The Paper Airplane Factory - *Observer/Customer Score Sheet*

Level Loading Time Study Sheet
Fill out sheet to assist with level loading.

Team Name: _____

	Time (Seconds)
Fold 1:	
Fold 2:	
Fold 3:	
Fold 4:	
Fold 5:	
Fold 6:	
Fold 7:	
Fold 8:	
Fold 9:	

Step 1: Pick one person to make an entire airplane.

Step 2: Using this sheet, record the time it takes to make each individual fold of the airplane.

Step 3: Divide the folds up among your assembly line employees so that every station has the same cycle time.

Paper Airplane Simulation – Facilitator Guide

Observations

1. Teams will react to WIP and start cutting production back to avoid having any WIP. To account for this, don't tell them how long the round is or give them time during the round to adjust. Changed last round to 6 minutes and didn't tell them and it worked.
2. Teams can be over sensitive to WIP particularly if it is too high. Teams will loose sales trying to keep WIP down. To address, I changed the WIP cost to $2 from $4.

Paper Airplane Simulation – Facilitator Guide

Facilitator determines customer order by randomly pulling colors from a draw box. To assist observers/customers you may have the drawing before class and give the order out to observers/customers in advance. This will give them a list to check off and help them maintain correct order.

Final round lasts 6 minutes

First minute – pull one color every 20 seconds (3)
Second minute – pull one color every 15 seconds (4)
Third minute – pull one color every 10 seconds (6)
Fourth minute – pull one color every 10 seconds (6)
Fifth minute – pull one color every 10 seconds (6)
Sixth minute – pull one color every 10 seconds (6)

At the end of the round, observer is to fill out the round score card for the team and turn in to the scorekeeper.

Scorekeeper writes scores on the board.

Earnings/loss will determine who gets all the future airplane business (the winner).

Paper Airplane Simulation – Facilitator Guide

Customer Instructions:

Be animated and make it fun. When you don't get what you want, let them know. Push them to be faster and faster in rounds 1 – 3.

Sales: In rounds 1 through 3 you will buy every airplane the team can make. In round 4, you will only take the planes ordered in the sequence they were ordered. Reject any planes that are not delivered in sequence.

Quality:

- **Round 1:** Customer should be aggressive. Any airplanes with excess, missing, or improper folds should be rejected and scrapped.
- **Round 2:** Ideally you want teams to show improvement in quality and fewer rejects. Consider planes that have all the folds in generally the right place with no extra or missing folds to be good quality.
- **Round 3:** Same as round 2. Consider planes that have all the folds in generally the right place with no extra or missing folds to be good quality.
- **Round 4:** Reject only planes that are missing folds or those that clearly have bad folds. Only accept planes that are delivered in order. Do NOT accept any planes out of order.

Assistance:

Help teams as much as you want during rounds 1 through 3. The goal in these rounds is for students to get an understanding of the concepts presented.

Round 4 is for competition and help should be at a minimum. Students are on their own to take what they have learned and build a successful factory.

"X" Plane

In rounds 1 through 3 teams are to manufacture 1 "X" plane. The "X" plane is simply a sheet of paper with an "X" drawn on it. Your job is to time how long it takes the "X" plane to go from an order to a delivery.

At about 1 minute into the round, you will instruct the teams to build the "X" plane (sheet of paper with a large "X" on it). Use a stop watch to determine the lead-time to manufacture the "X" plane.

There is no "X" plane in round 4.

Paper Airplane Simulation – Facilitator Guide

One observer per team serves as the customer. Airplanes produced must satisfy the customer. Customer determines quality and rejects. Any rejects will count as scrap. Rework of airplanes that have been sent to the customer is not allowed.

Quality – Ideally you want teams to show improvement in quality and fewer rejects. Consider planes that have all the folds in generally the right place with no extra or missing folds to be good quality.

Begin the simulation. Simulation is to last 5 minutes.

At the end of the round, observer is to fill out the round score card for the team and turn in to the scorekeeper.

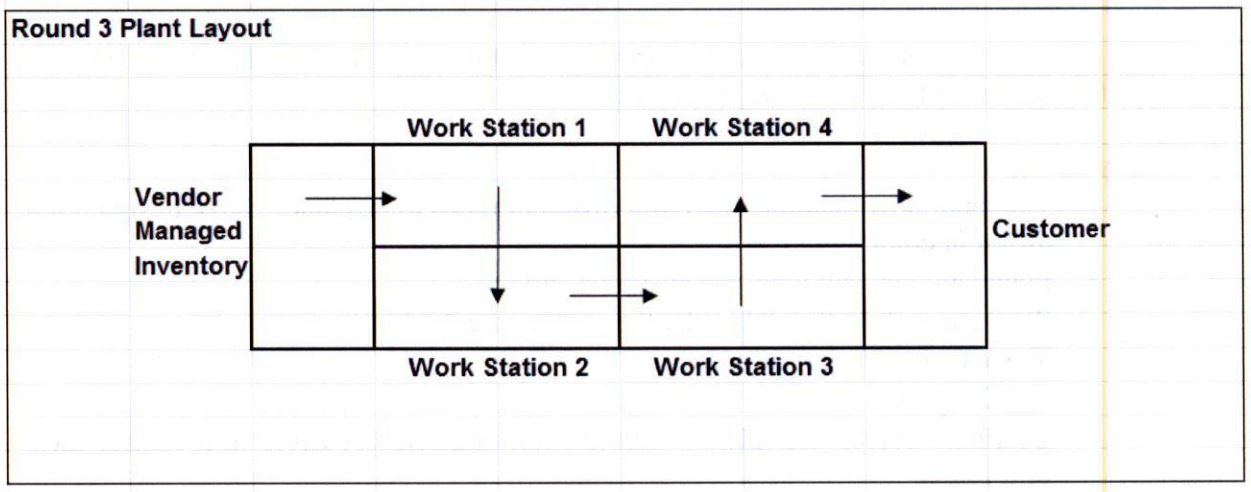
Scorekeeper writes scores on the board.

Results are discussed.

Round 3:

Teams are instructed to setup an OPS manufacturing plant. The plant is to consist of 4 workers.

Plant layout is to be set up per the diagram below.



Plant is to include level loading for each workstation.

Team is to implement a Kanban. Post-It notes at each workstation represent the Kanban to be filled. There should be one piece of WIP between workstations and 1 finished plane in the finished goods Kanban. Kanban is to be filled prior to the start of the round.

Paper Airplane Simulation – Facilitator Guide

Teams have 15 minutes to design level loading system, prepare the plant and fill Kanbans.

Raw materials are unlimited.

Business is good. The plant can sell as many airplanes as it can build.

One observer per team serves as the customer. Airplanes produced must satisfy the customer. Customer determines quality and rejects. Any rejects will count as scrap. Rework of airplanes that have been sent to the customer is not allowed.

Quality – Same as round 2. Consider planes that have all the folds in generally the right place with no extra or missing folds to be good quality.

Begin the simulation. Simulation is to last 5 minutes.

At the end of the round, observer is to fill out the round score card for the team and turn in to the scorekeeper.

Scorekeeper writes scores on the board.

Results are discussed.

Round 4 – Final Round:

All previous scores are thrown out. Earnings/loss for this round will determine who gets all the future airplane business (the winner).

Key changes

- The plant now manufactures four different types of airplane. Same design but 4 different colors.
- Plant can only sell what the customer orders.
- Plant can only sell in the order the customer calls for it.
- You cannot ship out of order.
- No "X" plane
- **Quality – reject only planes that are missing folds or those that clearly have bad folds.**

Teams are free to set up the plant as they wish – tables, people, Kanban, etc

Teams have 15 minutes to prepare the plant and **fill any Kanbans** they may have.

Raw materials are unlimited.

Paper Airplane Simulation – Facilitator Guide

At the end of the round, observer is to fill out the round score card for the team and turn in to the scorekeeper.

Scorekeeper writes scores on the board.

Do NOT count unfolded sheets as WIP

Facilitator writes scoring system on the board.

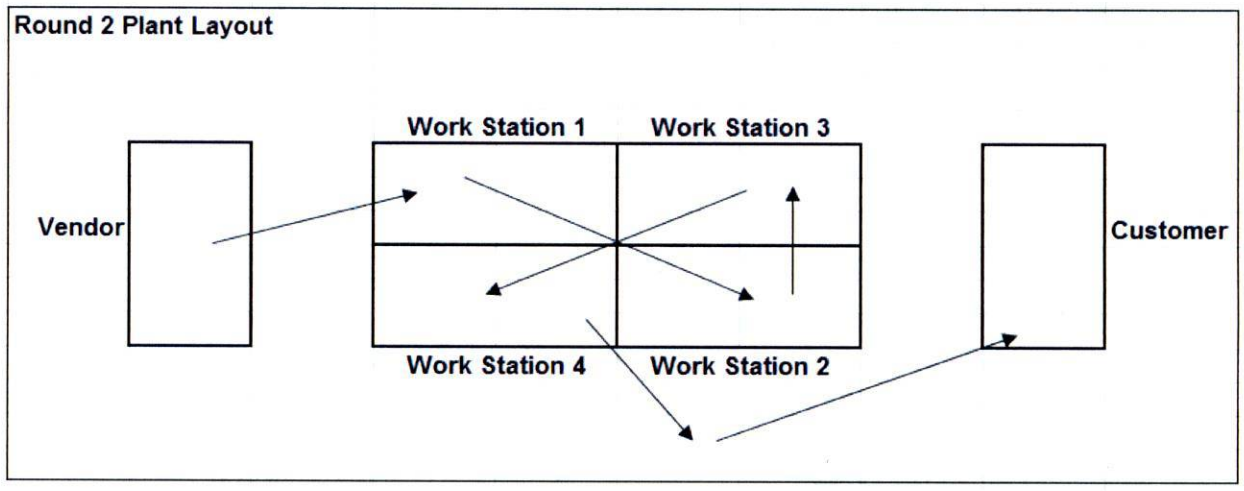
Results are discussed.

Round 2:

Teams are instructed to setup a mass production assembly line to manufacture their airplanes. Plant is to consist of 4 assembly line workers.

Raw materials move from the vendor to Work Station 1. WIP moves from WS1 to WS2, WS2 to WS3, and WS3 to WS4. Finished goods move from WS4 to customer.

Plant is to be setup as follows



Facilitator writes costs associated with the manufacturing plant on the board.

Give teams 5 minutes to setup their plant.

Raw materials are unlimited.

Business is good. The plant can sell as many airplanes as it can build.

Paper Airplane Simulation: Instructions for Quality/Customers

Round 1: Be aggressive. Any airplanes with excess, missing, or improper folds should be rejected. Have fun with it. It is good to be a little picky.

Airplanes produced must satisfy the customer. Customer determines quality and rejects. Any rejects will count as scrap. Rework of airplanes that have been sent to the customer is NOT allowed.

NOTE: When counting WIP, unfolded sheets are not WIP.

Round 2: Ideally you want teams to show improvement in quality and fewer rejects. Consider planes that have all the folds in generally the right place with no extra or missing folds to be good quality.

Round 3: Same as round 2. Consider planes that have all the folds in generally the right place with no extra or missing folds to be good quality.

Round 4: Reject only planes that are missing folds or those that clearly have bad folds. Only accept good airplanes delivered in order. Do not accept any planes delivered out of order.

Paper Airplane Simulation – Facilitator Guide

Round 1:

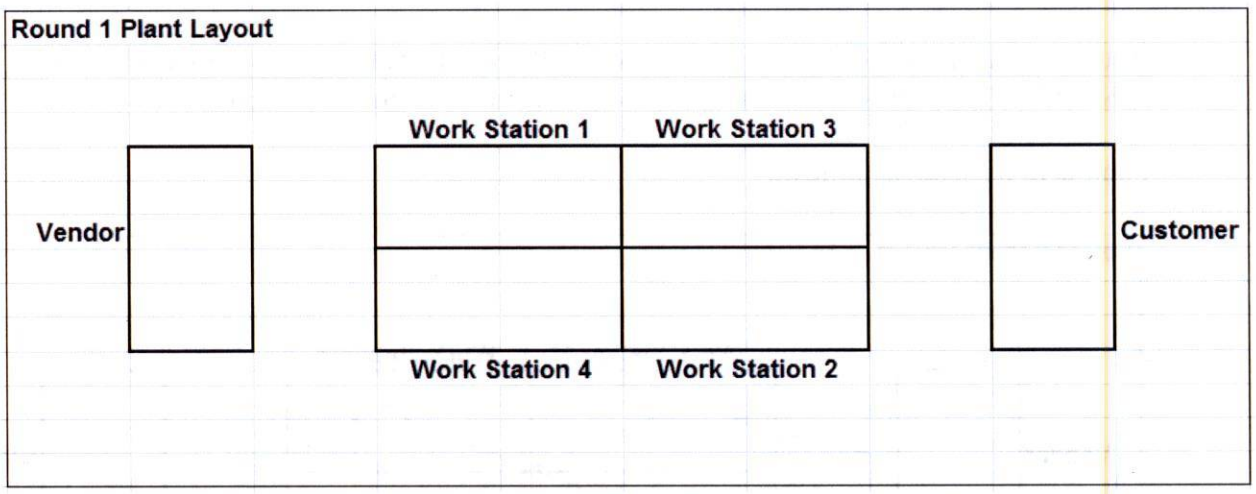
Teams of 4:

Explain to the teams that they are to set-up an airplane assembly plant. Plant is to consist of a 4 crafts people. Each craft person is to assemble an entire airplane.

One of the 4 craft persons is to be a team leader. The team leader is responsible for training the other 3 employees.

There is no material handler. The employees are responsible for their own material handling in whatever fashion the team or team leader decide.

Have teams set up plant as follows:



Team leader attends brief training session where he/she is showed how to build an airplane. No handouts and no standards should be used. Team leader then returns to the plant and trains the employees. Team leader has 5 minutes to train the plant employees.

Raw materials are unlimited.

Business is good. The plant can sell as many airplanes as it can build.

One observer per team serves as the customer. Airplanes produced must satisfy the customer. Customer determines quality and rejects. Any rejects will count as scrap. Rework of airplanes that have been sent to the customer is **NOT** allowed.

Quality – customer should be aggressive. Any airplanes with excess, missing, or improper folds should be rejected and scrapped.

Begin the simulation. Simulation is to last 5 minutes.

Paper Airplane Factory - Facilitator Score Sheet

Round 3 Performance Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold						
WIP						
Scrap						
# People						

Round 3: Cost Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold	$0	$0	$0	$0	$0	$0
WIP	$0	$0	$0	$0	$0	$0
Scrap	$0	$0	$0	$0	$0	$0
# People	$0	$0	$0	$0	$0	$0
Mat. Cost (Planes Sold)	$0	$0	$0	$0	$0	$0
Profit/(Loss)	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*

Round 4 Performance Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold						
WIP						
Scrap						
# People						

Round 4: Cost Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold	$0	$0	$0	$0	$0	$0
WIP	$0	$0	$0	$0	$0	$0
Scrap	$0	$0	$0	$0	$0	$0
# People	$0	$0	$0	$0	$0	$0
Mat. Cost (Planes Sold)	$0	$0	$0	$0	$0	$0
Profit/(Loss)	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*

Paper Airplane Factory - Facilitator Score Sheet

Airplane Simulation Terms

Good Airplanes Sold:	Good airplanes produced and shipped to the customer.
WIP:	Work-In-Process Inventory. # of partially assembled airplanes in the plant. Do NOT count unfolded sheets. Material in Kanbans is considered WIP Unfolded sheets are NOT considered WIP
Scrap:	Scrap airplanes produced inside the plant and those rejected by the customer.
# People:	Number of people employed by the plant for a given round.
Material Cost of Planes Sold:	Represents raw materials used in the planes that were sold.

Airplane Factory Cost Scale (x $1,000)

Sales Price	$30	sales price per airplane
WIP	$10	work in process material cost per airplane
Bad (Scrap)	$15	scrap airplanes. Bad folds have to be scrapped.
Employees	$30	per employee per round.
Material Cost	$10	per airplane

Round 1 Performance Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold						
WIP						
Scrap						
# People						

Round 1: Cost Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold	$0	$0	$0	$0	$0	$0
WIP	$0	$0	$0	$0	$0	$0
Scrap	$0	$0	$0	$0	$0	$0
# People	$0	$0	$0	$0	$0	$0
Mat. Cost (Planes Sold)	$0	$0	$0	$0	$0	$0
Profit/(Loss)	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***

Round 2 Performance Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold						
WIP						
Scrap						
# People						

Round 2: Cost Metrics

	Team A	Team B	Team C	Team D	Team E	Team F
Good Airplanes Sold	$0	$0	$0	$0	$0	$0
WIP	$0	$0	$0	$0	$0	$0
Scrap	$0	$0	$0	$0	$0	$0
# People	$0	$0	$0	$0	$0	$0
Mat. Cost (Planes Sold)	$0	$0	$0	$0	$0	$0
Profit/(Loss)	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***

The Paper Airplane Factory - *Observer/Customer Score Sheet*

4

Round 4: Customer Score Sheet
Fill out sheet and give to score keeper/customer at end of round.
Observers should assist customer with order of delivery.

Team Name: _____
(A, B, C, D, E, or F)

Good Airplanes Sold: _____ Good airplanes delivered in order to the customer. Accept no deliveries out of order.

WIP: _____ Work-In-Process Inventory. # of partially assembled airplanes in the plant. Do NOT count unfolded sheets. Count all folded sheets not sold including Kanbans.

Scrap: _____ Scrap airplanes produced and those rejected by the customer. Rework not allowed after customer receives.

 # People: _____ Include workers, material handlers, managers, etc.

The Paper Airplane Factory - *Observer/Customer Score Sheet*

2

Round 2: Customer Score Sheet
Fill out sheet and give to score keeper/customer at end of round.

Team Name: _____
(A, B, C, D, E, or F)

Good Airplanes Sold: _____ Good Airplanes Sold

WIP: _____ Work-In-Process Inventory. # of partially assembled airplanes in the plant. Do NOT count unfolded sheets. Count all folded sheets not sold including Kanbans.

Scrap: _____ Scrap airplanes produced and those rejected by the customer. Rework not allowed after customer receives.

 # People: _____ Include workers, material handlers, managers, etc.

The Paper Airplane Factory - *Observer/Customer Score Sheet*

3

Round 3: Customer Score Sheet
Fill out sheet and give to score keeper/customer at end of round.

Team Name: _____
(A, B, C, D, E, or F)

Good Airplanes Sold: _____ Good Airplanes Sold

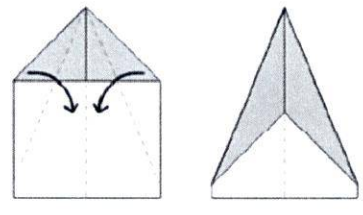
WIP: _____ Work-In-Process Inventory. # of partially assembled airplanes in the plant. Do NOT count unfolded sheets. Count all folded sheets not sold including Kanbans.

Scrap: _____ Scrap airplanes produced and those rejected by the customer. Rework not allowed after customer receives.

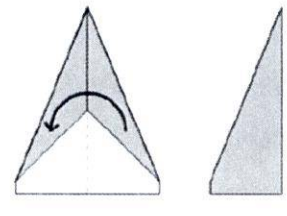
 # People: _____ Include workers, material handlers, managers, etc.

Paper Airplane Folding Instructions

- Folds 4 and 5: Fold each side again. Make sure the edges line up with the center crease.

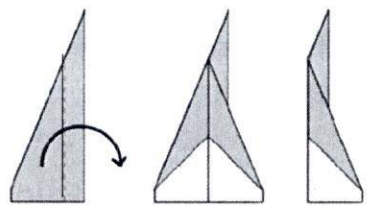


- Fold 6: Fold the paper in half along the center crease.

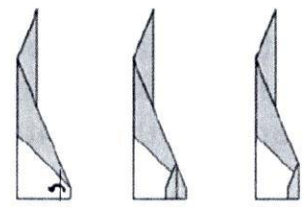


Paper Airplane Folding Instructions

- Folds 7 and 8: Fold the wing along the line shown. Repeat on the other side.



- Folds 9 and 10: Fold the wing fin along the line shown. Repeat on the other side.



The Paper Airplane Factory - *Observer/Customer Score Sheet*

1

Round 1: Customer Score Sheet
Fill out sheet and give to score keeper/customer at end of round.

Team Name: _____
(A, B, C, D, E, or F)

Good Airplanes Sold: _____ Good Airplanes Sold

WIP: _____ Work-In-Process Inventory. # of partially assembled airplanes in the plant. Do NOT count unfolded sheets. Count all folded sheets not sold including Kanbans.

Scrap: _____ Scrap airplanes produced and those rejected by the customer. Rework not allowed after customer receives.

 # People: _____ Include workers, material handlers, managers, etc.

Paper Airplane Simulation

Folding Instructions

Paper Airplane Folding Instructions

- Fold 1: Fold paper in half, crease the edge and unfold.
- Folds 2 and 3: Fold the two upper corners down at a 45-degree angle. Make sure the edges line up with the center crease.