Total Recall

BEST 2010 Design Contest

Game Specific RULES

Version 1.2

August 23, 2010

Boosting Engineering, Science & Technology™

BEST Game Specific Rules
ACMR00006 Revision 1.2; August 23, 2010

1.0 Introduction

BEST Inc. has decided to produce and market unique products for two emerging industries[1]. To compete in the world market, our production facilities must incorporate the most advanced robotic control systems available today. BEST Inc. has decided to build four initial factories and contract with suppliers to develop the robotic control systems. Suppliers are asked to propose and demonstrate strategic processes that will result in a production facility yielding the highest quality products given the constraints of the factory. BEST Inc. is looking for suppliers with good track records in quality improvement methodologies such as Total Quality Management, Kaizen, Zero Defects, Six Sigma, and Poka Yoke with an ability to incorporate these approaches into their overall production strategy.

As a key supplier of robotic control systems, your team has been selected to compete in trial production runs in all four factories in order to determine which system and strategies will be implemented. You will have six weeks to develop your factory strategies and design a working prototype robotic control system. Factory constraints require that the systems be limited to 24 inches on a side, have a total weight no greater than 24 pounds and meet all construction requirements[2] of BEST Inc. Trial production runs will begin in October and your team's results will be compared against other suppliers in a head-to-head competition at that time. As part of your development, it will be imperative that you provide complete technical documentation for evaluation by BEST Inc. management; you are strongly encouraged to provide a marketing plan and exhibit materials as well. In addition, we will be conducting interviews of your design team to learn the key advantages of your proposal. We look forward to your proposal and participation in the trials. Good luck!

2.0 Objective

Teams are tasked with performing product manufacturing operations on two independent production lines. The object is to successfully process and package as much "good" product as possible while striving for Six Sigma[3] quality levels on each production line. Some products may be identified as "defective" and will be "recalled". These defective products should be removed from the production floor and returned to the manufacturer.

Production Line	Type of Production	Product
Gadget Line	Partially Automated	Gadgets
Gizmo Line	Fully Automated	Gizmos

[1] An industry, usually formed by a new product or idea that is in the early stages of development.

[2] See BEST Generic Game Rules for information on robot construction requirements.

[3] Six Sigma is a business strategy that seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes.

2.1 The "Gadget" Production Line

The gadget production line is a partially automated line used to produce high quality gadgets for the "Over 65" recreational industry. It is intended for large scale production, processing a high volume of products in a short time-frame. Gadget production consists of test and inspection of an incoming Original Equipment Manufacturer (OEM) product (gadget) to ensure that it meets the strict production quality standards of BEST Inc., followed by packaging of the product for shipping to the customer (see Figure 1). There are three gadget OEMs providing product to BEST Inc.; a particular product can be tracked to an OEM through its designated color.

It has been determined through past experience that some gadget OEMs will deliver defective products. Automated test methods are employed through a special gadget scanning tube (GST) to identify OEM products that are defective. If an OEM provides defective products, a product recall is initiated and these defective products must be removed from the production floor and returned to the product recall center; further use of product from the identified OEM should be eliminated for the remainder of the production shift. Factory robots may determine which products are defective by interfacing with the Factory Data Port.

The gadget production line often encounters congestion at the beginning of a production shift due to product remaining in the process "pipeline". This can be resolved through a "line reset" by one of the factory robots. A line reset is accomplished by moving the mobile recall trailer to its docking position at the gadget pack and ship center.

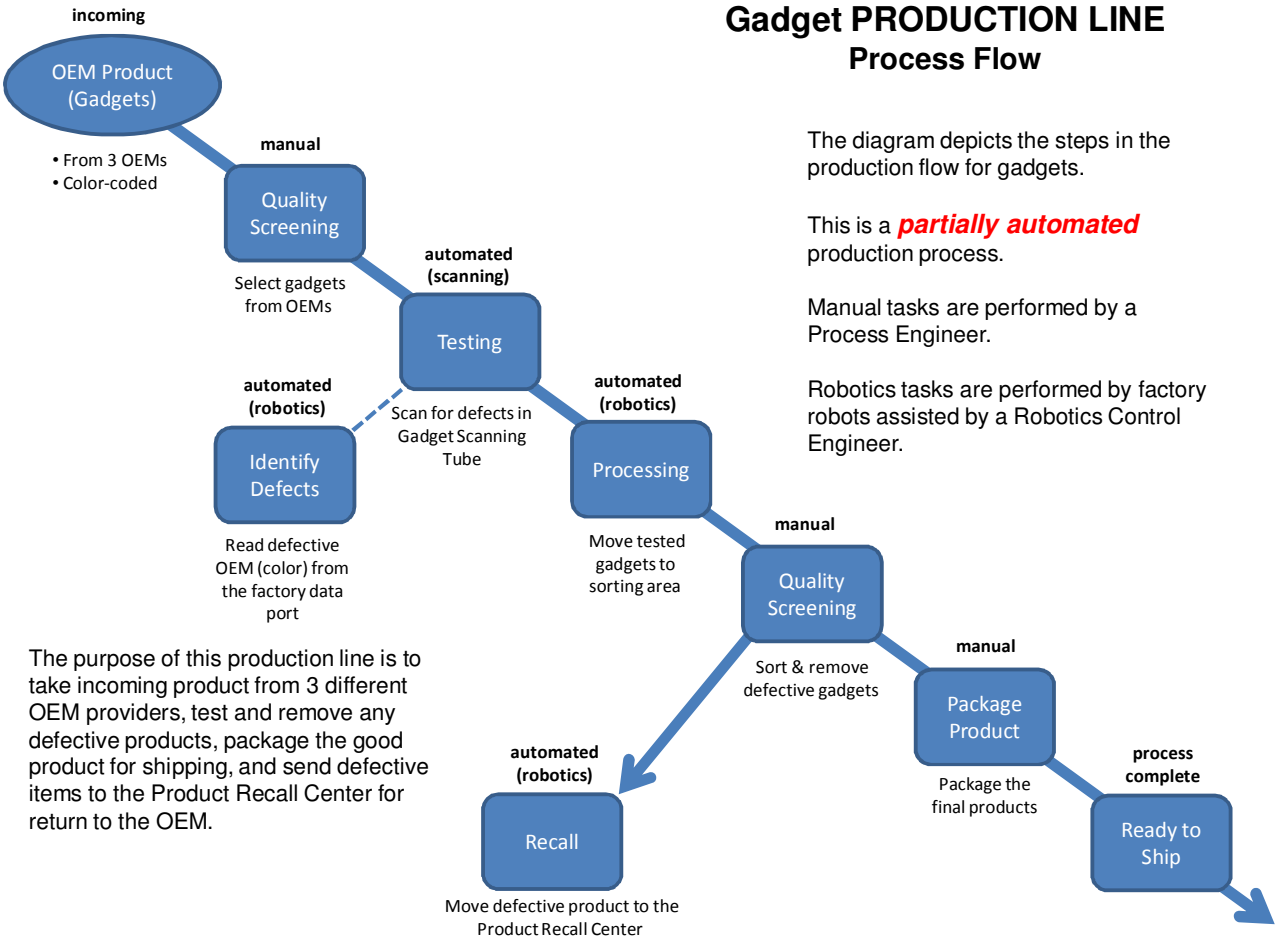


Figure 1. Gadget Production Line Process Flow

2.2 The "Gizmo" Production Line

The Gizmo Production Line is a fully automated line used to produce high quality gizmos for the pre-adolescent hunting industry. BEST Inc. uses a single gizmo manufacturer and therefore the quality screening of these parts is of significant concern. Factory robots are used to accomplish defect screening as quickly and accurately as possible. Because of the advanced technology used in these products, only a small number of gizmos are produced during a single production shift.

Gizmos are manufactured using the most advanced nano-technology in order to yield the best possible product. However, process variation has the potential to cause latent defects[4], which manifest themselves in the form of a change in the magnetic properties of the gizmo. Only BEST robots have the potential to detect this unique fault which may

[4] A latent defect is a fault in the product that could not have been discovered through reasonable thorough inspection.

be indicated by either full magnetism or no magnetism. Factory robots will be equipped with specialized instrumentation for detecting and distinguishing the magnetic properties of gizmos. Gizmos with defects of this type are not repairable and, unlike gadgets, will not be returned to the manufacturer; they will simply be scrapped. Figure 2 shows the process flow for the gizmo production line.

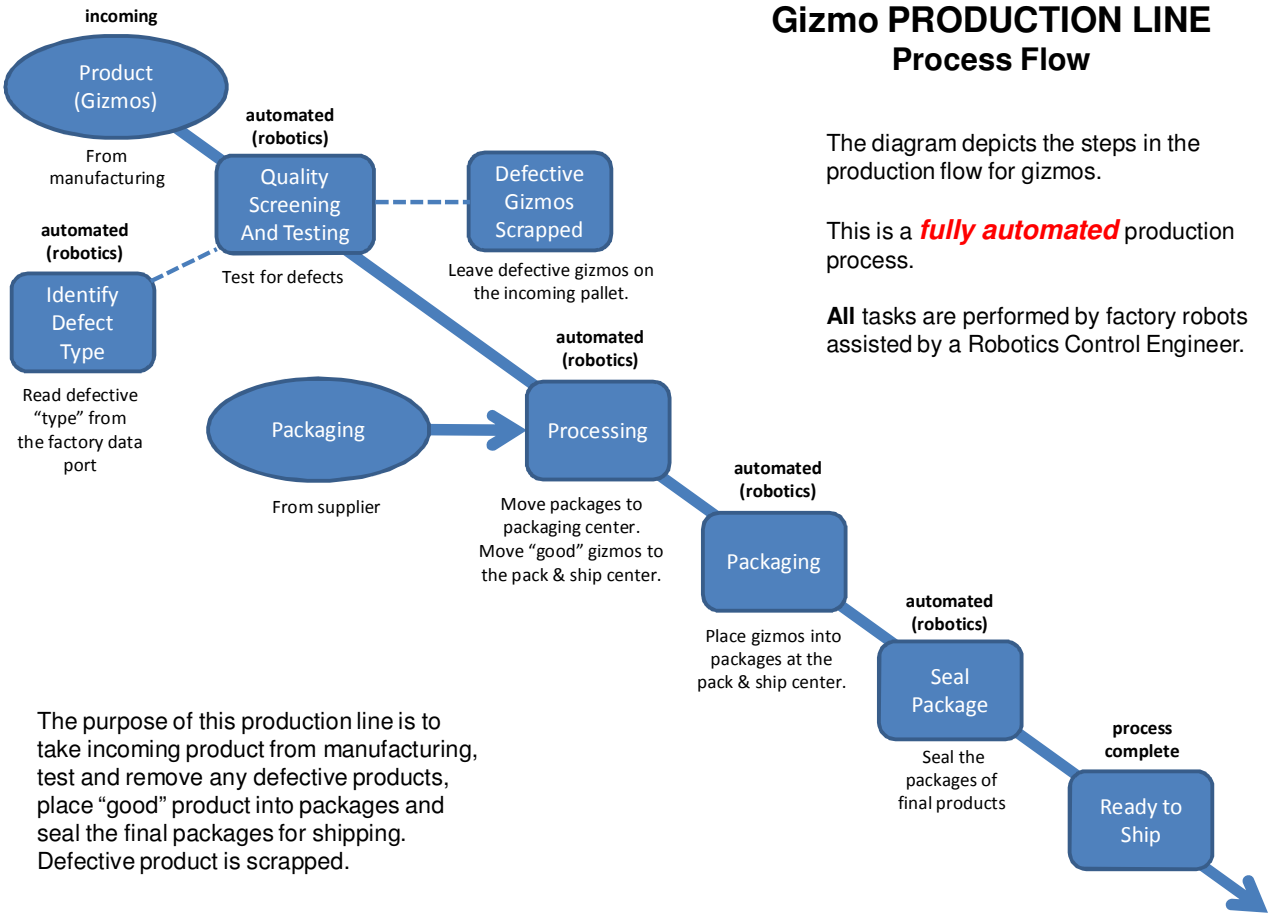


Figure 2. Gizmo Production Line Process Flow

3.0 The Production Facilities (Game Field) Description

The game field is approximately 23 ½ feet by 23 ½ feet and is arranged as shown in Figure 3 and Figure 4. The field is divided into four identical quadrants, designated as "factories". Each factory consists of an automated production floor and a manual processing center. A robot may move about its production floor freely and manipulate the objects within its designated factory under the control of a Robotics Control Engineer. A Process Engineer will reside within each to perform the manual processing tasks associated with the Gadget Production Line.

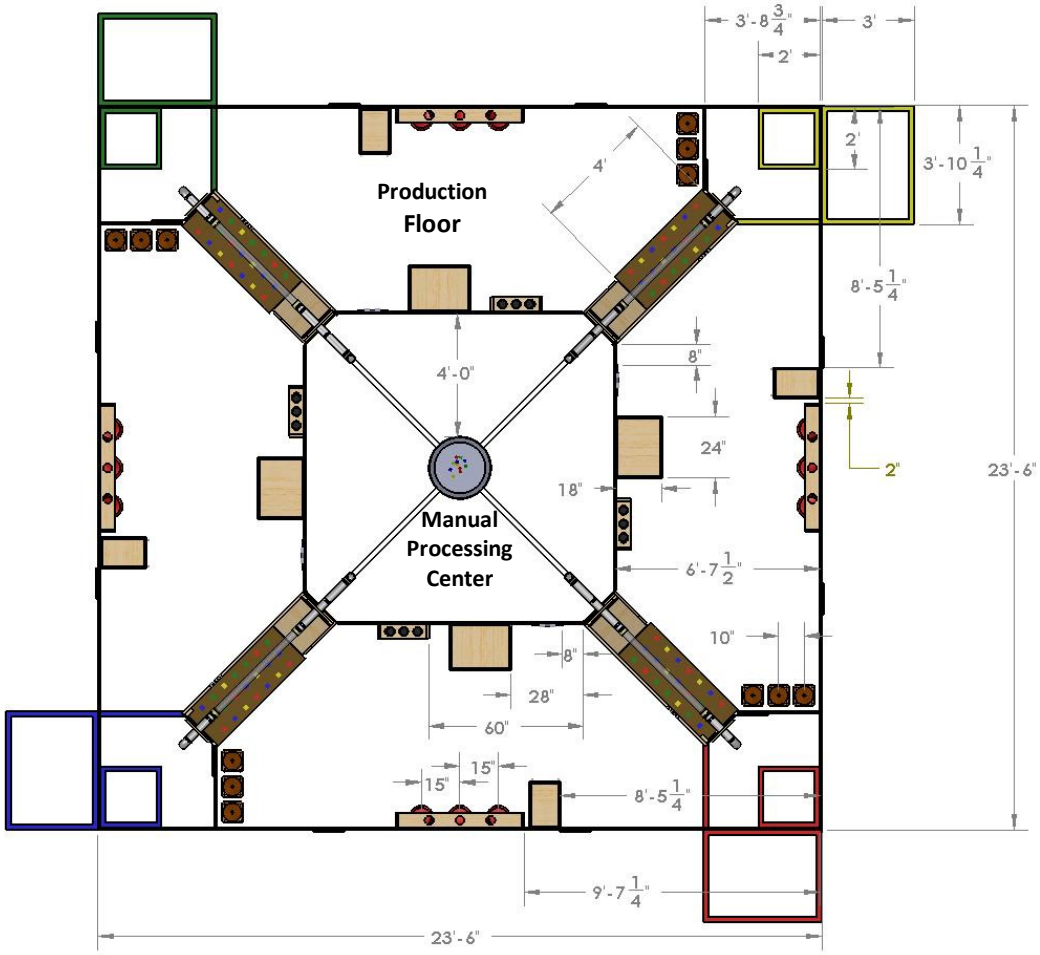


Figure 3. Total Recall Playing Field Layout

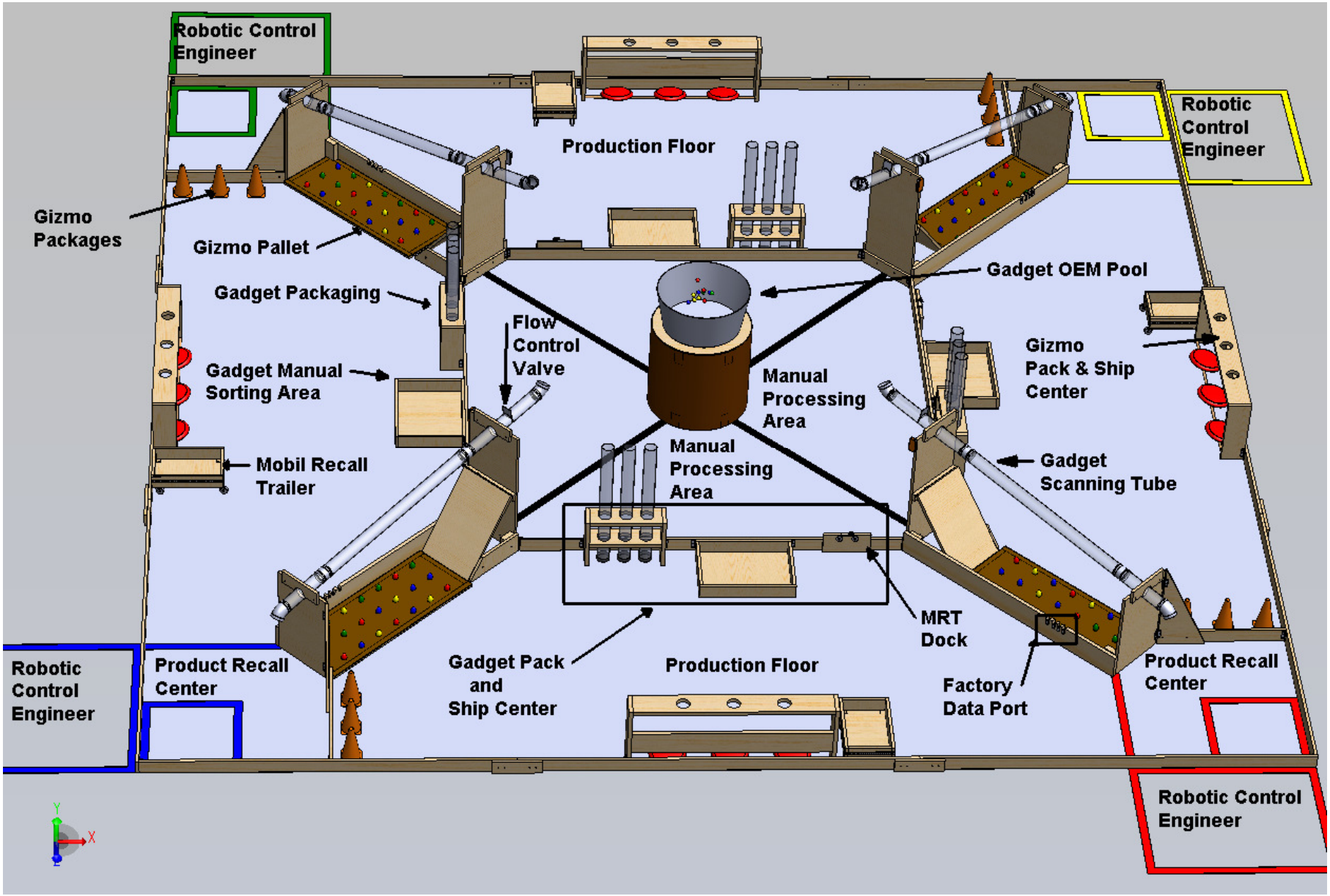


Figure 4. Total Recall Playing Field (Perspective View)

Each factory contains the following designated areas and objects:

Gadget OEM Pool	A shared pool of OEM products (gadgets) to be processed by each factory.
Mobile Recall Trailer (MRT)	A movable trailer used to carry defective gadgets from the *Pack & Ship Center* to the *Product Recall Center*. It may be moved by the robot anywhere on the *Production Floor*.
Product Recall Center (PRC)	Where defective gadgets are taken to return them to the OEM.
Gadget Scanning Tube (GST)	Where gadgets are scanned for defects as they enter the production floor. Its outlet is 16-3/4 inches above the floor of the *Product Recall Center*.
Flow Control Valve	A removable piece of the GST that allows gadgets to travel through the tube freely and enter the *Production Floor*.
Gadget Pack & Ship Center	Where gadgets are taken for manual inspection & final packaging. This includes the *Gadget Sorting Area*, *Gadget Packing Tubes*, and the MRT when it is docked.
Gadget Sorting Area	The container where gadgets are taken for manual inspection (sorting).
Gadget Packing Tubes	Final packaging for gadgets; the clear cylindrical tubes at the *Gadget Pack and Ship Center*.
MRT Docking Station	Where the *Mobile Recall Trailer* must be docked before gadgets can be loaded into it by the *Process Engineer*. A "MRT Docking Lamp" is visible to both the *Process Engineer* and *Robotics Control Engineer*. When lit, this lamp indicates that the MRT is successfully docked and products may be loaded into it.
Gizmo Pallet	A pallet where incoming gizmos reside.
Gizmo Pack & Ship Center	Where gizmos are packaged and sealed for shipping.

Factory Data Port	A physical interface where a factory robot can learn (i.e., read) which products are to be considered "defective" during the current production shift.
Production Floor	The automated area of the factory where all product processing is performed by factory robots. This includes the *Gizmo Pallet*, the *Gadget Pack and Ship Center*, the *Gizmo Pack and Ship Center*, and the *Product Recall Center*.
Manual Processing Center	The area of the factory where all manual processing of products by human operators is accomplished. This includes the *OEM Pool* and the *Gadget Pack and Ship Center*.
Factory	The area including the *Production Floor* and *Manual Processing Center* for a given team.

Figure 5 shows the boundaries for key areas within a factory.

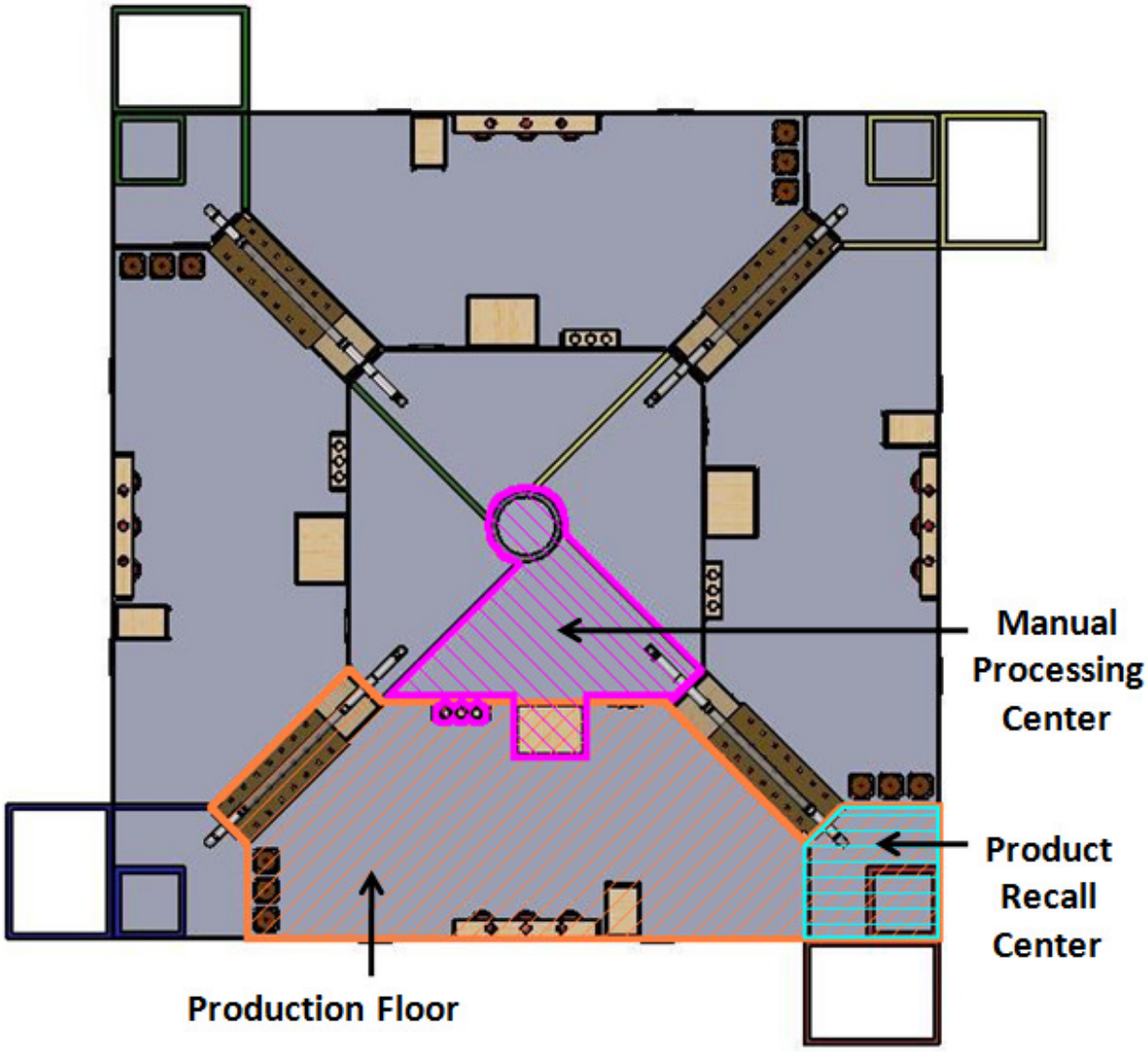


Figure 5. Designated Areas within a Factory

3.1 Production Line Personnel

Each factory will be operated by both humans and robots working together. The production line personnel will consist of:

A Robotics Control Engineer (driver)

–the person remotely controlling the factory robot; i.e., the "driver".

An Automated Factory Robot

– a team's robot, designed to manipulate products and field objects.

A Process Engineer (spotter)

– the person working with the factory automation robot to perform processing steps on the gadget production line.

A BEST Quality Assurance (QA) Engineer

– a BEST Inc. representative that oversees the production line operations, corrects problems, initiates Customer Quality Inquiries and other penalties, calculates process sigma, etc. QA engineers are identified by their black and white striped shirts.

3.2 Factory Shifts (Match Protocol)

There will be a total of three production runs each with multiple production shifts. This will include a Pilot Production run (seeding), followed by a Low Rate Initial Production (LRIP) run (semi-finals), and then a Final Production run (finals).

Production lines will be run in 3 minute shifts (matches) with a maximum of four teams. If necessary, shifts may be run with fewer than four teams. The scoring software will assign teams' shifts and will determine the teams' factory for that shift.

Production shifts will begin and end at the sound of the shift whistle or buzzer. During shift changes, incoming factory teams will be allotted 30 seconds to setup their robots and take their operating positions.

During each shift, two members from the team will participate and assume the roles of Robotics Control Engineer and Process Engineer. At the start of each shift, both team members must be in their designated areas; the robot must be in its starting area and in compliance with BEST Generic Game Rules. The starting area for each robot is a 2 ft. x 2 ft. subset of the physical area designated as the *Product Recall Center* (refer to Figures 3 and 4). The Robotics Control Engineer and Process Engineer must remain in their designated game field positions for the duration of the shift. Either or both of the two may place the robot in its starting position prior to the beginning of the shift. Factory personnel will work two back-to-back shifts, assuming the role of Process Engineer in their first shift and then the role of Robotics Control Engineer in their second shift before rotating out of the factory. This rotation will continue uninterrupted through all production runs. The minimum number of factory personnel for a team will be as defined in the BEST Generic Game Rules, minimum number of drivers.

At the hub's discretion, a student may be allowed to skip the role of Process Engineer if the student is determined to be incapable of playing that role (e.g., due to a disability). In this case, a replacement will be designated to assume the role of the Process Engineer. A team must have hub approval for such a substitution prior to their scheduled Machine Compliance day. The replacement must be named on the team's driving roster, along with the student they will replace as Process Engineer.

4.0 Definitions

For the purposes of this document and to fully understand the rules herein, the following definitions will apply.

Term	Definition
Process Sigma	A measure of process quality calculated as the number of standard deviations away from the mean. In a Six Sigma process, this equates to 3.4 defects per million opportunities, which is the most economically achievable quality level for most processes.
Product Yield	The number of good (non-defective) units produced divided by the total number of units that entered the process. A Six Sigma process equates to a product yield of 99.9997%.
Defective product	A product that has entered the process and is identified as defective.
Temporary Factory Shutdown	Temporary stoppage of work within the factory, usually as a result of violations in production rules and regulations. All work in the factory, including all robot and human activities, will stop for 20 seconds. The attending QA Engineer will measure 20 seconds from the last motion of the machine or Process Engineer. The attending QA Engineer may declare a Customer Quality Inquiry (see below) if the team does not make a clear effort to stop all activity immediately. The QA Engineer may physically take possession of the machine's transmitter if they deem it necessary.
Customer Quality Inquiry (CQI)[5]	Production is stopped and the team is disqualified for the shift. All robot and human activities within the factory stop. Only a team's Process Sigma will be calculated for the shift in which the CQI is received. The team's accumulated points for the shift will be zero. The attending QA Engineer may take possession of the team's transmitter, remove their machine, or ask the team to leave the field if they deem it necessary.

[5] A CQI is normally a result of defective products reaching the customer. This is the worst possible scenario in terms of the quality of a manufacturing/production process. It greatly influences the customer's perception of the manufacturer's capability. Major changes to the process may be required as a result.

Term	Definition
Inside	To be completely inside the infinite vertical boundaries of a designated area, relative to the outermost face of the boundary. For virtual boundaries such as a tape line, the outermost edge of the tape defines the boundary.
Outside	To be completely or partially outside the infinite vertical boundaries of a designated area, relative to the outermost face of the boundary.
Touching	Physically in contact with.
Covered	Completely hidden and not visible when viewed from above.
Docked	When the MRT is touching the magnets at the MRT Docking Station and the “MRT Docked” lamp is illuminated.
Resting on	Inside and touching.
Out of Play	Any factory item that touches the surface of the floor outside of the field's outer boundary. Any item that is "out of play" cannot be returned to the field.
Successfully Recalled	Any defective gadget that has been placed inside the *Mobile Recall Trailer* which has then been placed inside the *Product Recall Center* before the end of the production shift.

Term	Definition
Factory Waste	At the end of the match: Any gadget or gizmo that is touching the factory robot or Process Engineer. Any gadget or gizmo that originated in the factory and is out of play. Any gadget that does not meet any of these criteria: 1. Inside the Gadget Sorting Area or Gadget Packing Tubes 2. Resting on the floor of the MPC 3. Inside the OEM Pool 4. Successfully Recalled 5. Inside the GST with the Flow Control Valve closed Any gizmo that does not meet either of these criteria: 1. Resting on the Gizmo Pallet 2. Inside a properly placed Gizmo Package

5.0 The Products (Game Pieces)

5.1 Description of Game Pieces

Product / Item	Description	Quantity
Gadgets	Standard golf balls, 3 colors. Each golf ball weighs 1.6 ± 0.2 oz.	150 Black, 150 Yellow, 150 White
Gizmos	2” plastic Easter eggs, colors not specified. Each egg weighs 1.8 ± 0.3 oz.	21 total per factory: - 10 magnetic - 11 non-magnetic
Gizmo Packages	9” plastic agility cones (orange) with vertical perforation	3 per factory
Gizmo Packing Lids	9” flying disc	3 per factory

5.2 Starting Position of Game Pieces and Other Mobile Field Objects

SP1	A team's Process Engineer will start the shift with all parts of their body inside the team's *Manual Processing Center* and must remain that way for the duration of the match.
SP2	Factory robots will start the shift inside the robot starting area of the *Product Recall Center*.
SP3	A team's Robotics Control Engineer will be located outside of the playing field, near the corners of the field, and must remain inside the designated area for the entire shift.
SP4	Gadgets will begin the shift randomly mixed inside the *OEM pool* at the center of the field, available for processing by all factories.
SP5	Six (6) gadgets, two (2) from each OEM (color) will begin the shift preloaded into the *Gadget Scanning Tube* of each factory.
SP6	All gizmos will begin the shift resting on the *Gizmo Pallet* under the *Gadget Scanning Tube* of the team to the left of the *Robotics Control Engineer*. All gizmos will be equally spaced on the *Gizmo Pallet* to begin the shift.
SP7	*Gizmo Packages* will begin the shift resting on the surface of the *Production Floor* in a normal upright orientation near the *Gizmo Pallet* (See Figures 3 & 4).
SP8	*Gizmo Packing Lids* will begin the shift stored horizontally on the lower portion of the *Gizmo Pack and Ship Center*.
SP9	The *Mobile Recall Trailer* will begin the shift adjacent to the *Gizmo Pack and Ship Center* as indicated in Figures 3 and 4.

6.0 General Production Rules

Global Factory Rules

G1	Unless otherwise specified, the team's first violation of any rule during a production shift will result in a Temporary Factory Shutdown. The team's second rule violation will result in a Customer Quality Inquiry.
G2	A team's products shall be confined to their own factory. Care should be taken to ensure this is true. Intentional violations will result in a Customer Quality Inquiry (CQI).
G3	Machines may not deliberately leave the Production Floor of their assigned Factory.
G4	Defective gadgets and gizmos will be randomly determined for each team at the beginning of the shift.

Process Engineer Rules

G5	Only the Process Engineer may move gadgets from the *OEM Pool* to their factory's *Gadget Scanning Tube*.
G6	The movement of gadgets from the *OEM Pool* to the GST must be accomplished by hand only, without the aid of any other devices or containers.
G7	The Process Engineer may only place gadgets inside the *Mobile Recall Trailer* while it is docked.
G8	The Process Engineer may not remove gadgets inside the *Mobile Recall Trailer*.
G9	Process Engineers may place gadgets inside their factory's *Mobile Recall Trailer* only when all portions of the factory robot are outside of this area.
G10	Process Engineers may never move the *Mobile Recall Trailer*.
G11	Process Engineers may not touch gizmos, gizmo packages, gizmo packing lids or the surface of the *Production Floor*.
G12	Process engineers may not touch any gadget that is also touching the robot or the surface of the *Production Floor*.
G13	Process Engineers may not touch factory robots.
G14	Process Engineers may manipulate gadgets inside their factory's *Gadget Sorting Area* only when all portions of the factory robot are outside of this area.
G15	Process Engineers may not simultaneously manipulate gadgets originating from the *OEM Pool* and the *Gadget Pack and Ship Center* (including the docked *MRT*).
G16	The Process Engineer may move gadgets from the *Gadget Sorting Area* to the *Gadget Packing Tubes*.
G17	The Process Engineer may remove the *GST Flow Control Valve* only while the *MRT* is docked.

Gadget Production Rules

G18	Once the Flow Control Valve has been removed from the GST, it may not be re-inserted.
G19	The color of the defective gadgets will be electronically accessible by the robot from the *Factory Data Port* for the entire shift.
G20	The color of the defective gadgets will be visually revealed to the Process Engineer via lamps near the GST during the last half of the shift (i.e., the last 1 ½ minutes).
G21	Gadgets may not be removed from the *Gadget Packing Tubes* after being placed there. The *Gadget Packing Tubes* themselves may only be moved by QA Engineers.

Gizmo Production Rules

G22	The condition (magnetic/ non-magnetic) of the defective gizmos will be electronically accessible by the robot from the *Factory Data Port* for the entire shift.
G23	The condition (magnetic/ non-magnetic) of the defective gizmos will be revealed to the Process Engineer via lamps near the GST during the last half of the shift (i.e., the last 1 ½ minutes).

7.0 Scoring

All scoring is determined at the end of each production shift. Scores are determined by:

1) The quantity of packaged products or correctly placed packaging.
2) The process Sigma quality measure for each production line.

Refer to the scoring formula given in section 7.3, rule SC10.

7.1 Scoring Summary

Item / Location at end of shift	Pts. Each
Collected Gadgets: Non-defective gadgets (golf balls) inside the *Gadget Sorting Area*.	2 pt
Packaged Gadgets: All non-defective gadgets from the same OEM (uniform color) inside the same *Gadget Packing Tube*.	3 pt
Gadgets from more than one OEM (colors) inside a *Gadget Packing Tube*.	0 X contents of packing tube (all gadgets in tube = defective)
One or more defective gadgets inside a *Gadget Packing Tube*.	0 X contents of packing tube (all gadgets in tube = defective)
Packaged Gizmos: Non-defective gizmo (egg) inside a successfully placed gizmo package at the *Gizmo Pack and Ship Center*.	10 pts
Sealed Gizmos: Non-defective gizmo inside a properly sealed (i.e., covered with a flying disc) gizmo package at the *Gizmo Pack and Ship Center*.	20 pts
Placed Gizmo Packages: Gizmo package (cone) successfully placed at the *Gizmo Pack and Ship Center*.	50 pts
Dual Production: For successfully collecting or packaging at least one non-defective gadget and packaging at least one non-defective gizmo during the shift.	1 pt.
Defective Products: Defective products (gadgets or gizmos) regardless of their location inside the *Production Floor*, *Sorting Area*, or in *Packaging*.	0 pts
Any Factory Waste.	0 pts

7.2 Process Sigma Calculations

S1	The quality level of each production line will be calculated using the line's process Sigma (σ). A sigma value of 6 will be the highest achievable quality level.
S2	Successfully recalled products will not be considered in the process Sigma calculations.
S3	All factory waste will be considered "defective product" and will be included in the process Sigma calculations as such.
S4	The number of defects per million opportunities (DPMO) for a process will be calculated as: (# defective products) / (total # products entering the process) * 1,000,000 Where, total # products entering the process = factory waste + product at sorting area (gadgets only) + packaged product.
S5	The process Sigma[6] for each production line will be based upon the number of defects per million opportunities (DPMO) for that line and will be determined using Table 1. Process Sigma Lookup Table. DPMO will be rounded to the nearest value in Table 1.
S6	The process Sigma for each product line (gadget, gizmo) will be calculated and maintained independently.
S7	The defective and non-defective products processed in each product line will be cumulative over all production shifts and will be reset to 0 at the beginning of the Low Rate Initial Production run (semi-final rounds).
S8	The process Sigma used in the Wildcard Match will be unique to that match and will not affect the process Sigmas for other rounds.
S9	Defective gizmos resting on the *Gizmo Pallet* at the end of the shift will not be included in the process Sigma calculation. They are considered as never having entered the process and will be scrapped.
S10	Gadgets resting on the floor of the *Manual Processing Center* at the end of the shift will not be considered Factory Waste and will not be included in the process Sigma calculation.
S11	Gadgets inside the *OEM Pool* will not be considered Factory Waste and will not be considered in process Sigma calculations.

[6] The Process Sigma value can be calculated in MS EXCEL using the formula:
Process Sigma = ROUND(NORMSINV(1-(#defective/#total)) + 1.5,1)

Table 1. Process Sigma (σ) Lookup Table

DPMO	Sigma	Yield	DPMO	Sigma	Yield
0	**6**	**100.00%**			
3.4	6	100.00%	66,807	3	93.30%
5.4	5.9	100.00%	80,757	2.9	91.90%
8.5	5.8	100.00%	96,801	2.8	90.30%
13	5.7	100.00%	115,070	2.7	88.50%
21	5.6	100.00%	135,666	2.6	86.40%
32	5.5	100.00%	158,655	2.5	84.10%
48	5.4	100.00%	184,060	2.4	81.60%
72	5.3	99.99%	211,855	2.3	78.80%
108	5.2	99.99%	241,964	2.2	75.80%
159	5.1	99.98%	274,253	2.1	72.60%
233	5	99.98%	308,538	2	69.10%
337	4.9	99.97%	344,578	1.9	65.50%
483	4.8	99.95%	382,089	1.8	61.80%
687	4.7	99.93%	420,740	1.7	57.90%
968	4.6	99.90%	460,172	1.6	54.00%
1,350	4.5	99.87%	500,000	1.5	50.00%
1,866	4.4	99.81%	539,828	1.4	46.00%
2,555	4.3	99.74%	579,260	1.3	42.10%
3,467	4.2	99.65%	617,911	1.2	38.20%
4,661	4.1	99.53%	655,422	1.1	34.50%
6,210	4	99.38%	691,462	1	30.90%
8,198	3.9	99.18%	725,747	0.9	27.40%
10,724	3.8	98.90%	758,036	0.8	24.20%
13,903	3.7	98.60%	788,145	0.7	21.20%
17,864	3.6	98.20%	815,940	0.6	18.40%
22,750	3.5	97.70%	841,345	0.5	15.90%
28,716	3.4	97.10%	864,334	0.4	13.60%
35,930	3.3	96.40%	884,930	0.3	11.50%
44,565	3.2	95.50%	903,199	0.2	9.70%
54,799	3.1	94.50%	919,243	0.1	8.10%

7.3 Score Calculation

SC1	Points will be divided into four categories: *GadgetPoints*, *GizmoPoints*, *GizmoPkgPoints*, and *DualProductionPoints*.
SC2	A team's *GadgetPoints* for a particular shift will be the sum of all points received for collected gadgets and packaged gadgets during that shift.
SC3	A team's *GizmoPoints* for a particular shift will be the sum of all points received for packaged gizmos and sealed gizmo packages during that shift.
SC4	A team's *GizmoPkgPoints* for a particular shift will be the sum of all points received for properly placed gizmo packages during that shift.
SC5	A team's *DualProductionPoints* for a particular shift will be those points received for successfully scoring on both the gadget and gizmo product lines.
SC6	Points will be cumulative for each category (gadget, gizmo, gizmo packaging, dual production) over multiple shifts and will be reset to zero at the end of Pilot Production and after the Wild Card match.
SC7	*GadgetSigma* and *GizmoSigma* for each team will be reset to zero at the beginning of Pilot Production, at the end of Pilot Production, and after the Wild Card match.
SC8	At the end of every shift, a team's process Sigma (σ) for the gadget product line (*GadgetSigma*) will be calculated using all gadget accumulations (defective & non-defective) since the *GadgetSigma* was last reset.
SC9	At the end of every shift, a team's process Sigma (σ) for the gizmo product line (*GizmoSigma*) will be calculated using all gizmo accumulations (defective & non-defective) since the *GizmoSigma* was last reset.
SC10	A team's score at the end of Pilot Production, LRIP and Final Production will be calculated as follows: Team Score = (*GadgetPoints* * *GadgetSigma)* + (*GizmoPoints* * *GizmoSigma)* + (*GizmoPkgPoints*) + (*DualProductionPoints* * 10 * *GadgetSigma* * *GizmoSigma)*
SC11	A team's score will be rounded to the nearest whole number at the end of Pilot Production, LRIP and Final Production.

7.4 Infractions and Penalties

P1	A team will receive a CQI if a Process Engineer DELIBERATELY moves gadgets from the *OEM pool* to any location other than the team's *GST*.
P2	A team will receive a CQI if any products are DELIBERATELY pushed, carried or otherwise moved out of the boundaries of their assigned *Production Floor*.
P3	Gadgets dropped onto the floor of the *Manual Processing Center* may be: • placed back inside the OEM pool, or • placed inside the GST, or • left in place without penalty.
P4	A team will be assessed a Temporary Factory Shutdown for each gadget the QA engineer observes entering any *Production Floor* by any means other than through the *GST*. Such gadgets will be left in place and scored the same as any gadget entering the *Production Floor* through the *GST*.

7.5 Tie-breaker

The tie-breaker will only apply at end of Pilot Production, Low Rate Initial Production and Final Production when determining which teams should advance to the next production run.

Tiebreakers will be (in order of precedence):

1. Gadget Sigma + Gizmo Sigma (rounded to hundredths)
2. Gadget Points + Gizmo Points
3. Number of gizmos Packaged (both sealed and unsealed)
4. Number of gadgets Packaged (only those in the gadget packing tubes)

8.0 Factory Data Port

Each factory contains a Factory Data Port where factory robots can learn which products are defective. Robots must physically and electrically connect to the Factory Data Port using their microcontroller's digital inputs and a uniquely designed connector.

The physical description of the Factory Data Port is shown in Figure 6. A successful physical connection will improve the chances for a successful electrical connection.

A successful electrical connection between the factory robot and the Factory Data Port requires a sustained contact to the ground port (PG) and one or more of the data ports (P2, P1, P0). The "sustained contact time" required may vary depending on the team-provided robot software and its physical connector. Teams must design their robot to interface with the Factory Data Port if they wish to identify "defective product types" within the first 1 ½ minutes of the shift. The interface requirements between the robot and the Factory Data Port are as follows:

- One ground terminal from any of the microcontroller's digital input ports must connect with the field's ground port (PG).
- The data/signal terminal on any of microcontroller's digital input ports may be used to connect with any of the factory data ports (P2, P1, P0).
- DO NOT connect any of the (+5v) terminals on the microcontroller's digital ports to any of the factory data ports.

Once a physical/electrical interface between the robot and Factory Data Port is established, a robot which has been pre-programmed can read information through the microcontroller's digital inputs.

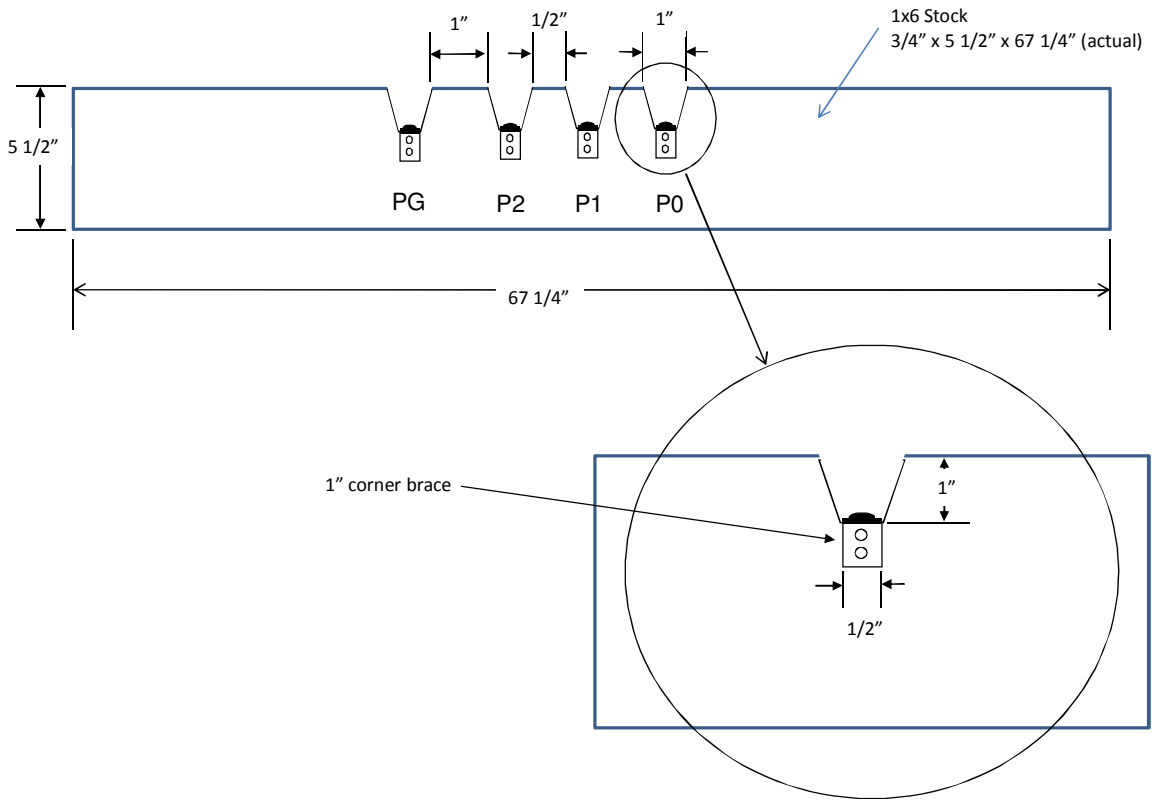


Figure 6. Factory Data Port Diagram

The information provided at the "Factory Data Port" identifies the defective products for that shift. With microcontroller user code, a robot can detect the state of the factory data port via the microcontroller's digital inputs. The state of the data port will either be open (detected as a 1 by the robot) or closed (detected as 0 by the robot). "Open" means that there is an open circuit (no electrical connection) between the ground port and the data port, and "closed" means that there is a closed circuit (electrical connection) between the ground port and the data port. The interpretation of information presented at the factory data port is shown in Table 2.

Table 2. Interpreting Factory Data Port Information

Factory Data Port			Defective Products	
P2	**P1**	**P0**	**Gadgets**	**Gizmos**
0	0	0	Black	Magnetic
0	0	1	Yellow	Magnetic
0	1	0	White	Magnetic
1	0	0	Black	Non-Magnetic
1	0	1	Yellow	Non-Magnetic
1	1	0	White	Non-Magnetic
0	1	1	No Connection	
1	1	1	No Connection	

9.0 Factory Visual Indicators

A number of visual indicators are available near the gadget *Manual Processing Area*.

MRT Docked Lamp

When lit, the "MRT Docked" lamp indicates that the *Mobile Recall Trailer* (MRT) has been satisfactorily docked at the *MRT Docking Station* and the MRT is ready for loading with defective gadgets.

Defective Product Indicators

Three light emitting diode (LED) indicators are used to "reveal" the defective product information for the shift to the Process Engineer 1 ½ minutes after the production shift begins; they do not illuminate at any other time. Each indicator represents the same electronic information provided at one of the data ports (P2, P1, P0) on the Factory Data Port as shown in Table 3.

Table 3. Defective Product Indicator Map

LED2 on ➔ P2 = 1 LED2 off ➔ P2 = 0	LED1 on ➔ P1 = 1 LED1 off ➔ P1 = 0	LED0 on ➔ P0 = 1 LED0 off ➔ P0 = 0

10.0 Gizmo Failure Detection Instruments

Each team will receive four specialized instruments to aid the factory robots in detecting failed gizmos. The instruments (known as reed switches) can be interfaced to the robot's microcontroller via the digital input ports. Embedded robot software can be developed by the factory teams to utilize these instruments in a variety of ways to help the robot detect the faulty gizmos. There are two instruments of low sensitivity and two instruments of high sensitivity provided to each team.

11.0 Production Runs (Rounds)

There will be a total of three production runs each with multiple production shifts as follows.

11.1 Pilot Production (seeding)

During pilot production, each team will participate in up to eight shifts against randomly selected opponents. Fewer than eight shifts per team may be played when time limitations exist, but all teams will participate in the same number of shifts.

The team ranking after Pilot Production will be based on the total points accumulated during the Pilot Production shifts and the process Sigma for each product line. The process Sigma for each team will be calculated at the end of each shift for the product accumulated throughout the entire Pilot Production run. The process Sigma from Pilot Production will not carry over into Low Rate Initial Production.

11.2 Low Rate Initial Production (semi-finals)

The top 7 teams from Pilot Production will automatically advance to Low Rate Initial Production. The eighth team to proceed into LRIP will be selected from the remaining teams by a single "wild card match" between the four teams with the highest BEST design notebook scores. Process Sigma values will be reset to zero for this match and will have no effect on the process Sigmas for any other production run. The "wild card match" will, otherwise, be conducted according to the rules for the Pilot Production run. The team that achieves the highest score during this "wild card match" will advance to LRIP.

The total points for each team will be reset to zero at the beginning of LRIP. The process Sigmas from previous production runs will not carry forward to LRIP; the process Sigmas for each team will be reset to zero at the beginning of LRIP. Process Sigmas for each team will be calculated at the end of each shift for the product accumulated throughout the remaining LRIP and Final Production runs.

During LRIP, each team will participate in a total of three shifts based on the rotation shown in Table 4. The team ranking at the end of the LRIP will be based on the total points accumulated during their three shifts and the process Sigma for each product line.

Table 4. Factory Assignments for LRIP Run

LRIP Shift	Factory Assignment			
	Yellow	Blue	Red	Green
1	Seed 4	Seed 1	Seed 5	Seed 8
2	Seed 2	Seed 8	Seed 3	Seed 7
3	Seed 6	Seed 4	Seed 7	Seed 1
4	Seed 3	Seed 2	Seed 4	Seed 5
5	Seed 5	Seed 7	Seed 8	Seed 6
6	Seed 1	Seed 3	Seed 6	Seed 2

11.3 Final Production (finals)

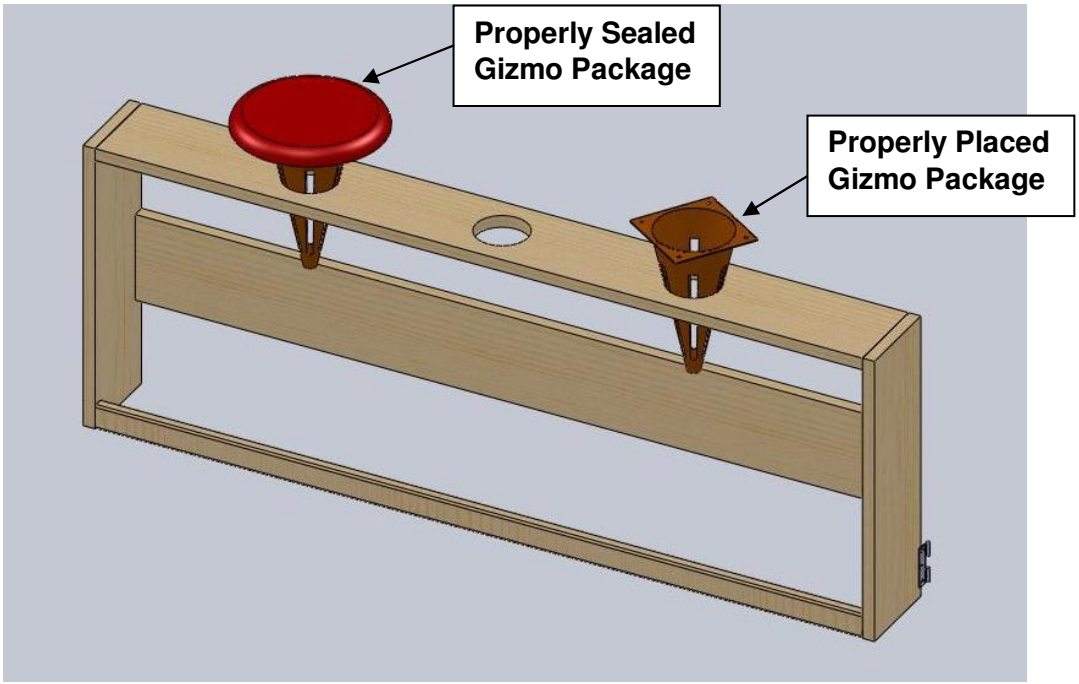
The four top ranked teams from the LRIP will advance to Final Production where they will participate in three additional production shifts in the factory assignments shown in Table 5. Process Sigmas and points from LRIP will carry forward into Final Production. The final team ranking will be based on the total points accumulated throughout LRIP and Final Production and the process Sigma for each product line.

Table 5. Factory Assignments for Final Production Run

Final Production Shift	Factory Assignment			
	Yellow	Blue	Red	Green
1	LRIP 1	LRIP 2	LRIP 3	LRIP 4
2	LRIP 4	LRIP 3	LRIP 2	LRIP 1
3	LRIP 3	LRIP 1	LRIP 4	LRIP 2

Appendix. Example Scoring

Gizmo Packaging Example



Gadget Packaging Example