

# QFD

TEAM 3641 – The Flying Toasters

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Jan 2013

[theflyingtoasters.org](http://theflyingtoasters.org)



# How to make better Toast: **Toaster Engineering**

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Ron Weber

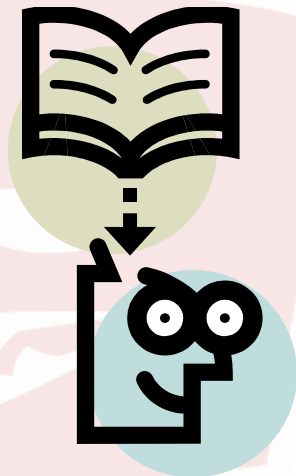
May 2012

[theflyingtoasters.org](http://theflyingtoasters.org)



# Sources

- “Tops Shops”
  - Robert Wilson & John Linscott
- “How Useful is QFD?”
  - John L Sanford – Thunderhawks – Team 1038
- Special Thanks to
  - Ed Debler
    - Thunder Chickens – Team 217
    - The Flying Toasters – Team 3641



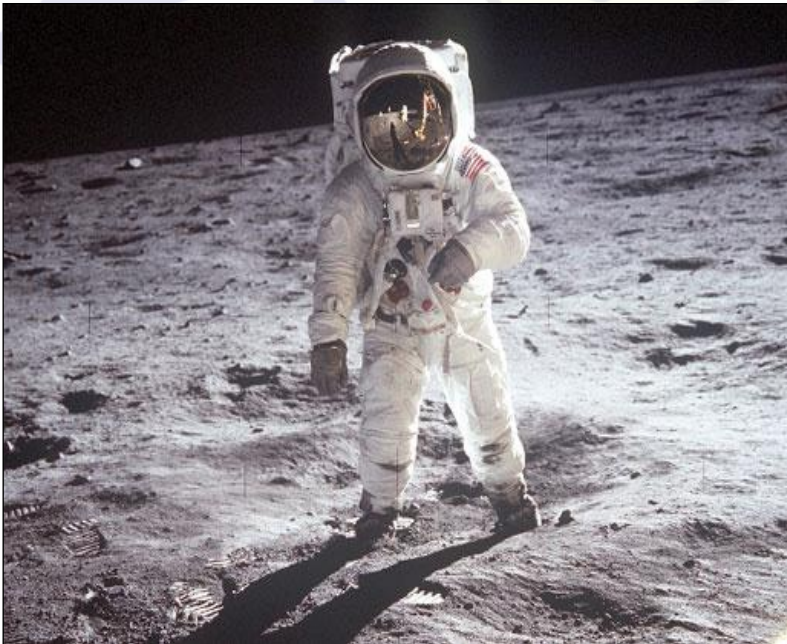
# Topics

- Systems Engineering
- Toaster Design Process:
  - QFD (Quality Function Deployment)
- Q & A

# Systems Engineering

The Internet

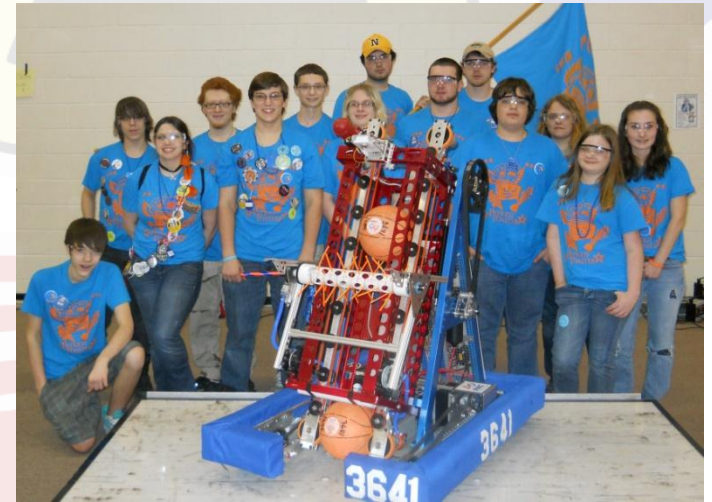
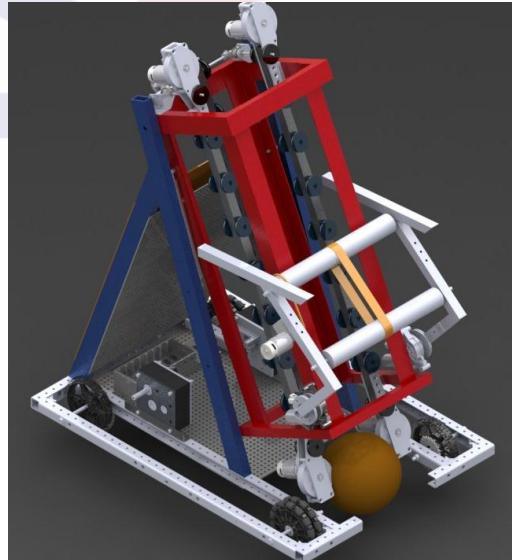
- How do you accomplish the following?
- Where do you start?





# Systems Engineering

- > How do you accomplish the following?
- > Where do you start?



# Systems Engineering

- Systems engineering is the branch of engineering concerned with the development of large and complex systems, where a system is understood to be an assembly of combination of interrelated elements of parts working together toward a common objective.

-University College London





# QFD

## EXHIBIT I

### Startup and preproduction costs at Toyota Auto Body before and after QFD

January 1977  
Pre QFD



April 1984  
Post QFD  
(39% of pre QFD costs)

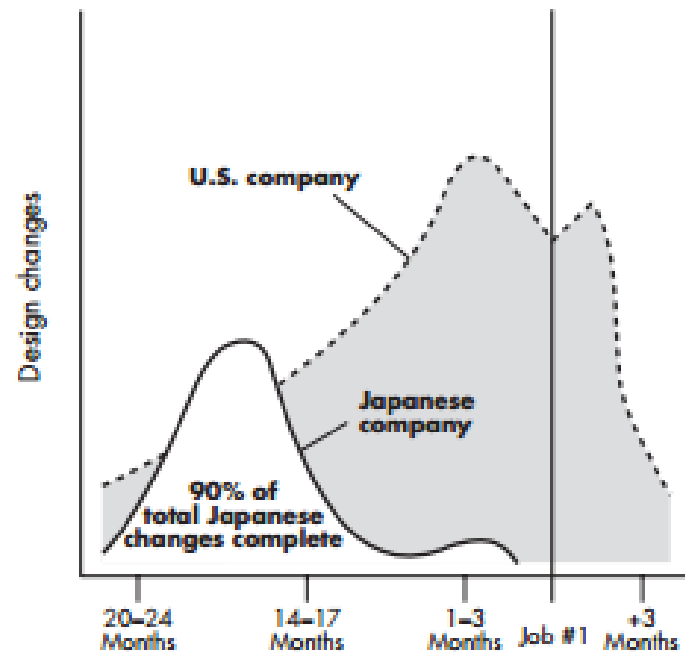


- Preproduction costs
- Startup costs



## EXHIBIT II

### Japanese automaker with QFD made fewer changes than U.S. company without QFD

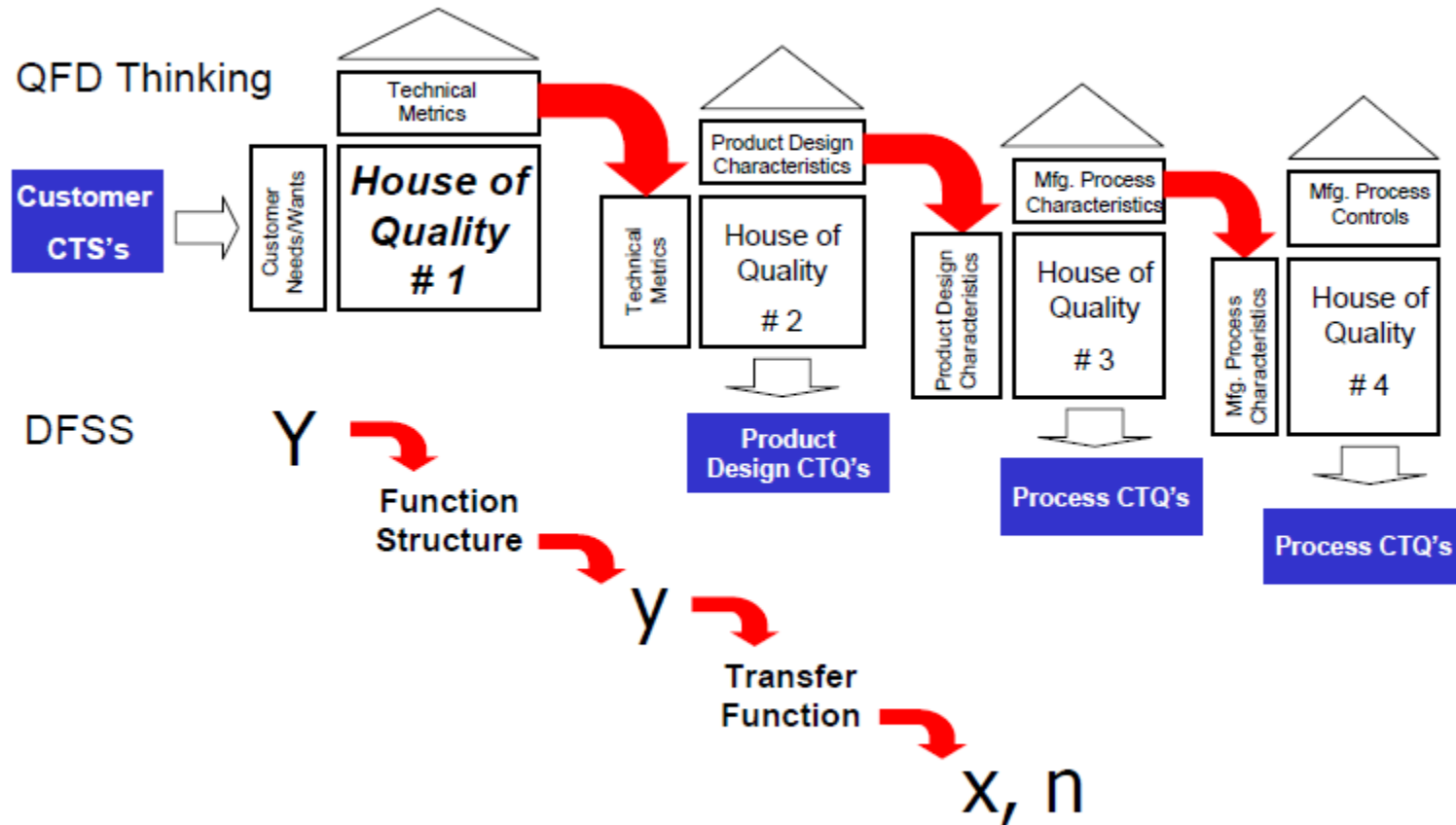


# QFD

## Getting to a Transfer Function



Design for Six Sigma



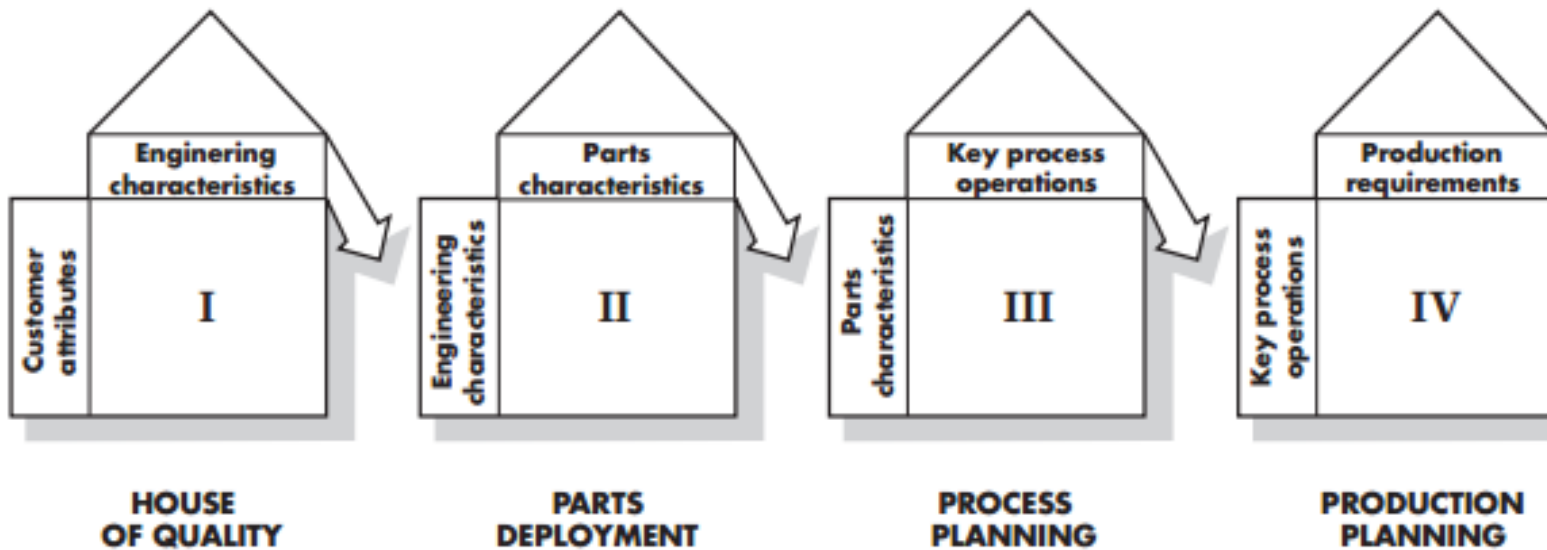
DFSS provides an approach for rigorously capturing the relationships shown in QFD in the form of a transfer function

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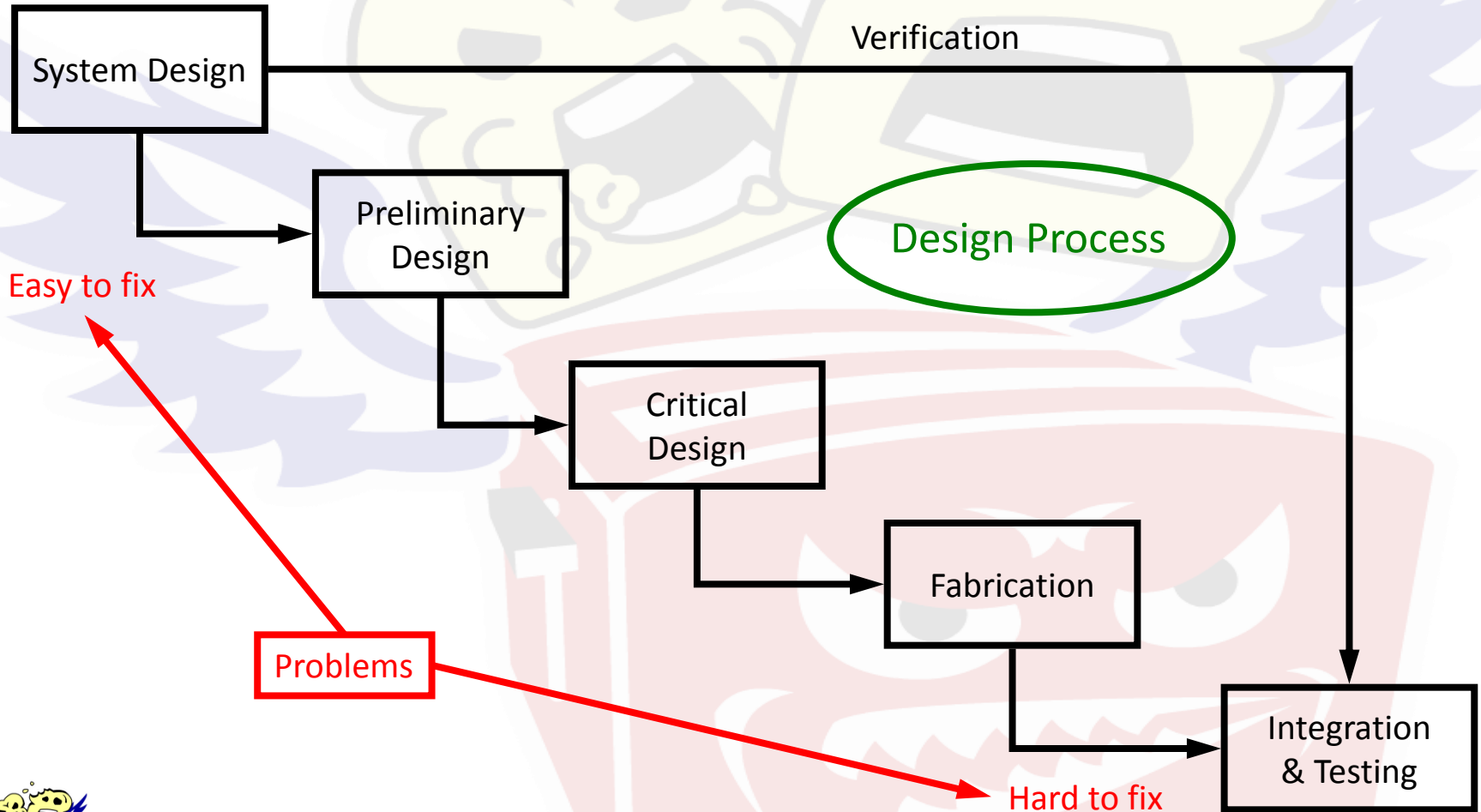
# QFD

## EXHIBIT XI

Linked houses convey the customer's voice through to manufacturing



# Systems Engineering



*Think and plan BEFORE you act!*

# Toaster Design Process

(QFD) Quality Function Deployment

- > A scientific method to integrate design and strategy
  - > Pioneered by Yoji Akao at Mitsubishi

WHAT

HOW

Relationship between WHAT & HOW

Difficulty rating: Impact vs Effort

Strategic Importance  
Ranked (least) 1-5 (most)

Capabilities and features	HOW																											
	Strategic importance	Accurate autonomous	Speed of autonomous	Multiple openings	Extended	Punch/kick 2x ball	Grab/hold 2x ball	Stuff the goal with the 2x ball	Head multiple balls	Control and move 2x balls through narrow opening	Pick up and hold bonus balls	Pick up and hold small balls	Ability to throw balls	Control/kick with short goal	Hook up at 18-foot bar and support weight/robot	Ability to spread out the robot	Climb variable heights (6 inches or 12 inches)	Operator friendly controls	Driving speed	Drive torque	Traction	Immovable	Maneuverability	Durability	Serviceability			
Release balls first	3	⊙	○	○	○								△						○			△		△				
Uncap 2x ball from goals	5					○	○						△		○													
Control 2x ball	3	○	○	○		△								⊙					○	△	○		△	△	△			
Deliver balls to the shooter	5								⊙	○	○	○				△			○					△	△			
Cap 2x balls into goals	4				⊙		⊙								△									○				
Moving small balls to your side	5								⊙	○	○	○				△			△	△				△	△			
Chin-up (50 points)	4				⊙									⊙	⊙	⊙					⊙	○	⊙	⊙	⊙			
Dominant all space under chin-up bar (keep others away)	2				△									△	△	△					⊙	⊙	⊙	⊙	⊙			
Be able to get onto the platform	4														△							⊙	⊙	⊙	⊙			
Be aggressive in playing field quickly	5		○	○													⊙	⊙	⊙	⊙	○							
Unscore stuffed cap	3				⊙	○	○	○							△					○								
Control 2x balls	4	⊙	⊙	⊙	⊙	△	○	○							△										△			
Block opponent's goal	3	○	○	⊙	⊙	⊙	⊙	⊙																				
Block opponent's doggy door	1	△	△	⊙												○				○	○	○	○		⊙			
Be reliable	5																								⊙	⊙		
Control bonus balls	1	⊙	⊙	⊙	⊙			○				⊙	○															
Difficulty rating (impact vs. effort) 5 = high impact/low effort																												
Absolute importance (score)																												
	59	58	78	126	37	82	36	65	50	38	18	18	34	34	68	114	45	47	85	32	94	72	25					
Relative importance																												
	4.2%	4.1%	5.5%	8.9%	2.6%	5.8%	2.5%	4.6%	3.5%	2.7%	3.7%	3.4%	1.3%	3.7%	2.4%	4.8%	8.0%	3.2%	3.3%	6.0%	2.3%	6.6%	5.1%	1.8%				



Objective: Take the guess work out by assigning values in an organized fashion.

# Toaster Design Process

1. Watch the Kickoff Video (fill out worksheets)
2. Read and Understand the Rules (fill out worksheets)
3. Simulate the Game (fill out worksheets)
4. Determine Strategic Importance (Scoring Opportunities & Necessary Attributes)
5. Brainstorm Robot Capabilities and Features
6. Determine Strategic (Scoring Opportunities & Necessary Attributes) vs Capabilities and Features Relationship-QFD
7. Determine Importance of Design Features
8. Brainstorm Whole Robot Concept
9. Check Robot solutions against QFD



*Failure to plan is planning to fail!*



# Toaster Design Process

## 1. Watch the Kickoff Video

- How many ways can you score?
- How many teams are playing?
- How big is the field?
- What objects are on the field?
- What are the penalties?
- What did they say you can't do?
- Use the Kickoff Worksheet.

Team 3643 Kickoff Video Worksheet      Game Name: \_\_\_\_\_

Game Scoring Options						Maximum Possible Points: 200 Points					
SC43	SC44	SC45	SC46	SC47	SC48	SC49	SC50	SC51	SC52	SC53	SC54
Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
Score	Score	Score	Score	Score	Score	Score	Score	Score	Score	Score	Score

• # Team Playing: \_\_\_\_\_ # Robots Playing: \_\_\_\_\_ Home player function: \_\_\_\_\_

• How big is the field: \_\_\_\_\_ feet W x \_\_\_\_\_ feet L      Field Surface: \_\_\_\_\_

Game Objects				Game Pieces				Field Markings			
SC43	SC44	SC45	SC46	SC47	SC48	SC49	SC50	SC51	SC52	SC53	SC54
Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
Score	Score	Score	Score	Score	Score	Score	Score	Score	Score	Score	Score

Team 3643 Kickoff Video Worksheet      Game Name: \_\_\_\_\_

Game Objects					
SC43	SC44	SC45	SC46	SC47	SC48
Value	Value	Value	Value	Value	Value
Score	Score	Score	Score	Score	Score
Use	Use	Use	Use	Use	Use
SC43	SC44	SC45	SC46	SC47	SC48

Game Pieces					
SC43	SC44	SC45	SC46	SC47	SC48
Value	Value	Value	Value	Value	Value
Score	Score	Score	Score	Score	Score
Use	Use	Use	Use	Use	Use
SC43	SC44	SC45	SC46	SC47	SC48

Field Markings					
SC43	SC44	SC45	SC46	SC47	SC48
Value	Value	Value	Value	Value	Value
Score	Score	Score	Score	Score	Score
Use	Use	Use	Use	Use	Use
SC43	SC44	SC45	SC46	SC47	SC48

Team 3643 Kickoff Video Worksheet      Game Name: \_\_\_\_\_

Team Penalties					
TP43	TP44	TP45	TP46	TP47	TP48
Value	Value	Value	Value	Value	Value
Score	Score	Score	Score	Score	Score
Conditions	Conditions	Conditions	Conditions	Conditions	Conditions
TP43	TP44	TP45	TP46	TP47	TP48

What the Rules DON'T Say				Section Referenced	



**Objective:**  
Have a basic understanding of the game.

# Toaster Design Process

## 2. Read and Understand the Rules

- Read the rules aloud
  - “Read” what the rules don’t say
- Discuss the rules
- Analyze the game
  - Create a list of scoring differential opportunities
    - Defense is a ‘scoring’ opportunity
- Fill out the Kickoff worksheet



**Objective:**

Create a list of scoring opportunities.

# Toaster Design Process

## 3. Simulate the Game

- Use robot analogues (you!)
  - Play the game with humans acting it out on full size area
- Make it realistic
  - Limit motion and shorten match times
- Be creative and test out different strategies
- Add more to Kickoff worksheets



*Objective:*

**Dynamically test the game and its nuances**

# Toaster Design Process

A	B	C	D	E
	Scoring Opportunities & Necessary Attributes	Earning Potential	Strategic Importance Rank 1-5 (Most)	Comments
Sample	Minibot	30-20-15-10	5	If a minibot is deployed and reaches the top in time, at minimum you will get 10 points

## 4. Determine Strategic Importance

- **WHAT** do you want to do? **NOT HOW!**
- WHAT are the Scoring Opportunities?
  - (Both Explicit and Implicit)
- WHAT are the Necessary Attributes?
  - (Both Explicit and Implicit)
- Obtain unanimous support or consensus
- Assign strategic importance
  - Scale 1 to 5 (1 = low; 5 = high)



**Objective:**

Assign strategic importance to scoring opportunities.

# Toaster Design Process

	A	B	C	D
1		Capabilities & Features	Difficulty Rating (Impact vs. Effort) 5=High impact/Little effort	Comments
2	Sample	Autonomous	3	Requires a lot of time programming just to get a few points

## 5. Brainstorm Robot Capabilities and Features

- What must your robot do to score points?
  - What must it push? Pull?
  - How fast should it go?
  - What should it manipulate?
  - How high does it need to reach?
  - Autonomous modes?
- Don't get too detailed just yet....Stay General

### *Objective:*

Create a list of possible features that could work for all scoring opportunities: such as autonomous, drive, drive speed, etc.



# Toaster Design Process

## 6a. Determine Strategic vs Design Feature

- Some features work better with different strategies
- Assign a value into the matrix
  - Blank = no relationship
  - 1 = weak relationship
  - 5 = medium relationship
  - 9 = strong relationship

Relationships	
Strong	●
Moderate	○
Weak	▽

Scoring Opportunities & Necessary Attributes (Explicit and Implicit)	Auto Speed	Autonomous	Auto-Target Cycle	Drive over barrier	Drive Maneuverability	Drive reliability	Getting on bridge	Hopper - reload	Kinects	Launching multiple possible	Launching balls	manipulating bridge	Pick up balls from floor	Shifting CG	Tele-op Speed
Auton-Scores	●	●	○		○	○		●	○	○	●		○		
Ball Storage		●	○		○			●			●		●		
Bridges Balance					●	○	●					●		●	●
Co-opertition					●	○	●					●		●	●
Defense Pushing					●	●	○					○		●	●
Extension 14"		●	○	●	○		●				●	●	●	●	
Foul Alley					●	●	▽						●		●
Foul Bridge				▽	●	○	●					▽			



**Objective:**

Fill up the QFD Matrix. Be concise, Be honest, Be analytical.



# Toaster Design

## Process

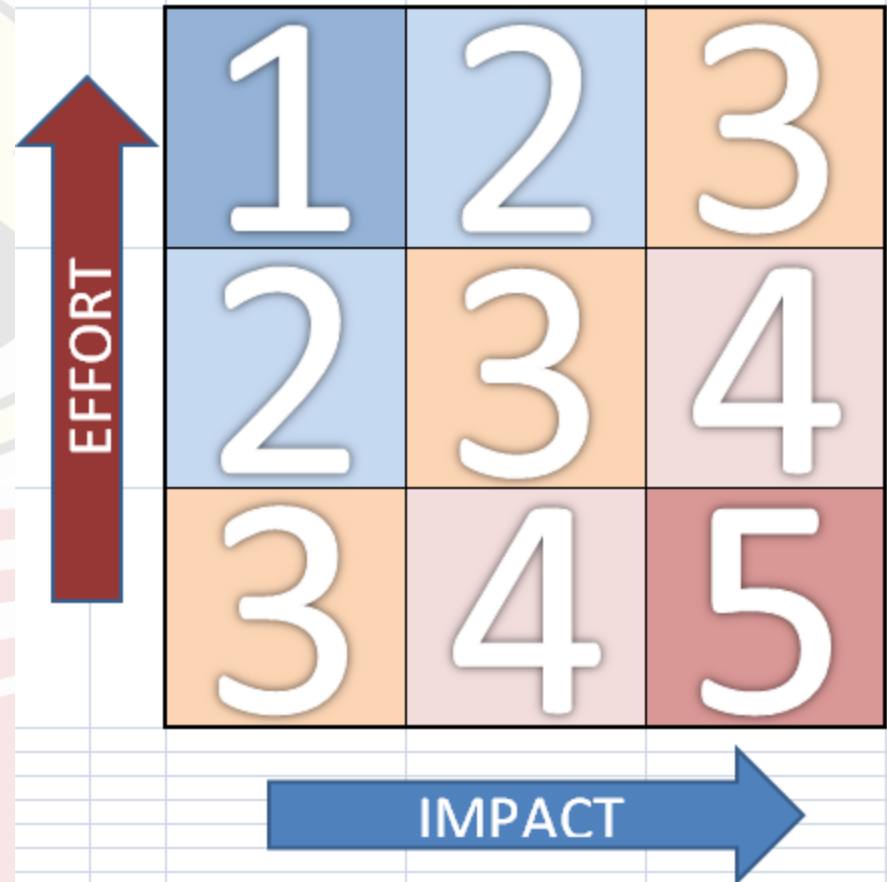
### 6b. Difficulty Rating: Impact vs. Effort

- Rank the impact the item/task will have against the amount of effort it will take to accomplish the item/task.
- Example: If it takes you very little effort but you get a big impact on the robot, then it scores a 5.

*Hint:*

In Nature, energy follows the path of least resistance. You want your successes to take the least amount of effort.

Impact vs. Effort Diagram



# Toaster Design Process

## 7. Determine Absolute Importance of Robot Capabilities & Features

- > The sum of the relationship score \* strategic importance

SUM OF THE RELATIONSHIP SCORE

X

=

STRATEGIC IMPORTANCE

Absolute Importance

Relationships	
● = Strong	5
○ = Medium	3
△ = Weak	1

Capabilities and features	Strategic importance		
	Strategic importance	Accurate autonomous	
Scoring opportunities and necessary attributes			
Release balls first.	3	●	3 x 5 = 15
Uncap 2x ball from goals.	5		
Control short goals.	3	○	3 x 3 = 9
Deliver balls to the shooter.	5		
Cap 2x balls into goals.	4		
Moving small balls to your side.	5		
Chin-up (50 points).	4		
Dominate all space under chin-up bar (keep others away).	3		
Be able to get onto the platform.	4		
Be anywhere in playing field quickly.	5		
Unscore stuffed cap.	3		
Control 2x balls.	4	●	4 x 5 = 20
Block opponent's goal.	3	○	3 x 3 = 9
Block opponent's doggy door.	1	△	1 x 1 = 1
Be reliable.	5		
Control bonus balls.	1	●	1 x 5 = 5
Difficulty rating (impact vs. effort)			
5 = high impact/little effort			
Score (score)	15 + 9 + 20 + 9 + 1 + 5 = 59		59
Relative importance			42%



**Objective:**

Calculate the importance of the design features and prioritize.



# Toaster Design Process

## 8. Brainstorm Whole Robot Concept

- Everyone presents
- Create cartoon concept drawings
- Discuss various mechanisms
- Roughly allocate motors



**Objective:**

Create a cartoon sketch of what the robot will look like

# Toaster Design Process

## 9. Check robot solutions against QFD

- Assess/evaluate each solution against every category in QFD
- Rank on 1-5(best) scale
- See if you can combine top solutions to make even better solutions



### *Objective:*

Make sure the solution chosen will best accomplish what the QFD says as important

# Questions & Answers

