selected concept?
2) Is there ways to remove risks and undesirable features from the selected concept?
3) Can we combine functions to improve the concept selected?

After selection process, the team should sit back and take a fresh look. Does the selection match intuition? If not, why not? Was there anything that was missed? Does the team feel comfortable about the choices? Remember, these are important decisions that are being made. You're putting the life of the project into your chosen concept. It better be the best or else you will be in trouble down the line.

10 INSTRUCTIONS: KICKOFF

10.1 Kickoff Meeting

When watching the game animation, consider the following and write responses in your notebook:

1) What ways can you score?
   a) Point values for each possible action?
      1. Autonomous
         Ex. Scoring into top basket for 2x points [2012-Rebound Rumble]
      2. Tele-Op
         Ex. Scoring Frisbees into the middle goal [2013-Ultimate Ascent]
      3. Endgame
         Ex. Mini bot racing up pole [2011-Logo Motion]
   b) Risks involved?
      1. *Ex. Potential damage from trying to climb the pyramid* [2013-Ultimate Ascent]

2) What important rules were mentioned in the game animation?
   a) *Ex. No pinning (contact for excess of 5 seconds)* [2012-Rebound Rumble]
3) Were there any implied or explicitly stated suggestions? If so, what were they?
   a) *Ex. Robot that shoots baskets* [2012-Rebound Rumble]
   b) *Ex. "… wise teams will design robots that can right themselves in case this happens…" (referring to flipping over when crossing the barrier)* [Breakaway]
4) Did the animation mention any important features? If so, what?
   a) Ex. Massive barrier dividing field [Breakaway]

10.2 Bus Trip to HFL

On the way back to HFL consider the following and enter them into your notebook:

1) Do not panic that you do not have the foggiest idea how the robot can be built.
2) Review the kickoff questions with others on the bus.
3) Think of ways you would play the game as if you were the robot

Back at HFL we will be having a working lunch by watching the video again in our alliance groups/teams that were defined before the kickoff meeting. This organization will be determined by the team captains.

10.3 Kickoff Meeting

When watching the game animation, consider the following and write responses in your notebook:

5) What ways can you score?
   c) Point values for each possible action?
      1. Autonomous
         Ex. Scoring into top basket for 2x points [2012-Rebound Rumble]
      2. Tele-Op
         Ex. Scoring Frisbees into the middle goal [2013-Ultimate Ascent]
      3. Endgame
         Ex. Mini bot racing up pole [2011-Logo Motion]
   d) Risks involved?
      1. *Ex. Potential damage from trying to climb the pyramid* [2013-Ultimate Ascent]
6) What important rules were mentioned in the game animation?
   b) *Ex. No pinning (contact for excess of 5 seconds)* [2012-Rebound Rumble]
7) Were there any implied or explicitly stated suggestions? If so, what were they?
   c) *Ex. Robot that shoots baskets* [2012-Rebound Rumble]
   d) *Ex. "… wise teams will design robots that can right themselves in case this happens…" (referring to flipping over when crossing the barrier)* [Breakaway]
8) Did the animation mention any important features? If so, what?
   b) Ex. Massive barrier dividing field [Breakaway]

10.4 Bus Trip to HFL

On the way back to HFL consider the following and enter them into your notebook:

1. Do not panic that you do not have the foggiest idea how the robot can be built.
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3. Think of ways you would play the game as if you were the robot

Back at HFL we will be having a working lunch by watching the video again in our alliance groups/teams that were defined before the kickoff meeting. This organization will be determined by the team captains.

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11 INSTRUCTIONS: GAME OBJECT-SCORING ANALYSIS

11.1 Analysis Start

1. First things first: Introduce all members of the alliance team
2. READ THE GAME MANUAL TO YOUR ALLIANCE TEAM

11.2 Match Timing

Define a match time allocation for:

1. Autonomous
2. Tele-operation
3. Endgame (it there is one)

For example (2019 Deep Space):

Start Autonomous:	***T = 150 sec***
Start TeleOp:	***T = 135 sec***
Start End game warning:	***T = 30 sec***
Start End Game:	***T = 20 sec***

Autonomous: 15 sec; Teleop: 115 sec; End Game: 20 sec

11.3 Game Objects and Quantity

List game objects and quantity for game

For example (2019 Deep Space)

1. ***Game Objects***
   a. ***Hatch (19in Disk with 6in hole in center)***
   b. ***Cargo (13in ball)***
2. ***Alliance Quantity***
   a. ***11 Hatches for Human player***
   b. ***6 Cargo for Human player, 6 in Depot***

11.4 List Scoring Values

1. Autonomous
2. Teleop
3. End Game
4. Ranking points

For example: (2019 Deep Space):

1. ***Autonomous***
   a. ***Passed HAB line and from HAB Level 2: 3pts***
   b. ***Passed HAB line and from HAB Level 2: 6pts***
   c. ***Hatch scored: 2pts***
   d. ***Cargo scored: 3pts***
2. ***Teleop***
   a. ***Hatched scored: 2pts***
   b. ***Cargo scored: 3pts***

3. ***End Game***
    a. ***HAB Level 1: 3pts***
    b. ***HAB climb Level 2: 6pts***
    c. ***HAB climb Level 3: 12pts***
4. ***Ranking***
    a. ***Win game: 2 ranking pts***
    b. ***Tie game: 1 ranking pts per alliance***
    c. ***Complete rocket (6-Hatches, 6-Cargo): 1 ranking pt***
    d. ***HAB climb (Alliance 15pts or greater): 1 ranking pt***

11.5 Scoring Complexity

List scoring opportunities by height level.

For example (2019 Deep Space):

Complexity Level 1: Cargo Ship - both Hatch and Cargo => 1ft-7in (center)
Complexity Level 2: Rocket (Level1) - both Hatch and Cargo: 2ft-31/2in center from floor
Complexity Level 3: Cargo Ship - Cargo => 2ft-71/2in bottom of opening; 4ft top of opening
Complexity Level 4: Rocket (Level2) - both Hatch and Cargo => 4ft-71/2in center
Complexity Level 5: Rocket(Level3) - both Hatch and Cargo => 6ft-111/2in

Complexity HAB Level 1 => 3in with ramp
Complexity HAB Level 2 => 6in from Level 1
Complexity HAB Level 3 => 19in from Level 1

11.6 Scoring Opportunities

List all scoring opportunities, quantity for each game object, and scoring cycles.

For example (2019 Deep Space):

1. ***Hatch***
    a. ***Rocket-6x2, Cargo Ship-8 => 20 opportunities x 2pts = 40pts***
    b. ***20 cycles***
2. ***Cargo***
    a. ***Rocket-6x2, Cargo Ship-8 => 20 opportunities x 3pts = 60pts***
    b. ***20 cycles***

11.7 Super Alliance Max Score

1. Add up the following:
    a) All the ranking points
    b) All the scoring opportunities
2. How many cycles are required for this score

For example (2019 Deep Space):

1. ***Ranking points***
    a. ***Winning Match = 2 Ranking pts***
    b. ***Complete a Rocket = 2 Ranking pts (2 rockets)***
    c. ***End game = 1 Ranking pt (robots on level 2 and 3)***
2. ***Autonomous***
    a. ***1 Bot over HAB line, 2 Bots over HAB line and from HAB Level 2 = 15pts***
    b. ***Score 3 Hatches-6pts and 3 Cargo-9pts = 15pts***

3. ***TeleOp***
    a. ***Score 20 Hatches = 40pts***
    b. ***Score 20 Cargo = 60pts***
4. ***End Game***
    a. ***3 bots at Level 3 = 36pts (Really-more like 1 Bot at Level 3 and 2 Bots at Level 2-24pts)***

Total Score

a. ***5 Ranking Points***
b. ***136 Hatch/Cargo/End Game points***

TeleOp Scoring Cycles

a. ***Hatch - 20 cycles and Cargo - 20 cycles => 40 cycles/3 teams ~13 cycles each team***

11.8 Regional Event Team Type

Determine Regional Event Final Team Type scoring cycles capability

1. Captain Team
2. 1st Pick Team
3. 2nd Pick Team

For example (2019 Deep Space)

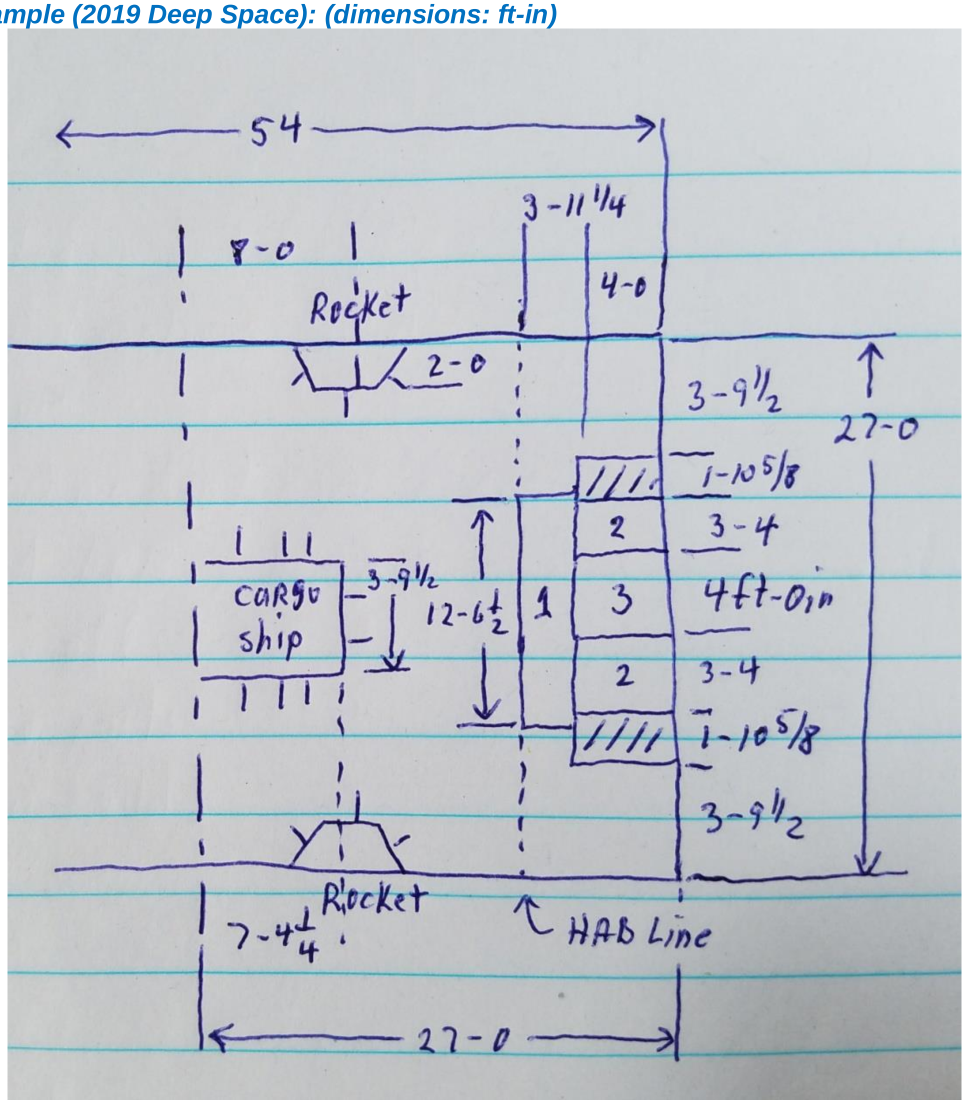
1. ***Captain Team - Cycles per match => ~ 60% of Super Team => 13 x .6 ~ 8 cycles per match***
2. ***1st Pick Team - Cycles per match => ~ 50% of Super Team => 13 x .5 ~ 6 cycles per match***
3. ***2nd Pick Team - Cycles per match => ~ 30% of Super Team => 13 x .3 ~ 4 cycles per match***

12 INSTRUCTIONS: GAME STATEGY PLAN

12.1 Game Playing Field

Make a diagram of the Playing field showing all game elements with dimensions.

For example (2019 Deep Space): (dimensions: ft-in)



12.2 Robot Travel Paths

Make a table of robot travel distances from game acquire element to game score element.
Calculate travel time. Assume robot speed to be 10ft/sec.

For example (2019 Deep Space):

Left load station to left rocket near side: (17.5 ft) / (10 ft/sec) ~ 1.8 sec x 2 = Total Travel Time
Left load station to left rocket far side: (20 ft) / (10 ft/sec) ~ 2.2 sec x 2 = Total Travel Time
....

Longest distance: Left load station to right cargo last bin: (51 ft) / (10 ft/sec) ~ 5.1 sec x 2 = Total Travel Time

12.3 Robot Acquire-Score Time Allowance

Make a table of robot Acquire-Score time allowance for longest travel distance and Event team type

For example (2019 Deep Space):

TeleOp time 115sec

Longest Distance Total Travel Time	4 cycle Team	6 cycle Team	8 cycle Team
10.2 sec	27.2 sec	19.2 sec	13.6 sec
Aquire-Score Time	17.0 sec	9.0 sec	3.4 sec

Note: CycleTime = TeleOp / #Cycles; Acquire-Score Time Allowance = Cycle Time - Total Travel Time

Max acquire and score time approximately acquire-score allowance / 2

12.4 Robot Game Strategy Opportunities

Develop game strategies for Autonomous, TeleOp, and End Game.

1. Develop strategies. Strategies should be listed from SMIPLEST TO MOST COMPLEX.
2. Develop strategies for 4, 6, 8 cycle teams
3. For each strategy determine game score for a team

For example (2019 Deep Space):

1. ***Robot Game Strategies - Autonomous***
   a. ***Move past HAB from level 1 - 3 pts***
   b. ***Move past HAB line from HAB level 2: 6 pts***
   c. ***After HAB line move, move to Cargo ship and place Hatch on front: 5 pts***
   d. ***Move, place Hatch, then get a Hatch from load station and move to Cargo ship bin 3: 2 pts***
   e. ***Team Points: 3 to 13***
2. ***Robot Game Strategies - TelOp***
   a. ***Score just Hatches Complexity Level 1(5 Opportunities - 3 Opportunities used in Auto): Team points - 8 to 16 points***
   b. ***Score just Hatches Complexity Level 1-2-3(9 Opportunities - 3 Opportunities used in Auto): Team points - 8 to 16 points***
   c. ***Score just Cargo Complexity Level 2-3(12 Opportunities): Team points - 12 to 24 points***
   d. ***Score half Hatches/Cargo Complexity Level 1-2-3(10 points to 20 points)***
   e. ***Alliance Strategy(Rocket Ranking point): TeamA(4cycles - Rocket Level 3; 2-hatches, 2-Cargo[10pts] / Rocket TeamB(4cycles - Level 2; 2-Hatches, 2-Cargo[10pts] / TeamC(4cycles - Rocket Level1(2-Hatches, 2-Cargo[10pts]): Alliance points - 30pts/1 Ranking pt***
3. ***Robot Game Strategies - End Game***
   a. ***Drive up onto HAB Level 1: 3 pts***
   b. ***Drive up onto HAB level 1 and then climb to Level 2: 6 pts***
   c. ***Drive up onto HAB level 1 and then climb to Level 3: 12pts***

d. ***Team Points: 3 - 12 pts (If another team gets to Level 2, the alliance gets a Ranking point)***

12.5 Your Team Game Strategy

Your robot can do five (5) cycles. Develop your game strategy for Autonomous, TelOp, and End Game. Report on your Team Score.

For example (2019 Deep Space)

1. ***Autonomous (Team Score - 11 pts)***
   a. ***Pass HAB line from Level 2 - 6 pts***
   b. ***Move to front of Cargo Ship and place Hatch - 2 pts + present Cargo 3pts***
   c. ***Move to Left or Right Load Station and get a Hatch. Then move to backwards to farthest bin of Cargo Ship***
2. ***TeleOP (Team Score - 5 Cargo = 15 pts)***
   This strategy is based on scoring Cargo. Our team is expecting other teams put on Hatches. For equal teams we have an Alliance combined 15 cycles - just hatches = 30 pts. For eight Hatches and seven Cargo = 37 pts. There are nine Level 1 Hatch and Cargo scoring opportunities.
   a. ***There are six Cargo in the Depot. Robot will pick up Cargo from Depot. The robot shall also be capable of getting Cargo from the Load Station.***
3. ***End Game (Team Score - 12 pts + 1 Ranking point)***
   a. ***At End Game time our robot will move to HAB level 1 and then climb to Level 3 - 12 pts***

12.6 Team 2228 Review

The RED and BLUE Alliance teams as a group review Game Strategy calculations and develop Team 2228 game strategy. Team 2228 game strategy process:

1. Round robin of teams to provide game data. This would be best collected on a spread sheet for the Engineering Notebook.
2. Red team provides their game strategy for Autonomous. Other teams then add/subtract/new strategy.
3. Blue team provides their game strategy for End Game. Other teams then add/subtract/new strategy.
4. Flip coin for teleOp game strategy for TeleOp. Other teams then add/subtract/new strategy.
5. Consolidated of game strategy is completed on Sunday.

13 INSTRUCTIONS: ROBOT REQUIREMENTS

13.1 Robot Requirements Process Steps

1. Complete Team 2228 game strategy.
2. For Autonomous/TeleOp/End Game develop a sequential list of steps the robot has to perform to execute the strategy
3. Strategies should be developed from easiest to hardest if there are multiple versions of a strategy.

13.2 Strategy Sequence Chart Instructions

In developing a robot strategy sequence chart words used matter. ***Use words(VERBS) that translate to mechanism functions (e.g. Raise/Lower, throw, pick up, climb, draw in, push/retract, catch, etc)***

For example (2019 Deep Space):
Autonomous strategy:

1. ***Robot Game Strategies - Autonomous***
   a. ***Move past HAB from level 1 - 3 pts***
   b. ***Move past HAB line from HAB level 2: 6 pts***
   c. ***After HAB line move, move to Cargo ship and place Hatch on front: 5 pts***
   d. ***Move, place Hatch, then get a Hatch from load station and move to Cargo ship bin 3: 2 pts***
   e. ***Team Points: 3 to 13***

Autonomous strategy sequence chart

STEP	***Sequence Description***
	We have 15 sec for this
1	***Put Hatch on robot. At autonomous start driver drives robot forward off of level 1 HAB toward Cargo Ship front. (2 sec)***
2	***Driver lines up robot with left or right bin and moves forward and presses Hatch to bin to attach Hatch to bin (2 sec)***
3	***After attaching Hatch driver drives backwards, rotates, and drives to nearest load station (5 sec)***
4	***Driver to line up robot to load station and drive forward to the load station pressing a Hatch to the robot (2 sec)***
5	***At load station grab Hatch and secure to robot at the correct height to score at a Level 1 Cargo Ship bin (3 sec) Ding-Ding [TeleOp has started]***
6	***Driver then drives robot straight backwards to Cargo ship, rotates 90 degrees and lines up to Cargo Ship bin. (5 sec)***
7	***Driver then moves forward to bin and presses Hatch to Cargo bin***
8	***Time for this sequence is 15 sec***

13.3 Team Robot Module Functional Specification

The robot has 3 major mechanical modules: Drive Base - Acquisition - Action(scoring). For each mechanical module define all the functions the module has to perform in Autonomous - TeleOp and End Game. The strategy time allowance should also be stated. This should list functions from simplest to hardest.

For example (2019 Deep Space):

1. ***Drive base Module***
   a. ***Drive base needs to move forward/backwards***
   b. ***A camera on the front and on the back is needed for the driver to see where the robot is going. The camera should have a vertical center line to help the driver line the robot up with game objects***
2. ***Acquisition Module***
   a. ***A garbing and orienting mechanism is needed to obtain a hatch from the load station***
3. ***Action Module***
   a. ***A pressing mechanism is needed to press a Hatch to a scoring object at level 1 on the Cargo Ship***

Repeat this for TeleOp and End Game and combine into one functional specification.

13.4 Robot Concept Path Forward

1. From the functions needed by the acquisition and action module the team should determine what kind of drive base to build. (Note: 95% of world champions have used a 6 wheel drive base.)
2. Plan teams to develop acquisition and action concepts.

14 INSTRUCTIONS: CONCEPT DEVELOPMENT

14.1 Robot Requirements and the Game Object

1. From the design specification review requirements (Functions & Constraints) for your general robot module.
2. What is the cycle time for the module?
3. Review the characteristics of the Game object. ***[IT IS ALL ABOUT THE GAME OBJECT].*** What are the best game object characteristics to use that fit to the functions required? Document the game object dimensions.

14.2 Module Concept Development Process

1. Technical team groups requirements to robot model modules.
2. Split the technical team into three or four research groups with respect to the 3 main modules on the robot (i.e. Chassis module, Acquisition / Orientation module, Execution module).
3. STUDY THE GAME OBJECT for characteristics that can be used to constrain the game object in acquiring, orienting and perform actions on the game object. **(It's all about the game object!!!)**
4. Each research member should develop a concept on paper. The concept includes: 1) Description of the module function, 2) A SKETCH, and 3) A concept assessment - SWOT analysis.
5. Review all concepts.

14.3 Convergent Thinking

1. Have you ever seen someone else accomplish the function or a similar function? (e.g. Frisbee thrower == baseball thrower) ***[DO NOT RE-INVENT THE WHEEL!!]***
2. You are the best robot. Physically go through the actions to perform the functions required.
3. What motion is required? (e.g. Rotary, Linear)
4. Does the action fit a mechanism type? (e.g. elevator, conveyor, arm)
5. What type of energy device is needed to accomplish the function? (e.g. motor, pneumatic cylinder, spring)
6. Is the game object constrained at the end of the function? (i.e. Is the game object oriented correctly for the next operation on the game object to occur without failure)
7. Using isometric paper DRAW A PICTURE. ***[IF YOU CANNOT MAKE A PICTURE THE MECHANISM YOU CANNOT BUILD IT!]***

14.4 Concept Documentation

1. Document the function to perform
2. A PICTURE OF YOUR CONCEPT.
3. SWOT Analysis of your Concept
4. Unanswered questions about your concept

14.5 Concept Analysis (SWOT Analysis)

SWOT Analysis

S-Strengths: Does concept meet the address the needs of the function?
Are the constraints of the function addressed?

W-Weaknesses: What are the limitations of the concept?

O-Opportunities: Can the concept do more than one function?

T-Threats: How can the concept fail? - Can you overcome the failure?

Engineering SWOT Analysis (For Robot Concept Development)

Description of Module operation

S-Strengths:

- Does concept meet function requirements
- Is the concept simple?
- Does the concept meet FIRST robot design constraints?
- Is the control concept simple? (Few parts)
- Does the concept have a small weight?
- Is the concept easy to build? To maintain?
- Is there tolerance adjustability in the design?
- Will concept be reliable? -- PERFORMS SAME OPERATION EVERY TIME

W-Weaknesses:

- What parts of the required function are not addressed?
- Do we have learn new technology?
- Does the concept require complex controls?
- Does the concept require a complex mechanical system?
- Did you use gravity as a process control?
- What don't we know about the concept?
- What do we have to prototype? How long will it take?
- What does the prototype have to prove?

O-Opportunities:

- HAVE YOU SEEN A SIMILAR CONCEPT BEFORE?
- Have you done pizza dough thinking?(What ifs)
- Can the concept do several functions?
- Can parts of this concept integrate into another concept
- Think of an opposite concept – For example: (typewriter moved carriage - today's printers move print head)

T-Threats:

- HOW CAN THE CONCEPT FAIL?
- Is the game object always constrained?
- How can you overcome weaknesses?
- How can you overcome concept failures?
- If broken in competition, can we fix it quickly?

Main Questions:

1 HAVE YOU SEEN A SIMILAR CONCEPT BEFORE?
2 IS CONCEPT RELIABLE – PERFORMS THE SAME OPERATION EVERY TIME
3 WHAT IS THE CYCLE TIME OF THE OPERATION
4 HOW CAN THE CONCEPT FAIL?