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Shad Process Flow Design

You have been hired by a small electronics manufacturing company that makes a variety of electronic products for original equipment manufacturer (OEM) customers. You have been assigned to a team that is responsible for designing the production process for a new product—an innovative light-flashing electronic module. The engineering department of the customer has provided design specifications for three different models. You must determine how to produce these models and to respond promptly to uncertain customer demand. You will have to decide what type of production system to use, how it will be staffed, on what cadence and in what quantities you will procure materials, and how to develop standardized work methods for the operators. Your team will place orders for the raw materials for everything needed to develop and fine-tune a production system for the new product and will be required to demonstrate your production process during two factory simulation runs. You will also have the opportunity to do a kaizen process improvement exercise between the two runs to maximize efficiency and productivity.

The Products

The three product models— "Economy," "Deluxe," and "Imperial"— each consist of a breadboard with an integrated circuit (IC) chip installed, several electronic components, and interconnecting wires. The configuration of these components varies by model. **Exhibits 1 - 3** show the design specifications. No deviations are permitted. Your customer will use these modules in its own products and is extremely quality conscious. Each module must function correctly, all wires must be of the correct color and length, and all wires and components must be mounted in the specified positions.

Your customer plans to order individual units at a rate of 1 order every 30 seconds (120 orders per hour). The customer expects its order mix to average, within each hour, roughly one-half Economy, one-third Deluxe, and one-sixth Imperial models. Although these order trends are likely to continue, the exact mix and sequence of future orders during any hour or day are uncertain.

You must deliver your products in the exact sequence in which they are ordered, and your customer will test each to ensure correct functionality and appearance. If one of your units is rejected for failing either test, your customer will only accept the next unit you delivered if it corresponds to the correct model that it is expecting. If the next unit is not in the desired sequence, it will be rejected. You will be responsible for picking up rejected units and returning them to your factory. You will receive revenue credit for each unit you deliver only when it is accepted by your customer. All other units remain in your inventory, including units under test and units that are rejected.

Professors Willy Shih and Michael W. Toffel prepared the original version of this exercise, "Shad Process Flow Design Exercise," HBS No. 622-035. This version was prepared by Professor Willy Shih as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

Your Team's Process Design Proposal

The president of the company recently informed your team, "This is a low margin business, and it will be important to use materials efficiently while being able to fulfill each order quickly. Come up with a production process to meet this objective." You must meet with your team to develop a process design (as detailed in **Exhibit 4**). You will need to:

- Map customer demand to cycle time. You will need to understand the *takt time* for each model and then measure the *cycle time* of your core process steps to establish the capability of your workers and process design.
- Evaluate *serial* versus *parallel* work decomposition, and key process design choices. Understand how *variability* might impact your process design choices and where and how you might use *buffers*. Decide how to *allocate tasks* to your workforce.
- Develop a *materials requirements planning* (MRP) strategy and a process for replenishment of raw materials. You should develop your own MRP system using either an Excel spreadsheet or manual bookkeeping so that you can pace your replenishment based on actual materials consumption and how your order fulfillment pace is going.
- Identify managerial levers available to maximize net profit (which for this exercise is gross profit less a charge of 5.0% of the value of the maximum amount of inventory owned during a period to reflect the cost of renting space for storage).

You have considerable flexibility in how to structure your work. The only constraints you cannot change are the product specifications, the quality test requirements, the customer demand characteristics, and the product price and cost data. You will find it helpful to test your ideas during the allocated practice time using your *materials kit* (see **Exhibits 5** and **6**). You must use your materials wisely, as you will use the same materials for your practice period and for two factory demonstrations. You should plan to reuse all components except wire.

Because the IC chip and breadboard come as a pre-assembled subassembly, you should perform quality inspections to ensure that the chips are installed with the correct orientation and position, with pin 1 of the IC chip placed in column F, row 14 (designated F_{14}) of the breadboard. Your supplier also may provide one of two interchangeable types of buzzers or one of two interchangeable types of capacitors (see **Exhibit 7**). **Exhibit 8** details component material costs and revenue credit you will receive for each unit delivered and accepted.

Your Factory Demonstration

Your factory demonstration will be conducted either in the Shad Gym or in Batten Hall. Your section's location and team assignments will be found on Canvas. Your team will demonstrate your factory to another team from your section who will pose as your customer. Teams will be assigned a number in the form (Section Letter)(Team number), e.g., B1, B2. There are eight teams per section, and odd numbered teams will be paired with even numbered teams within your section.

You will be provided a space that consists of tables arranged as shown in **Exhibit 9**. Your factory demonstration will be supported by the **Shad Universe** app, which will be accessible via Canvas. The app will present orders from your customer, and it will enable you to purchase materials that you need to produce your products, keep track of your inventory, and show delivery and quality metrics.

During the **Day 1** organization and practice session, you will have the opportunity to familiarize yourselves with the materials and product designs, and practice implementing your process. The factory demonstrations on **Day 2** will be organized as a series of three-minute blocks. There will be two three-minute preparatory blocks counting down to T = 0:00, at which time your first order will be presented to you electronically in the app. A new order will appear every 30 seconds thereafter. When the end of the simulation is announced (sometime between 15 and 30 minutes after the T = 0:00 start), any product deliveries that you have made that are already waiting in your customer's inspection process will be processed. Any units that are not accepted will be returned to you and will be counted in your inventory.

At the end of your *first* factory demonstration run, you should leave your factory in place. After both teams have completed their *first* demonstration runs, you will have the opportunity to hear feedback from your customer and conduct kaizens to try to systematically improve your processes (see **Appendix A**). After completing the kaizens and a break, you will have an opportunity to demonstrate your improved factory processes.

Factory Demonstration Roles

During the **Day 1** organization and practice session, you should assign roles to all team members. For your factory, we recommend that you consider:

1. **Co-Captain**. Your team may elect to do this if you would like to spread the captain's responsibilities and workload.
2. **Chief Financial Officer**. Someone who will do the financial planning for your operations could be quite valuable.
3. **Material Requirements Planning (MRP) Lead**. MRP is a system to plan production, identifying what materials are needed when and in what quantities, with the goal of ensuring that the right supplies are on hand to meet production needs. Most MRP systems are software based, although for this exercise building a simple spreadsheet and/or manual process should suffice. It will be helpful to assign someone to manage this for you, as you will want to order only the quantity of materials that you actually plan to use and avoid incurring excessive storage charges.
4. **Supply Chain Manager**. Managing your supply chain for inbound materials will be important. You should also think about how you will manage your supplier.
5. **Direct Labor**. Decide how many people you want to work in your process and how you want them deployed. The cost of labor will not be in your measurements.

After you decide the roles you will serve during the demonstration, your Team Captain should enter these role assignments into the Shad Universe app. The app will provide multiple tabs to support your factory. Tabs for the Factory Demonstration role are summarized in **Exhibit 10**.

Procuring Materials

For the six minutes preceding T = 0:00 and throughout the factory demonstration period, you may order the materials needed to produce your products by using the window on the Materials tab in the Shad Universe app. Ordering will be available only during the first minute of each three-minute window, and you should place your order before the first minute window closes by clicking the submit button on the order form. Placing your order within the first minute gives the Customer Audit Team time to fulfill your order by the end of the third minute of the same window. If you don't order during

this window, you will have to wait until the next window. Your order will be available for pick-up at your customer's **Supply Depot** during the third minute. You will be able to pre-edit an order for the next time window, but you will not be able to submit the order until that time window opens. Your purchases will be logged in Shad Universe which will keep track of your total inventory and charge you for the maximum level attained across all the three-minute windows.

The Factory Demonstration Team should produce bare wire by purchasing and stripping green wire; for inventory accounting it will be carried in your green wire inventory. Teams may order no more than nine circuit board assemblies within any three-minute block, up to a total of 60 across a full run. If sufficient materials (especially wire) are unavailable locally, the factory demonstration team's supply chain team will have to procure materials from the regional distribution center located at the center of Shad or Batten Hall.

Simulating the Customer

When your team plays the role of customer, you will sit at a set of tables that are configured as shown in **Exhibits 11** and **12**. As the customer, your team should have the roles and responsibilities described below assigned. Team Captains are responsible for assigning your Customer Audit roles in Shad Universe by selecting roles from the dropdown menus. You must rehearse these roles on the Practice Day (Day 1). On **Day 2**:

- The **Procurement Auditors** will set up and operate a **Supply Depot** that will dispense materials to the factory team (using the Factory Team's Materials Kit). To ensure that purchase orders from the Factory Demonstration Team are fulfilled quickly, you should assign one team member to cut wire to the lengths ordered, one to picking components, and one to interfacing with the app. Exact quantities must be recorded. Wire is sold by the centimeter (cm) and is available in red, green, and black. The Procurement Auditors must ensure that orders are ready for pickup during the third minute of each three-minute block. If an order is ready earlier than the third minute, it should be held by the audit team until the third minute begins. When the materials are ready, the Procurement Auditors should mark the order "Ready for Pickup" in the app.
- The **Receiving Auditor** will record in the app every product unit that the Factory Demonstration Team delivers to the Receiving Area buffer (sized for one unit) and should also record immediately when the buffer is emptied. Time stamps for these two actions will provide insights for both teams.
- The **Rejection Auditor** records all Functional and Visual rejections in the app. Each rejection is automatically time stamped. The Rejection Auditor does not record out-of-sequence rejections, which are recorded by the Acceptance Auditor.
- The **Functional Quality Auditor** will take deliveries from the Receiving Area buffer and perform a functional test. If a unit passes, it should be placed in the *Awaiting Visual Inspection* buffer. If a unit fails, the auditor should place it in the *Functional Rejects* buffer and tell the **Rejection Auditor** to log the reject in the app.
- The **Visual Quality Auditors** (at least two team members) will receive deliveries from the *Awaiting Visual Inspection* buffer (sized for one unit) and inspect products to ensure that they comply with the specifications. If the unit passes, they should place the product in the *Pre-acceptance* buffer. If it fails, they should place it in the *Visual Rejects* buffer and tell the **Rejection Auditor** to log the reject in the app. Visual Quality Auditors should be careful to preserve the sequence of products as delivered.

- The **Acceptance Auditor** should accept orders from the *Pre-acceptance* buffer (sized for one unit) as long as it corresponds to the next unfilled order's model type. If the unit is not the model type of the next unfilled order, the auditor should place it in the *Out-of-Sequence Rejects* buffer and reject the unit in the app. If it is the correct model, the auditor should accept it in the app. The delivery will be time-stamped, a revenue credit will be issued, and the factory demonstration team's inventory will be debited for the COGS of the raw materials. The accepted unit should be placed in the *Accepted Product Stock*.

- The **Factory Liaison(s)** should observe the factory during the first run and present formal feedback to the Factory Demonstration Team during the first 10 minutes of the Kaizen session. Feedback could include observations on work processes, labor utilization, efficiency of materials planning and usage, effectiveness of quality processes, effectiveness of rejection handling, and other things to help the Factory Demonstration Team improve.

When the end of a factory demonstration period is announced, the Audit Team must stop accepting any units that are not already in the Receiving Area buffer or are in the process of being tested. Unaccepted products will be counted in the factory demonstration team's inventory. Customer Audit Team roles and actions are summarized in **Exhibit 13**. The Audit Team should ensure that they can keep up with the order pace. They must be able to audit a unit within 30 seconds. Excessive auditing times as measured by the app may lead to sanctions or financial penalties when it is their turn to demonstrate their factory.

A master timeline for each demonstration period is shown in **Exhibit 14.**

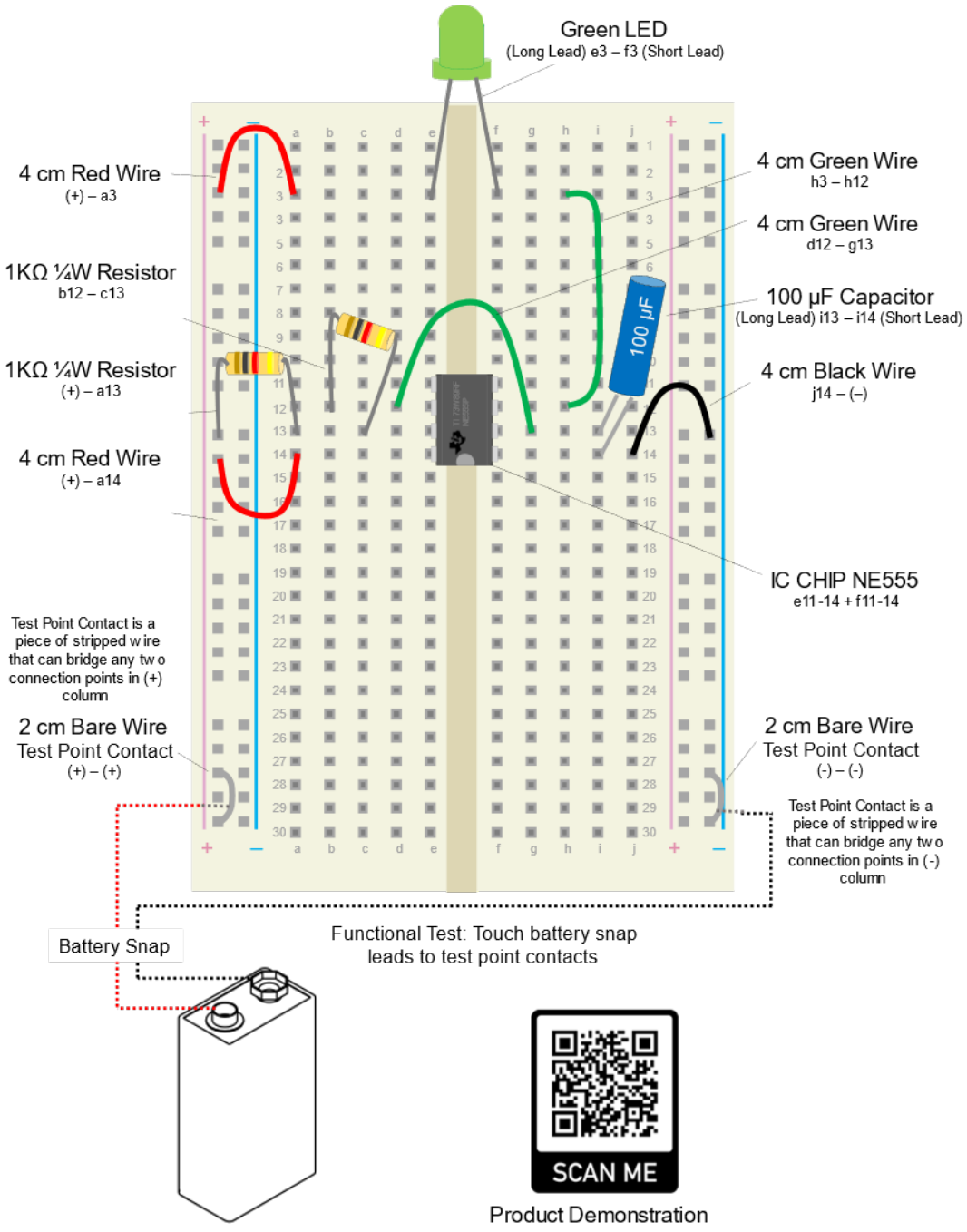
Process Design Considerations

As you prepare for the exercise, there are five broad categories of analysis you should consider when designing your process:

1. **How should you decompose the work to meet the pace of customer demand?** You know that the *takt time* is the cycle time required to meet customer demand. A logical first step might be to measure the cycle time of your core process steps to establish the capabilities of your workers. How long does it take to assemble each model? If you cannot assemble a model within the takt time for that unit, how can you decompose the work into a process that can deliver that model at the required pace?
2. **What are the likely sources of variability and how might the process design accommodate variability where it can't be controlled, or reduce it where it can be managed?** What is the impact of variability on your process design choices? Where should you use buffers and how large should they be? Will standard work reduce variability?
3. **How should you handle basic materials requirements planning?** You will need to purchase materials to support your production strategy, but there is a lead time associated with every order, and there are only certain windows during which you can place an order. How do you ensure you have enough materials on hand so your production team does not run out, but you also don't end up with excessive inventory which will impact your costs and overall measurements?
4. **Handling quality problems and abnormalities.** Your customer wants perfect quality and in-sequence delivery. Understanding the product acceptance process and how you will handle rejects will be a valuable part of your preparation.

5. **Understanding the broader scope within which the process needs to operate.** How will your team be measured? What are the managerial levers that will impact your performance?

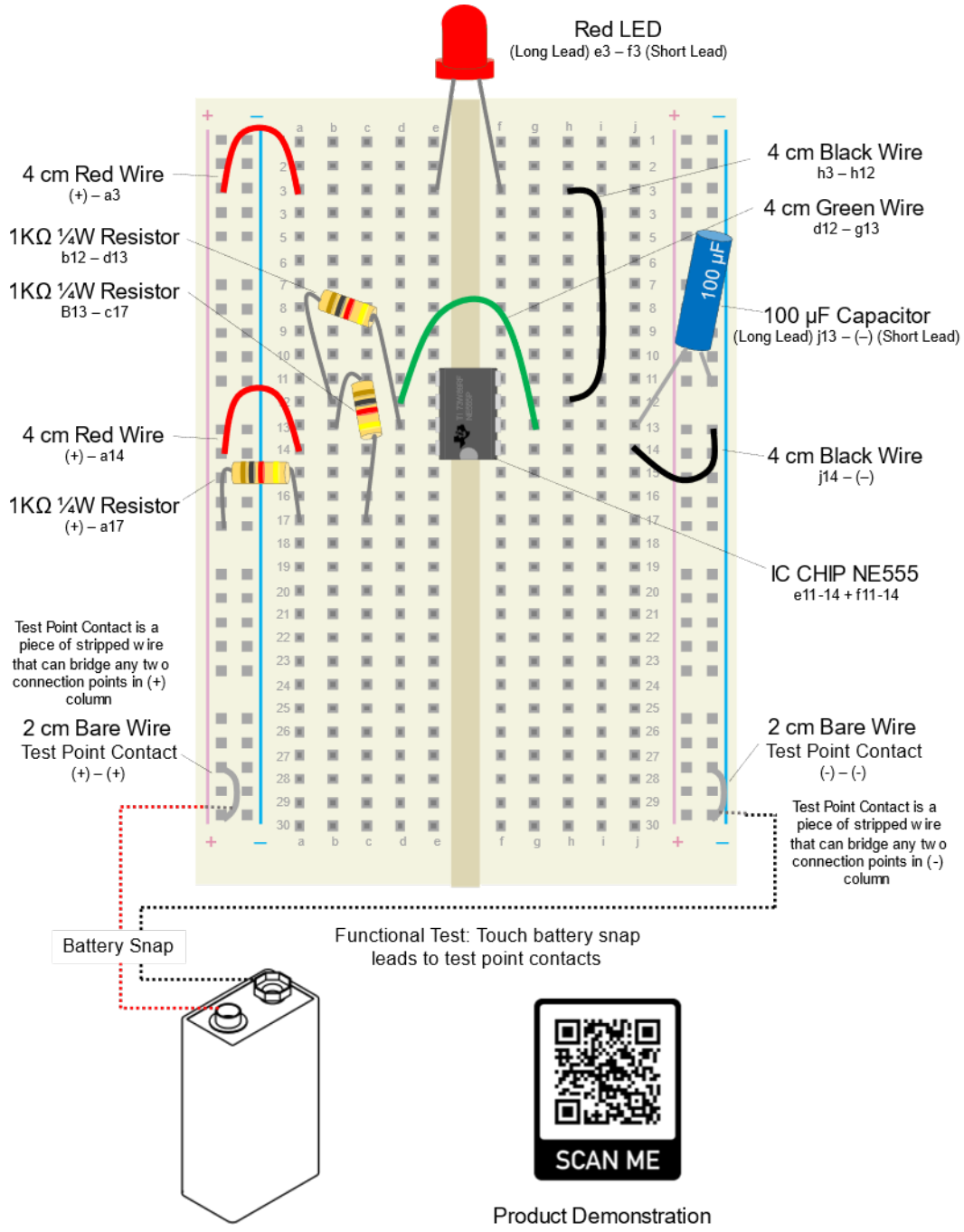
Exhibit 1 Design Specifications of "Economy" Model



Source: Prepared by casewriter.

Note: All components must be in the correct position, and all wires of the correct color and length (to within +/– 1 cm). The dot on the integrated circuit chip can be at the bottom center or the bottom right (as shown in **Exhibit 7**); both meet the specification. Link for video product demonstration is here.

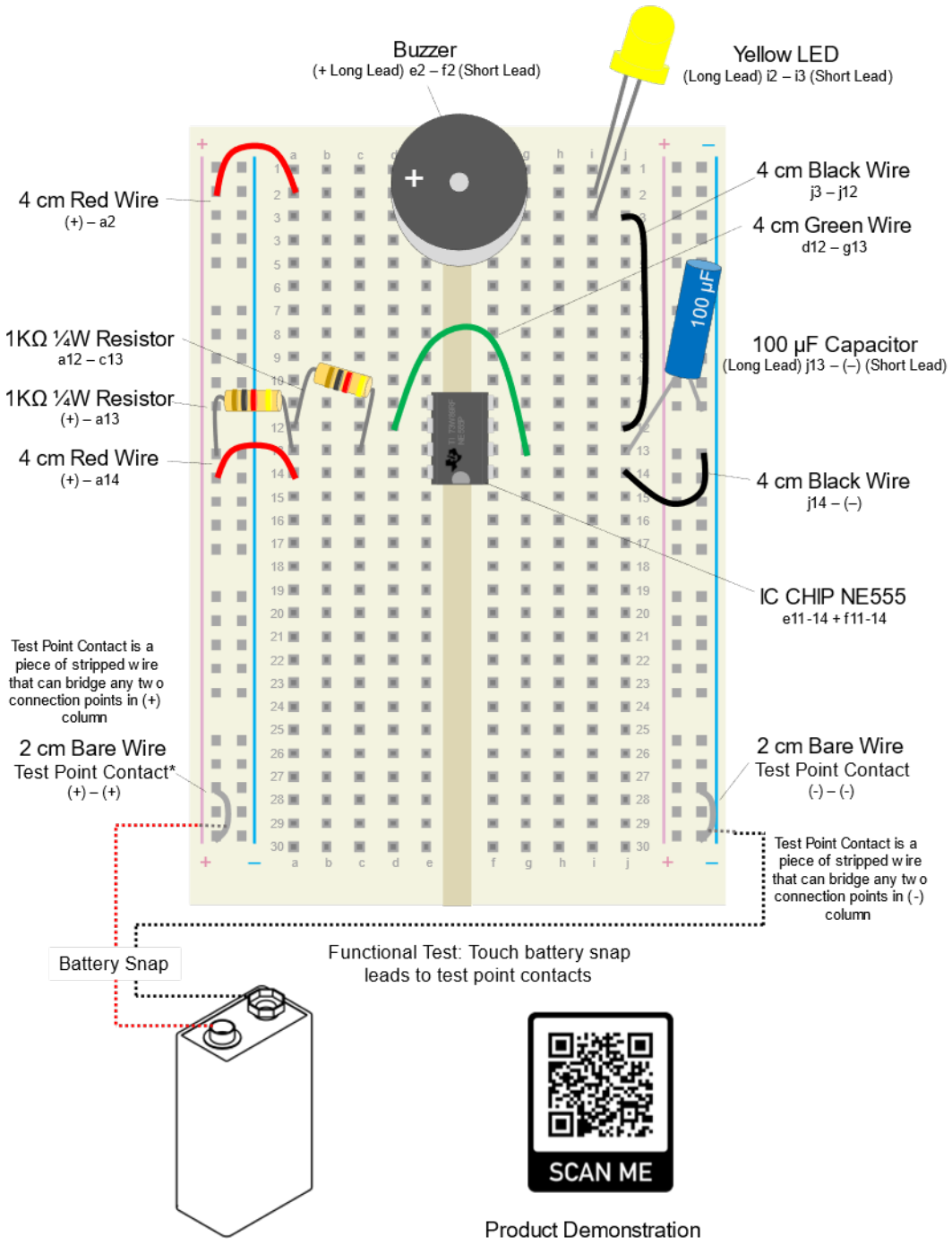
Exhibit 2 Design Specifications of "Deluxe" Model



Source: Prepared by casewriter.

Note: All components must be in the correct position, and all wires of the correct color and length (to within +/– 1 cm). The dot on the integrated circuit chip can be at the bottom center or the bottom right (as shown in **Exhibit 7**); both meet the specification. The light must flash for the product to be deemed functional. Link for video product demonstration is here.

Exhibit 3 Design Specifications of "Imperial" Model



Source: Prepared by casewriter.

Note: All components must be in the correct position, and all wires of the correct color and length (to within +/– 1 cm). The dot on the integrated circuit chip can be at the bottom center or the bottom right (as shown in **Exhibit 7)**; both meet the specification. The light must flash and the buzzer must sound for the product to be deemed functional. Buzzer size may vary and span holes E2-F2 or D2-G2. Link for video product demonstration is here.

Exhibit 4 Process Design Assignment

Note: Team Captains must submit their team's information, including the process flow diagram, to the Shad Universe website by the stated deadline.

[1] Process flow. Upload a JPG or PNG image of your process design (max file size: 12 MB).

- Prepare your process flow diagram, including the material and information flows. Be clear about each of the three product types.
- Designate the levels of inventory (work-in-process [WIP] and finished goods [FG] inventory) that you aim to have at the start T= 0:00 of the Factory Demonstration, the levels of each type assumed at steady state, and your predicted final inventory levels of each.

[2] Philosophy. What is your philosophy for how you will run your factory to meet your customer's uncertain demand? (*e.g.*, will you build inventory in advance to a plan – build to stock, build to order, or some other combination strategy?)

[3] Operating metrics.

1. When you produce Economy models, what is the cycle time for each of your process steps?

2. What is the cycle time for the whole assembly process for an Economy model? ___ secs

3. What is the throughput time (TPT) for an Economy model when your factory is operating at steady state? ___ secs

4. How many WIP units and FG units do you expect to create during the Factory Preparation (Phase 2)?

	WIP Units	FG Units
Economy		
Deluxe		
Imperial		

5. How does your output rate influence your strategy for how much and when to purchase raw material?

[4] Critical design considerations. (Each input box has a 200-character limit.)

	Design Feature What are the most important features or performance metrics of your process design?	*Rationale* Why are these features or measures considered important?	*Implementation* How will you incorporate these features in your production process?
Priority #1			
Priority #2			
Priority #3			

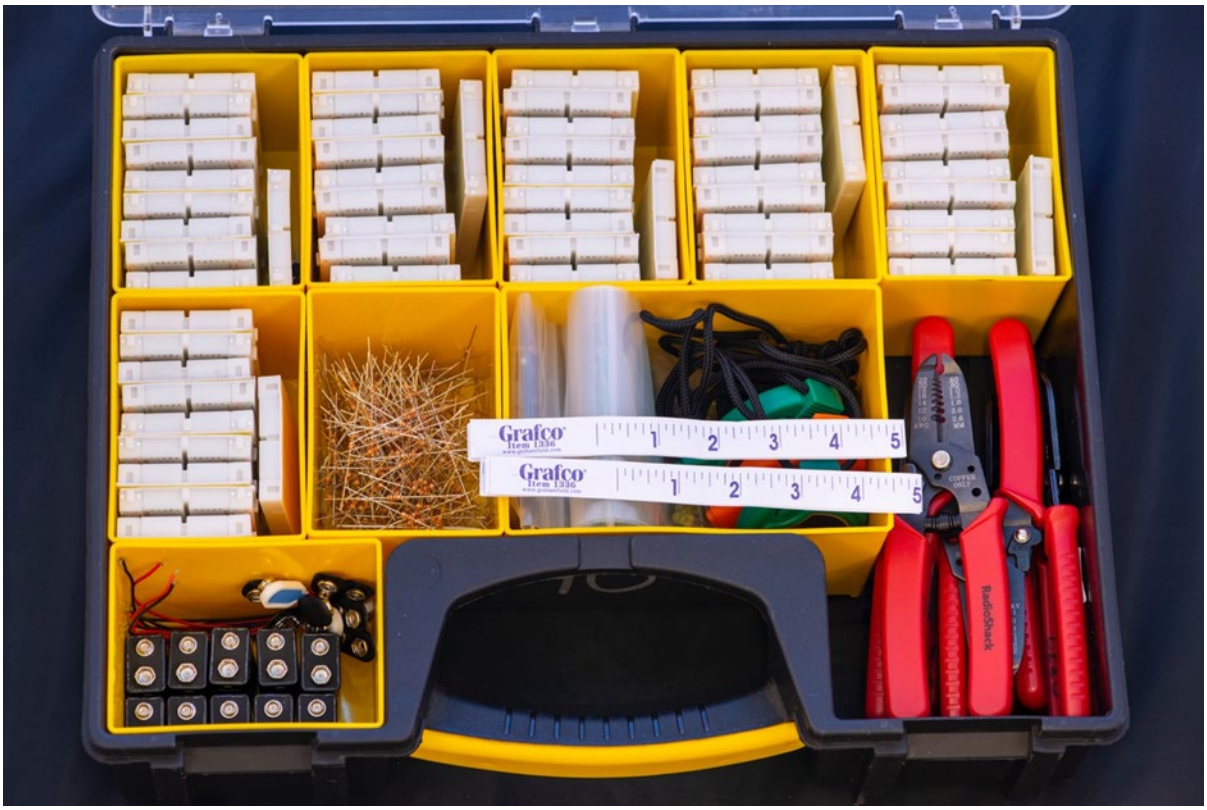
Source: Prepared by casewriter.

Exhibit 5 Materials Kit Contents

Source: Prepared by casewriter.

Note: One meter solid ruler may be substituted for tape measures.

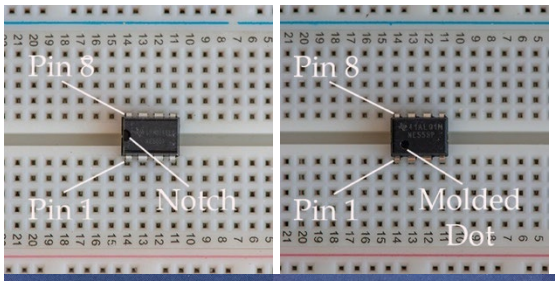
Exhibit 6 Assembled Materials Kit with Packing List

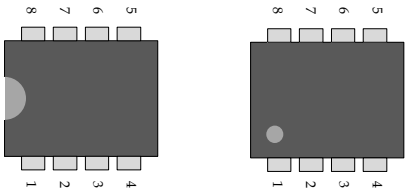


Component	Quantity Provided in Kit	Approximate unit count when provided by weight	Secondary packaging
Plastic carrying case	1 unit		
Yellow plastic insert box, for carrying case	10 units		
IC Chip/Circuit Board Assembly, 2-board press-fit assembly	60 IC Chip/Board subassemblies		Supplied in 10 per box in six yellow plastic insert boxes
Resistor, 1KΩ ¼ watt 5% axial	66.43 grams	350	Supplied in yellow plastic box
Capacitor, 100 µF, Electrolytic Kemet (Blue)	65.13 grams	150	One of two types provided, supplied in plastic bag in shared plastic box
Capacitor, 100 µF, Electrolytic Jackcon (Black)	146.79 grams		
Red LED	14.74 grams	50	Plastic bag, in shared plastic box
Green LED	22.01 grams	75	Plastic bag, in shared plastic box
Yellow LED	8.82 grams	30	Plastic bag, in shared plastic box
Buzzer	30 units		Plastic bag, in shared plastic box
Battery snaps	10 sets		Packed together in yellow plastic box
Batteries	10 units		
Wire Stripper	8 units		
Stop Watch	3 units		Supplied in yellow plastic box
Tape Measures	2 units		Laid on top of yellow plastic boxes; one meter measuring stick may be substituted

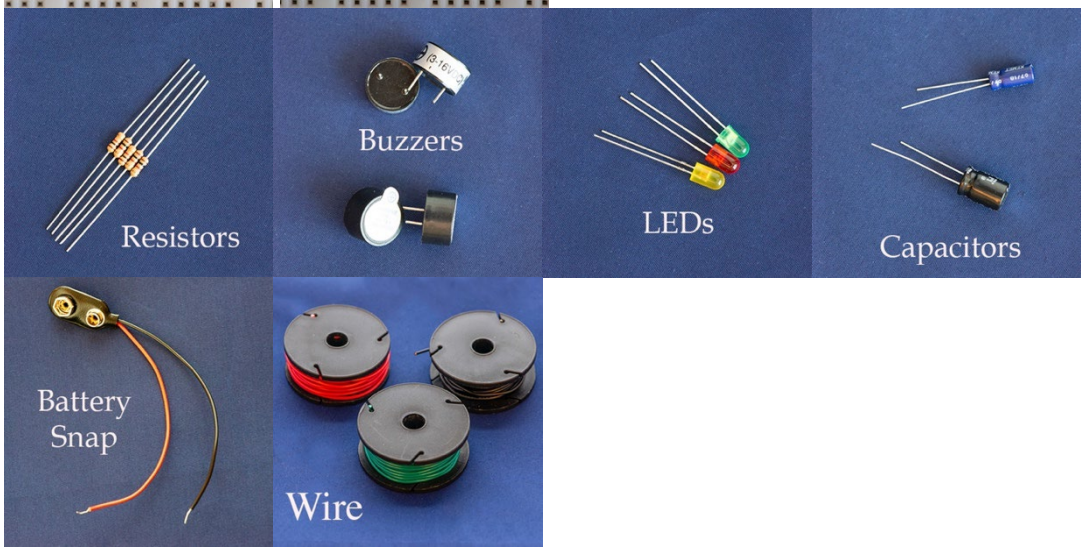
Source: Prepared by casewriter.

Exhibit 7 Component Details





IC Chip Pin Numbering Convention



Source: Prepared by casewriter.

Notes: Component details, showing different types of buzzers, LEDs, capacitors, wire. There are two versions of IC chips used. These have equivalent electrical functions. Wire may be supplied in spools or in bulk. DO NOT peel or remove the sticker from the bottom of the circuit board as this will expose the contacts and make it prone to short-circuits.

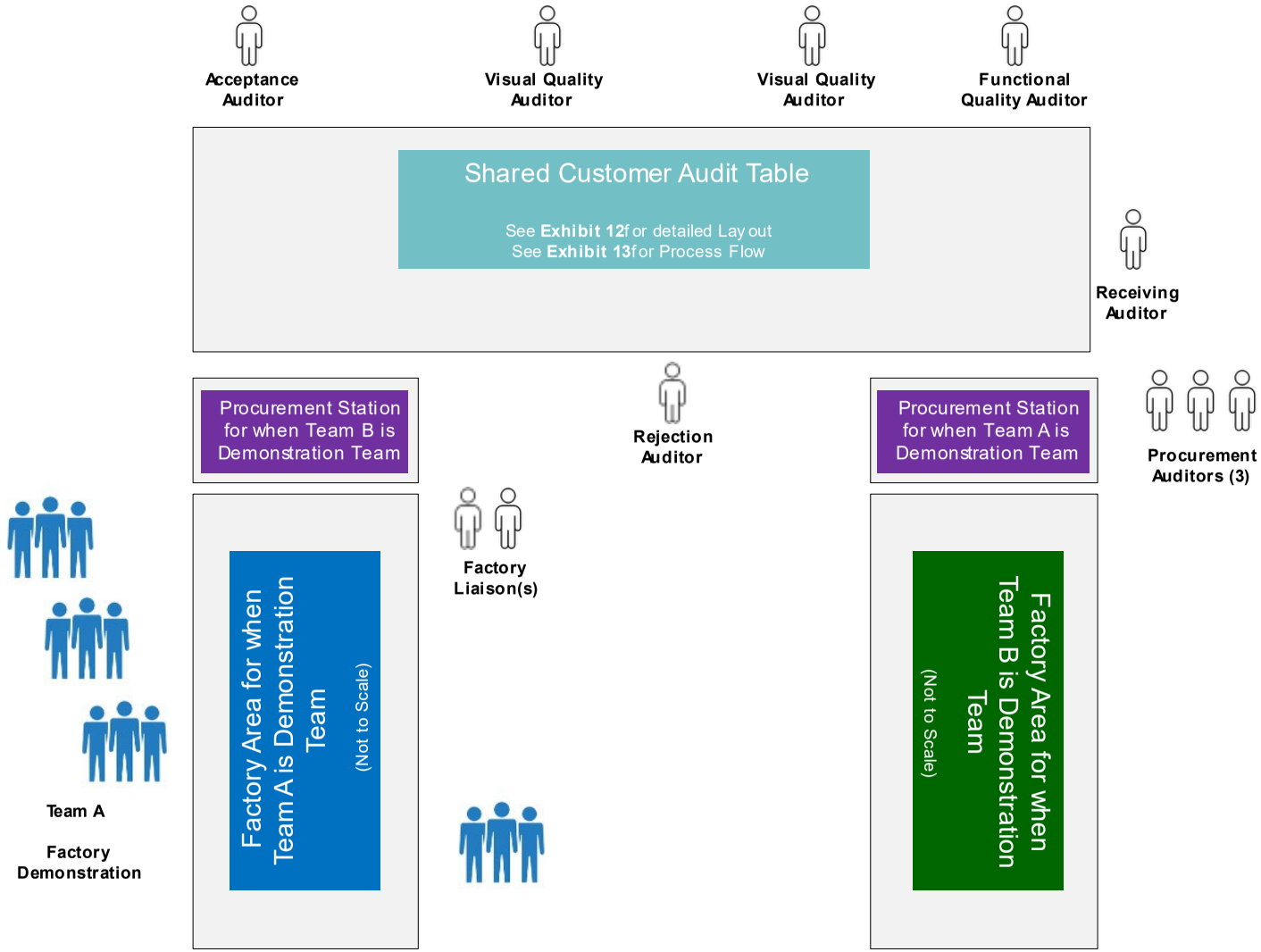
Exhibit 8 Material Costs and Finished Goods Inventory Value

Component Cost		Revenue Credit for Each Unit Delivered and Accepted	
Circuit Board + NE555 IC Chip	$150 each	Economy	$250 each
Capacitor, 100 µF, Electrolytic	$10 each	Deluxe	$260 each
Red LED	$10 each	Imperial	$325 each
Green LED	$10 each		
Yellow LED	$10 each		
Buzzer	$75 each		
Resistor, 1KW ¼ watt 5% axial	$10 each		
Wire, Green, per cm	$2.50 per cm		
Wire, Red, per cm	$2.50 per cm		
Wire, Black, per cm	$2.50 per cm		
Wire, Bare, per cm	$2.50 per cm		

Source: Prepared by casewriter.

Notes: Wire is sold by the cm but used in either 2 cm or 4 cm lengths, thus a 4 cm green wire is valued at $10. Bare wire is "manufactured" by stripping green wire; for inventory accounting bare wire is carried as green wire. You may purchase materials during the first minute of each three-minute cycle. Your inventory will be calculated and displayed in the Shad Universe app continuously, but your inventory held will be recorded at the end of each cycle. This will be calculated as: (Inventory at end of period) = (Inventory held at beginning of period) + (Materials purchases during period) – (cost of components in finished goods that are accepted by customer during period). You will be assessed a one-time charge of 5% of the maximum value during the three-minute period when your inventory holdings were highest. This will be deducted from your overall gross profit.

Exhibit 9 Table Setup



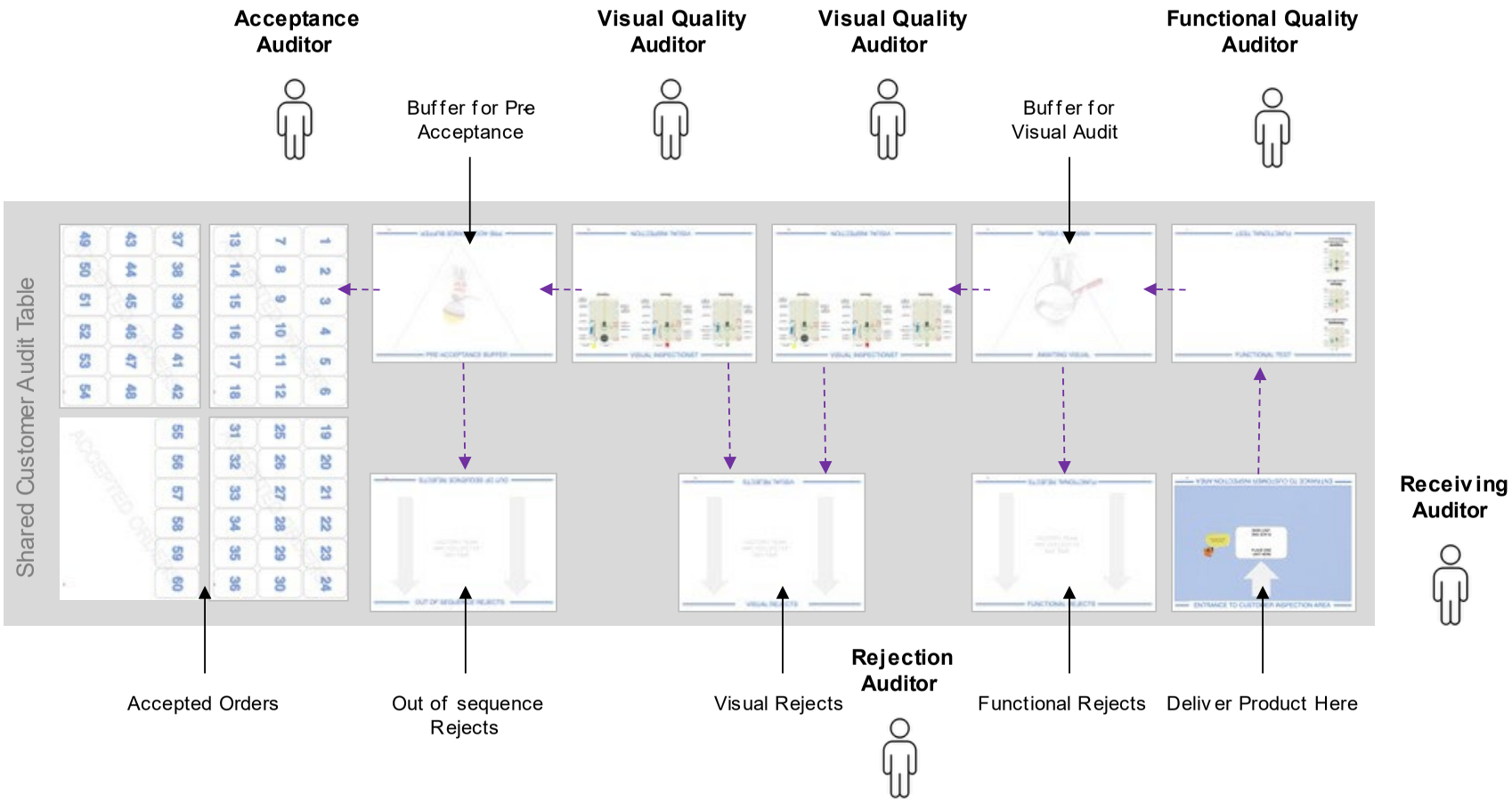
Source: Prepared by casewriter.

Exhibit 10 Shad Universe: Factory Demonstration Support

Shad Universe Tab	Functionality
Dashboard	Open customer orders Real-time financial summary showing revenue from accepted orders, cost of goods sold, gross profit, inventory charge, net profit Units delivered during each time window, delivery failures (products rejected by Customer) Quality metrics
Materials Purchases	Materials Orders by Time Window • Ability to submit purchase orders for current time window (in the first 60 seconds of the time window) • Ability to schedule orders in advance of window opening • Most recent placed and fulfilled orders will appear after submission Quantities of each type of material that have been purchased, by period; materials are charged when Procurement Auditor marks order "ready for pick-up" Table of Product Deliveries – COGS, with net inventory summary
Product Deliveries	Units ordered: Model type and sequence Responsiveness and Rejections statistics

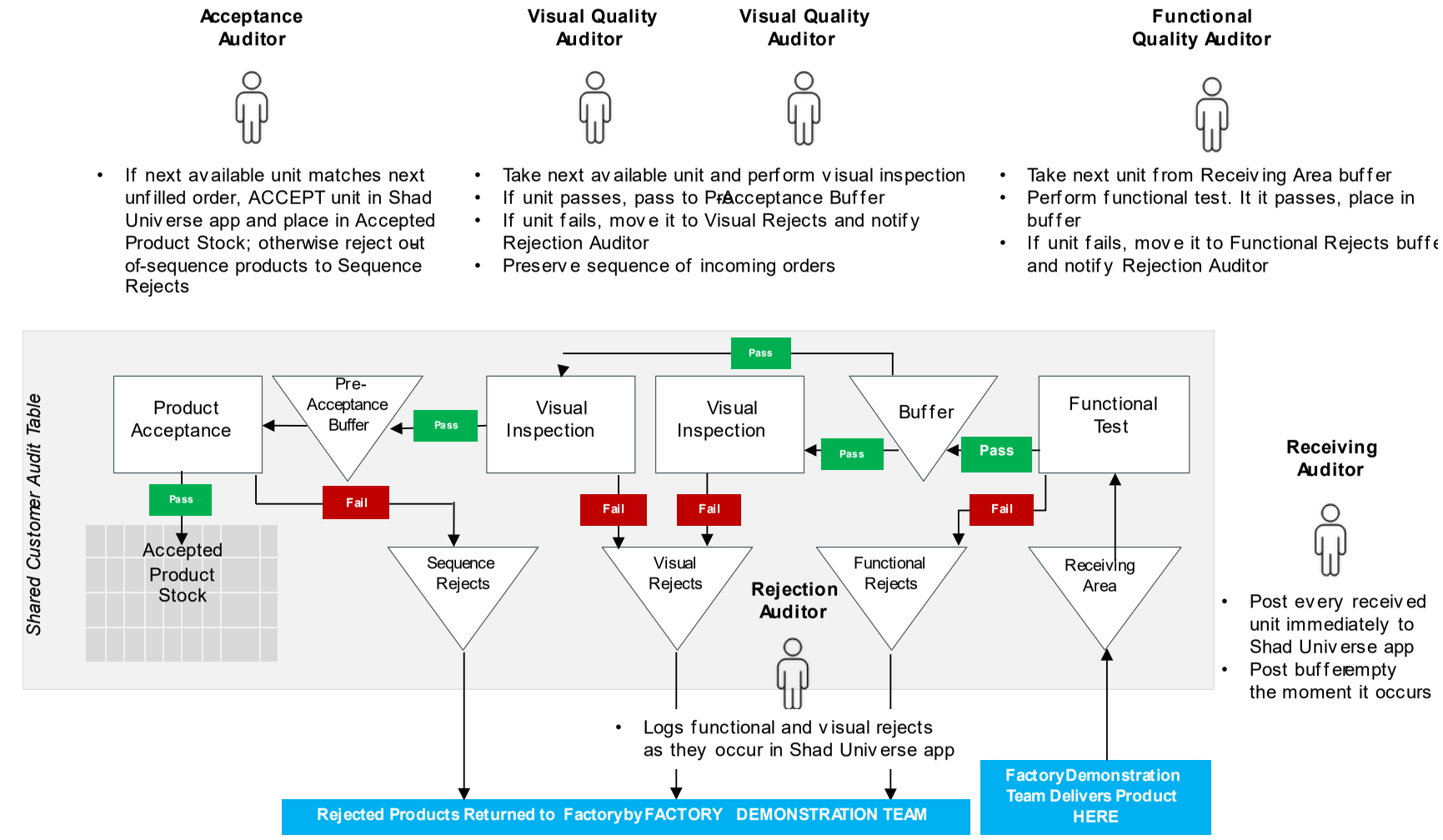
Source: Prepared by casewriter.

Exhibit 11 Shared Customer Audit Table Detailed Layout



Source: Prepared by casewriter.

Exhibit 12 Customer Audit Process Flow



Source: Prepared by casewriter.

Exhibit 13 Shad Universe: Customer Audit Team Support

Role	Data Entry in Shad Universe app?	Functionality | Job Responsibility
Receiving Auditor	Yes	Record deliveries of Factory Demonstration team by indicating product type in Shad Universe app When Functional Quality Auditor takes product for functional test, indicate that the receiving area is empty in Shad Universe app
Functional Quality Auditor	No	Move passed product to the buffer for Visual Audit; report functional quality defects to Rejection Auditor; move defective product to Functional Rejects buffer
Visual Quality Auditor	No	Move passed product to the Pre-Acceptance buffer; report visual quality defects to Rejection Auditor; move defective product to Functional Rejects buffer
Acceptance Auditor	Yes	Accept product if it has passed both quality inspections and it corresponds to the model for the next unfilled order; Reject out-of-sequence product to Sequence Rejects buffer and log rejection in Shad Universe app
Rejection Auditor	Yes	Record functional and visual quality rejects by type in Shad Universe app when notified verbally by one of the Quality Auditors
Procurement Auditor	Yes	Record material purchases by quantity, type, and order window; indicate when ready for pick-up in Shad Universe app
Factory Liaison(s)	No	Observe the factory during the first run and present formal feedback to the Factory Demonstration Team during the first 10 minutes of the Kaizen session. Feedback could include observations on work processes, labor utilization, efficiency of materials planning and usage, effectiveness of quality processes, and other things to help the Factory Demonstration Team improve.

Source: Prepared by casewriter.

Note: The Audit Team should ensure that they can keep up with the 30 second order pace. In other words, they must be able to audit a unit within 30 seconds. Excessive auditing times as measured by the app may lead to sanctions or financial penalties when it is their turn for the factory demonstration run.

Exhibit 14 Factory Simulation Detailed Timeline

Time	Factory Demonstration Team Activities		Customer Team Activities	
	Production Process Demonstration	**Materials procurement**	**Materials Supply**	**Order Testing and Acceptance**
T–6:00	Setup factory demonstration.	Place materials order, nine board maximum. Do this within the first minute to assure delivery within this 3-minute window. Supply chain team should prepare remote procurement if needed.	Fill materials orders during third minute of window, and mark orders as ready for pickup in Shad Universe app	
T–3:00	Begin production, produce desired work-in-process and finished goods inventory.	Place materials order, nine board maximum. Do this within the first minute to assure delivery within this 3-minute window.	Fill materials orders during third minute of window, and mark orders as ready for pickup in Shad Universe app	
T=0:00	Receive first order at T = 0:00 Subsequent orders will appear every 30 seconds. Deliver in the correct sequence.	Place materials order, nine board maximum. Do this within the first minute to assure delivery within this 3-minute window.	Fill materials orders during third minute of window, and mark orders as ready for pickup in Shad Universe app	Receive delivered units, perform Functional Test and Visual Inspection, accept if in correct sequence. Place all rejects in reject buffers for factory team to collect
T+3:00	Orders will appear every 30 seconds. Deliver in the correct sequence.	Place materials order, nine board maximum. Do this within the first minute to assure delivery within this 3-minute window. Board limit = 60 total.	Fill materials orders during third minute of window, and mark orders as ready for pickup in Shad Universe app	Receive delivered units, perform Functional Test and Visual Inspection, accept if in correct sequence. Place all rejects in reject buffers for factory team to collect
T+6:00				
T+9:00				
T+12:00	Repeat	Repeat	Repeat	Repeat
T+15:00				
T+18:00				
T+21:00				
T+24:00				
T+27:00	Latest possible last order will be issued at T=29:30			

Source: Prepared by casewriter.

Appendix A: Conducting Your Kaizen

During the Shad exercise, your team will conduct a short Kaizen focused on the rapid improvement of your process and overall activity. Because the Kaizen will be completed in a compressed time frame, the emphasis should be on solutions that your team can implement immediately.[1] The goal here is to analyze every step in your process to identify opportunities to eliminate various forms of *muda* (waste), such as:

- **Overproduction**—includes excessive work-in-process inventory and long lead times and storage times, which can delay the detection of defects, and inhibit quality and productivity.
- **Waiting**—occurs when goods are not moving or being worked on.
- **Transport**—involves goods being moved about; any unnecessary transport is considered waste. Arranging process steps to minimize handling improves the flow of work, improves communication between workers, and reduces damage to work-in-process.
- **Overprocessing**—consists of adding more value to a product than the customer actually requires.
- **Unnecessary inventory**—requires storage space, increases holding costs, and tends to increase lead times and slow down the identification of problems because defective parts may be in work-in-process for a longer period of time.
- **Unnecessary movement**—concerns the ergonomics of processes where workers have to stretch, bend, or pick items up. Unnecessary movements are tiring for workers and often lead to quality problems.
- **Defects**—incur direct costs and provide opportunities for immediate improvement. [2]

Kaizen emphasizes five approaches to eliminate *muda* that are referred to as the five S's (5s):

- **Sort.** Make work easier by eliminating obstacles and unnecessary items and removing all parts and tools that are not in use. Unwanted materials are segregated from the workspace.
- **Set in order.** Arrange items so that they can be easily selected and used. Work is arranged so that everything is in close proximity to avoid wasted motion. It should be easy to find and pick up items. Components should be placed according to where they will be used, with the closest being those most frequently used. The workflow should be smooth and easy.
- **Shine.** The workplace should be cleaned on a regular basis. Most teams use cleaning as an inspection opportunity. The space should be a clean and pleasing place to work.

[1] For more details, see Willy Shih, "Conducting a Kaizen," HBS No. 619-016 (Boston: Harvard Business School Publishing, 2018).

[2] These forms of *muda* and the 5s description are excerpted from "Conducting a Kaizen," note (HBS no. 619-016), and are based on Tatiana Karkoszka and J. Honorowicz, "Kaizen Philosophy a Manner of Continuous Improvement of Processes and Products," *Journal of Achievements in Materials and Manufacturing Engineering* 35, no. 2 (2009): 197–203; and Jagdeep Singh and Harwinder Singh, "Kaizen Philosophy: A Review of Literature," *IUP Journal of Operations Management* 8, no. 2 (2009): 51–73.

- **Standardize.** Procedures and schedules should be established to ensure consistency. Everyone should know their responsibilities. Photos, visual controls, and standardized color codes should make things obvious.
- **Sustain.** Workers should be able to do all of these steps without being told. Management should lead regular trainings and audits. Everyone should follow the process but be open to improvement.

During **Day 2**, after each team finishes demonstrating their process as part of Factory Demonstration Run 1, they should leave the demonstration area "as is" so that each team can conduct its Kaizen after both teams have completed their Run 1 demonstration. The goal of this Kaizen is for your team to develop a set of ideas to improve your process further for Run 2 and to anticipate their impact on key performance indicators (KPIs).

Your team should begin by reviewing your team's intact demonstration area (how it was left after Run 1) to look for clues and insights about improvement opportunities. **Table A-1** describes the required steps and suggested timing. Document your Kaizen ideas as you go. **Table A-2** provides a structure that your team should use on your whiteboard to prepare your Kaizen deliverable. Your team should brainstorm a host of ideas to reduce different forms of *muda* and write these ideas in the first column. Your team should then choose a subset of these ideas to implement for Run 2 and complete the remaining columns on the whiteboard pertaining to those ideas, documenting each one's anticipated impact on one or more KPIs. A photo of your whiteboard will serve as your Kaizen report. As soon as your team completes the Kaizen, your *Team Captain should submit a photo of your whiteboard to Shad Universe as the required Kaizen deliverable*.

Table A-1 Kaizen Tasks and Schedule

Suggested Time	Kaizen Tasks
10 minutes	**Customer Feedback.** Receive formal customer feedback from your Customer Audit Team.
10 minutes	**Review.** Review your existing process and consider how it aligned with and differed from your original process design. You should be sure to look at the overall process, including procurement and delivery to the Customer Quality Inspection Area. Pay particular attention to the processes that were used for handling rejects, causes of starving of the Line-side Stock buffer, procurement, and anything that touched your value stream.
5 minutes	**Choose KPIs.** As a team, establish the KPIs that you want to improve. These might include the time to complete particular steps, cycle time, quality metrics, work-in-process inventory levels, or other performance indicators. You may choose to use some of the metrics from your production process design (see **Exhibit** 6).
15-20 minutes	**Brainstorm.** Brainstorm improvement ideas and record these ideas in the first column of your whiteboard. Look for any of the forms of *muda* and consider some of the 5s principles as well. Write down specific improvement ideas, and make sure you solicit ideas from all team members. Prototype your improvements.
15-20 minutes	**Test.** Run your process with these improvements, and measure changes in your KPIs.
15-20 minutes	**Report.** Prepare the management presentation of results by completing the remaining columns pertaining to the ideas that you prototyped and tested.

Suggested Time	Kaizen Tasks
5 minutes	**Submit**. Team Captains should upload your Kaizen management presentation to Shad Universe.

Table A-2 Kaizen Whiteboard Structure

Kaizen of Team Number: ____			
Muda (waste)	**Plan to Improve**	**Change to be Implemented for Run 2**	**Anticipated Impact on KPIs**
Overproduction			
Waiting			
Transport			
Inappropriate Processing			
Unnecessary Inventory			
Unnecessary Movement			
Defects			
Other			

Source: Prepared by casewriter.

Notes: This table provides the structure of the whiteboard that each team should create for its Kaizen. Your team should complete at least four rows. At the end of the Kaizen, your Team Captain should submit a photo of this whiteboard in Shad Universe as your team's Kaizen required submission.