LEAN ROBOTICS

Surface Finishing Cobot Cell

Lean Robotics in Action

ROBOTIQ eLearning

Surface Finishing Application Example

For this example, let's take a look at how a chair manufacturer with new business contracts that requiring the workers to do other tasks.

The manufacturer needs to keep its production quality and reallocate workers to quality improvement tasks. Let's have a look on how the Lean Robotics methodology can help them reach their goal.

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Manual Map - Overview

Steps	Information to capture
1. Identify cell's customer	Where do the parts go when the station is done with them?
2. Define output	What are the qualities of a "good input" for the next station? In other words, how does the customer define value? • Parts and their specifications • Part presentation method • Pace/cycle time
3. Define input	What is coming to this station? • Parts and their specifications • Part presentation method • Pace/cycle time
4. Define process	How are the parts processed? • Which steps are done manually? • Which steps are value-added? Which are not?

Manual Map - Overview

Steps	Information to capture
5. Document flow of information	• What information is used at the station? • Where does it come from? In which form? • What information is produced and transferred from the station? Where to, and in what form?
6. Measure KPIs	• What are the KPIs and their target values? • How will the KPIs be measured? KPI examples include: • Cost of producing parts • Cycle time • Inventory at cell
7. Summarize map	• Combine all the previous information in a visual representation of the map
Manual Cell Layout	
Sketch current layout	• What is the current spatial arrangement of the station?

Manual Map

1. Identify cell customer

The cell's customer is the next station where the chair is assembled.

2. Define valuable output

As the internal customer (the operator), what I need you to give me is…
12.25 parts every 2 hours (50 parts/day).

… so I can…
Transport them to the assembly station.

Manual Map - Output

Are the parts singulated? What is the space around them?

The parts are located on a table and need to be picked manually.

What is the actual presentation?

On a table, one on top of the other.

Is the output target moving? How so?

No. They are on a stable surface.

Manual Map - Input

Number of parts

2 different models

Characteristics of the parts

Size:

max: 70 cm x 50 cm x 10 mm curved

min: 45 cm x 30 cm x 10mm curved

Weight: max: 1 kg

Material: Wood

Manual Map - Input

Variation in time

Are there changeovers at this station?

Once a week

Are you planning to introduce new parts in the near future?

Maybe in 9-12 months, similar kind of blank at input, will be within min-max defined above.

Manual Map - Input

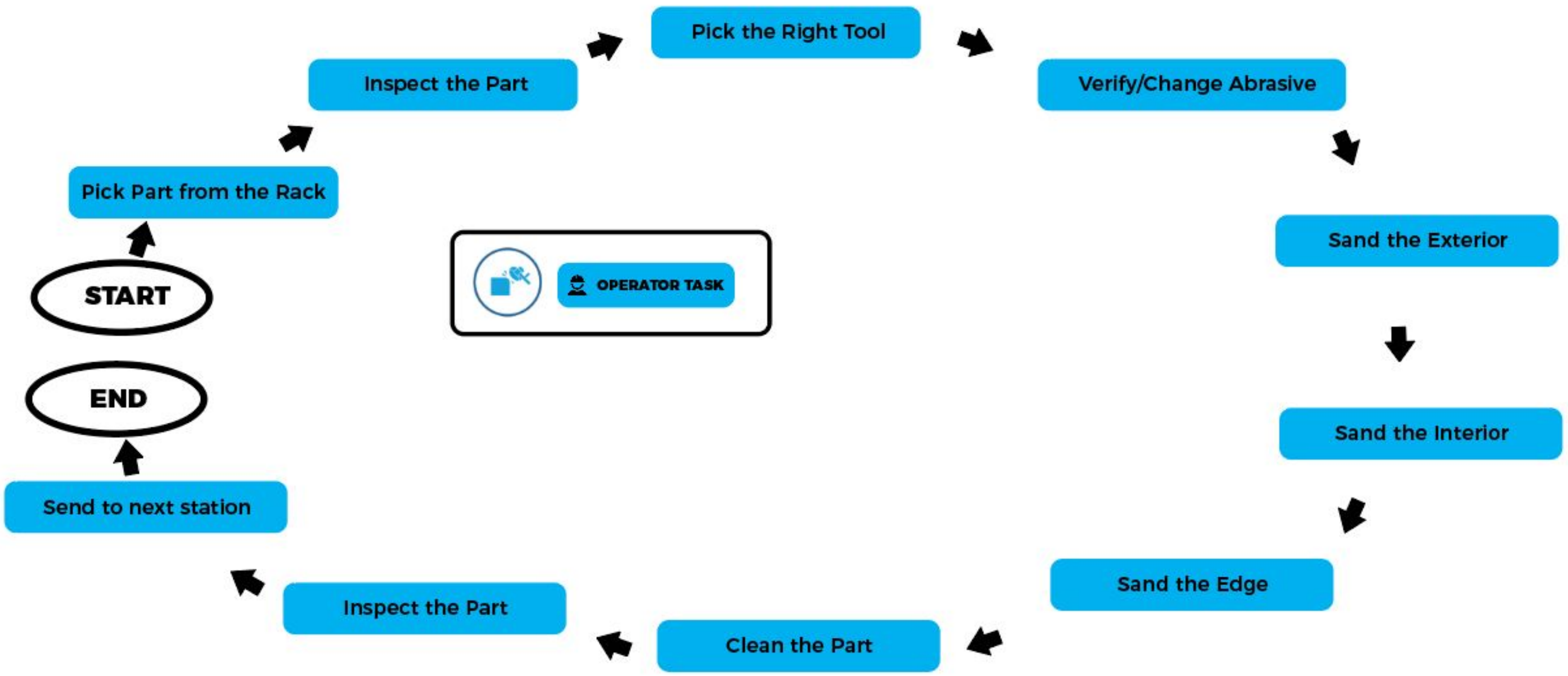
Part presentation

Are the parts singulated? What is the space around them?
Stacked on top of each other.

What is the actual presentation?
On a table.

Are parts moving when presented? How so?
Stopped when picked.

Manual Process



Manual Map - Process

	Non-Value-Added Time (seconds)	Value-Added Time (seconds)	Total Time (seconds)
Pick the part from the rack	5	-	5
Inspect the part	10	-	10
Pick the right tool	5	-	5
Verify/Change the abrasive medium	10	-	10
Sand the exterior of the part	-	120	120
Sand the interior of the part	-	120	120
Sand the edge of the part	-	60	60
Clean the part	15	-	15
Inspect/rework the part	70	-	70
Place part in next station’s rack	5	-	5
Total (s)	120	300	420

Manual Map - Information Flow

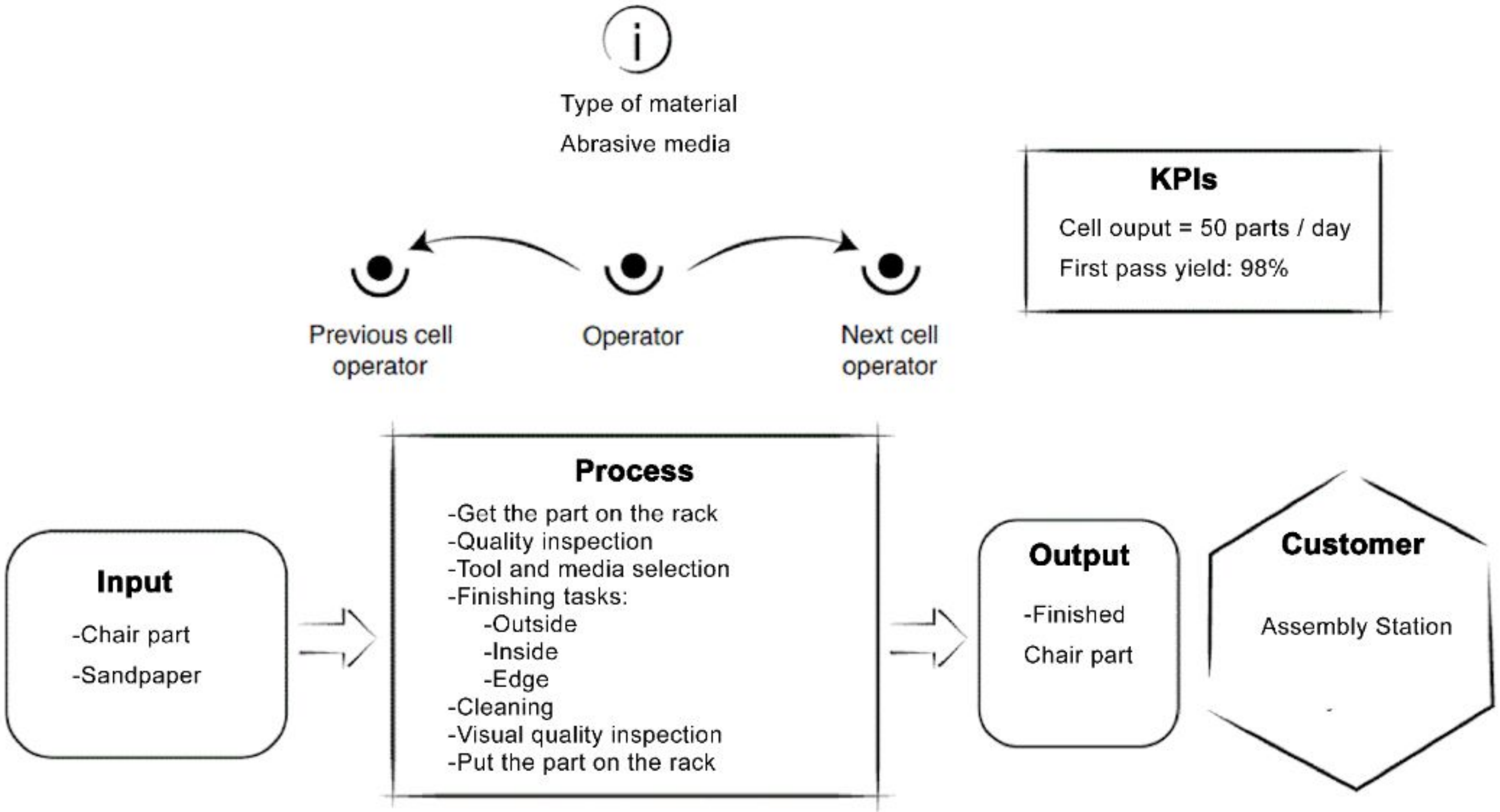
Information	Coming from	Going to	Format	How it's used
No infeed parts	Cell operator	Previous cell operator	Verbal	• Previous cell operator gets more blank parts
Outfeed full	Cell operator	Next cell operator	Verbal	• Next cell operator delivers part to assembly station

Manual Map - KPIs

The most important performance indicators for the cell are:

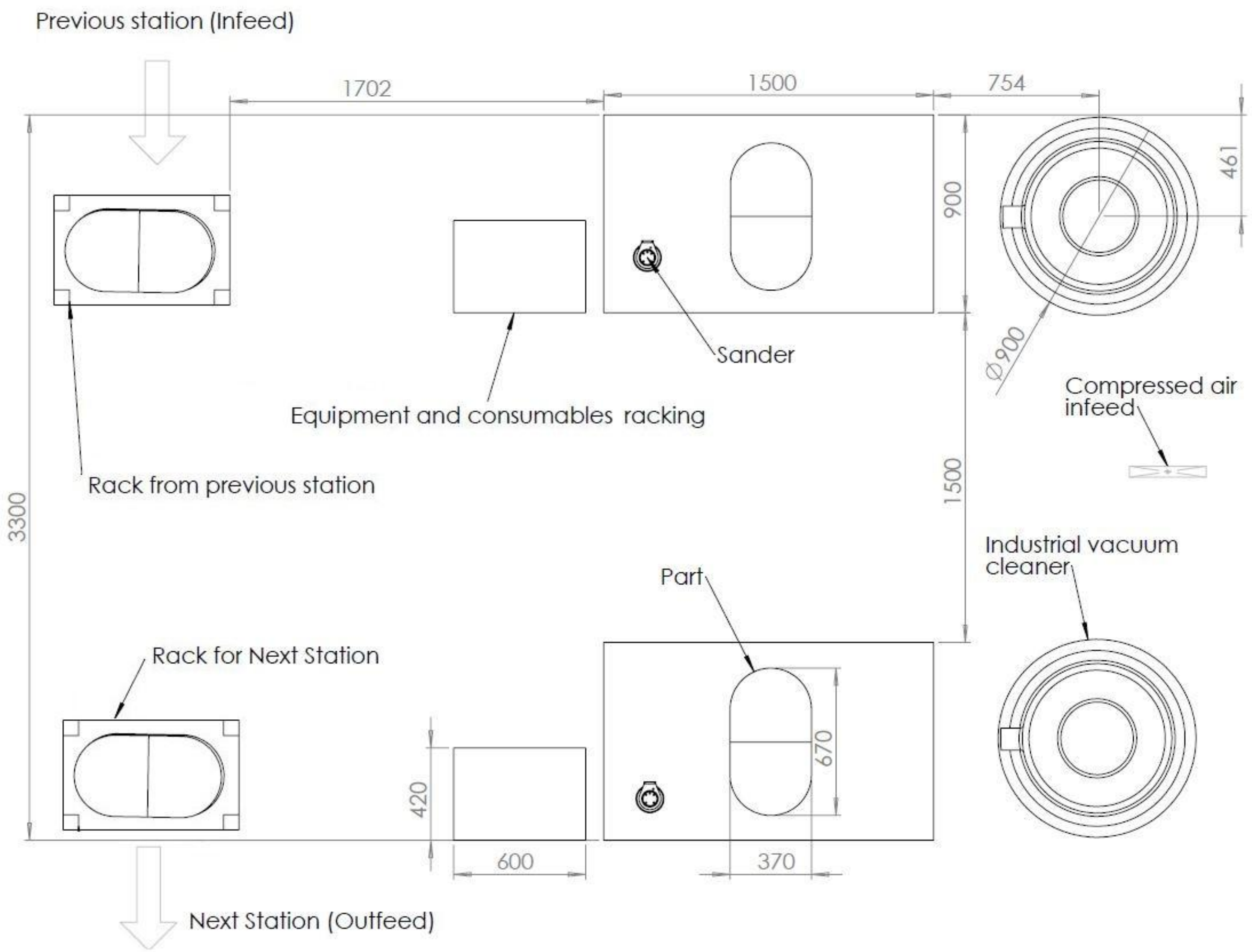
- Actual cell output — 50 parts per day.
- First pass yield — 98%
  (2% of the parts are rejected and need rework after the first sanding is done at quality inspection).

Manual Map - Task



Value-added time (s)	300
Non value-added time (s)	120
TOTAL (s)	420

Manual Map - Layout



Robotic Map - Overview

Steps	Information to define in the robotic task map
High level robotic cell concept	
Concept	Cell components and concept
Robotic cell layout	
Sketch of robotic cell concept	What would be the spatial arrangement of the station?
Robotic task map	
1. Identify customer	What's the next step after the robotic cell finishes its task?
2. Define output	How does the customer define value? • Part specifications • Part presentation • Pace/cycle time

Robotic Map - Overview

Steps	Information to define in the robotic task map
3. Define input	What's coming in at the robotic cell? • Parts (list of parts and specifications) • Part presentation • Pace/cycle time
4. Define process	• How are the parts processed? • What is the sequence of events happening at the station? • Which steps are value-added? Which are not?
5. Document information flow	• What information comes into the robotic cell, in what format, and where from? • What information goes out of the robotic cell, in what format, and where to? • Same thing within the robotic cell.
6. Measure KPIs	• What are the target KPIs? • How will we measure them?
7. Summarize task map	Combine all the previous information into a visual representation of the map.

Robotic Map - Output

1. Identify cell customer

The cell customer is the operator who brings the finished parts to the assembly station.

2. Define valuable output

As the internal customer (the operator), what I need you to give me is…
A total of 17.5 parts every 2 hours (70 parts/day).

so I can ...
Transport them to the assembly station.

Robotic Map - Output

Are the parts singulated? What is the space around them?

The parts will be laid on top of each other; the same presentation as in the manual task. The operator is picking the part.

What is the actual presentation?

On a table.

Is the output target moving? How so?

No. The parts are on a stable surface.

Robotic Map - Input

Number of parts

2 different models

Characteristics of the parts

Size:

max: 70 cm x 50 cm x 10 mm curved

min: 45 cm x 30 cm x 10mm curved

Weight: max: 1 kg

Material: Wood

Robotic Map - Input

Variation in time

Are there changeovers at this station?

Once time a week.

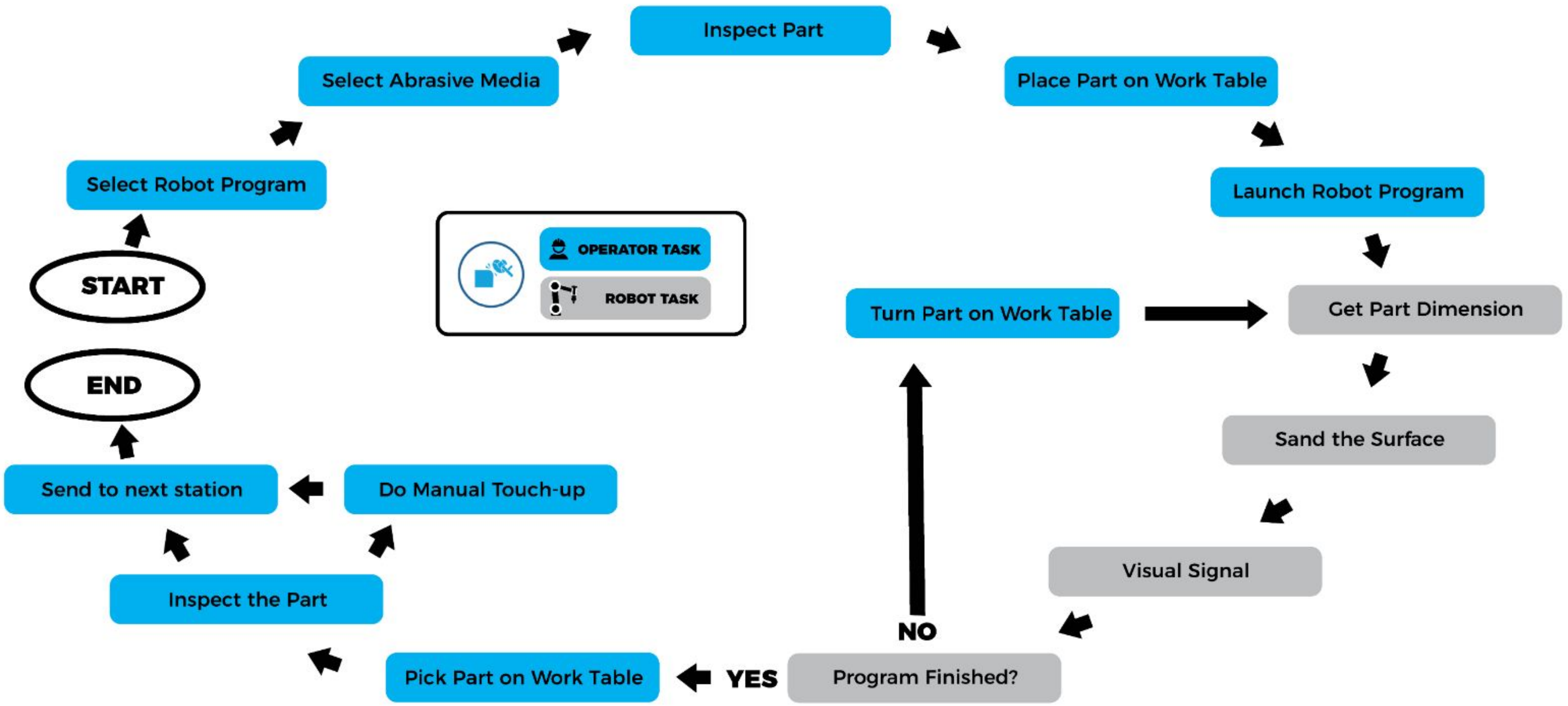
Are you planning to introduce new parts in the near future?

Maybe in 9-12 months, similar kind of blank at input, will be within min-max defined above.

Part presentation

The chosen concept is to keep it as it is and automated 80% of the task. The operator is doing the remaining 20%

Robotic Map - Process



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Robotic Map - Process

		Non-Value-Added Time (seconds)	Value-Added Time (seconds)	Total Time (seconds)*
Select the robot program	OPERATOR TASK	10*	-	5
Select/Inspect the abrasive mediuma	OPERATOR TASK	10*	-	5
Inspect the part	OPERATOR TASK	10*	-	5
Pick/Place the part on the work table	OPERATOR TASK	20*	-	10
Launch the robot program	OPERATOR TASK	10*	-	5
Get theimensions - sand the exterior of the part	ROBOT TASK	-	120	120
Turn the part on the work table	OPERATOR TASK	20	-	20
Sand the interior of the part	ROBOT TASK	-	120	120
Pick the part on the work table	OPERATOR TASK	5*	-	2.5
Sand the edges	OPERATOR TASK	-	60*	30
Inspect/rework the part	OPERATOR TASK	30*	-	15
Place the part in next station's rack	OPERATOR TASK	5*	-	2.5
Total		70	270	340

*Some actions performed by the operator are done simultaneously on both stations. Half of the time is added to the overall cycle time required for one part.

Robotic Map - Information Flow

A summary of the input/output signals exchanged for the robot communication can be found at the end of this document.

Information	Going from	Going to	Format	How it's used
Robot finished part on work table 1	Robot controller	Tower light 1 - Orange	Digital I/O	The robot needs a new part to sand on work table 1.
Robot is sanding on work table 1	Robot controller	Tower light 1 - Green	Digital I/O	The robot is sanding a part on work table 1.
Robot is in error on work table 1	Robot controller	Tower light 1 - Red	Digital I/O	The robot/process is in error on work table 1.
Robot finished part on work table 2	Robot controller	Tower light 2 - Orange	Digital I/O	The robot needs a new part to sand on work table 2.
Robot is sanding on work table 2	Robot controller	Tower light 2 - Green	Digital I/O	The robot is sanding a part on work table 2.
Robot is in error on work table 2	Robot controller	Tower light 2 - Red	Digital I/O	The robot/process is in error on work table 2.
Part model/dimensions	Operator	Robot controller	Teach pendant	A message appears on the teach pendant at the beginning of the program and prompts to enter the dimensions/model.
Start the sander	Robot controller	Pneumatic valve	Digital I/O	The air flow is activated to start the sander.
Start the vacuum dust collector	Robot controller	Relay	Digital I/O	The vacuum dust collector is activated when the sander is in operation.

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*A tower light can be used in this project to clarify the steps and indicate that operator assistance is required. Please note that this will not be presented in the Integration phase tutorial video.

Robotic Map - KPIs

What is the target KPI?

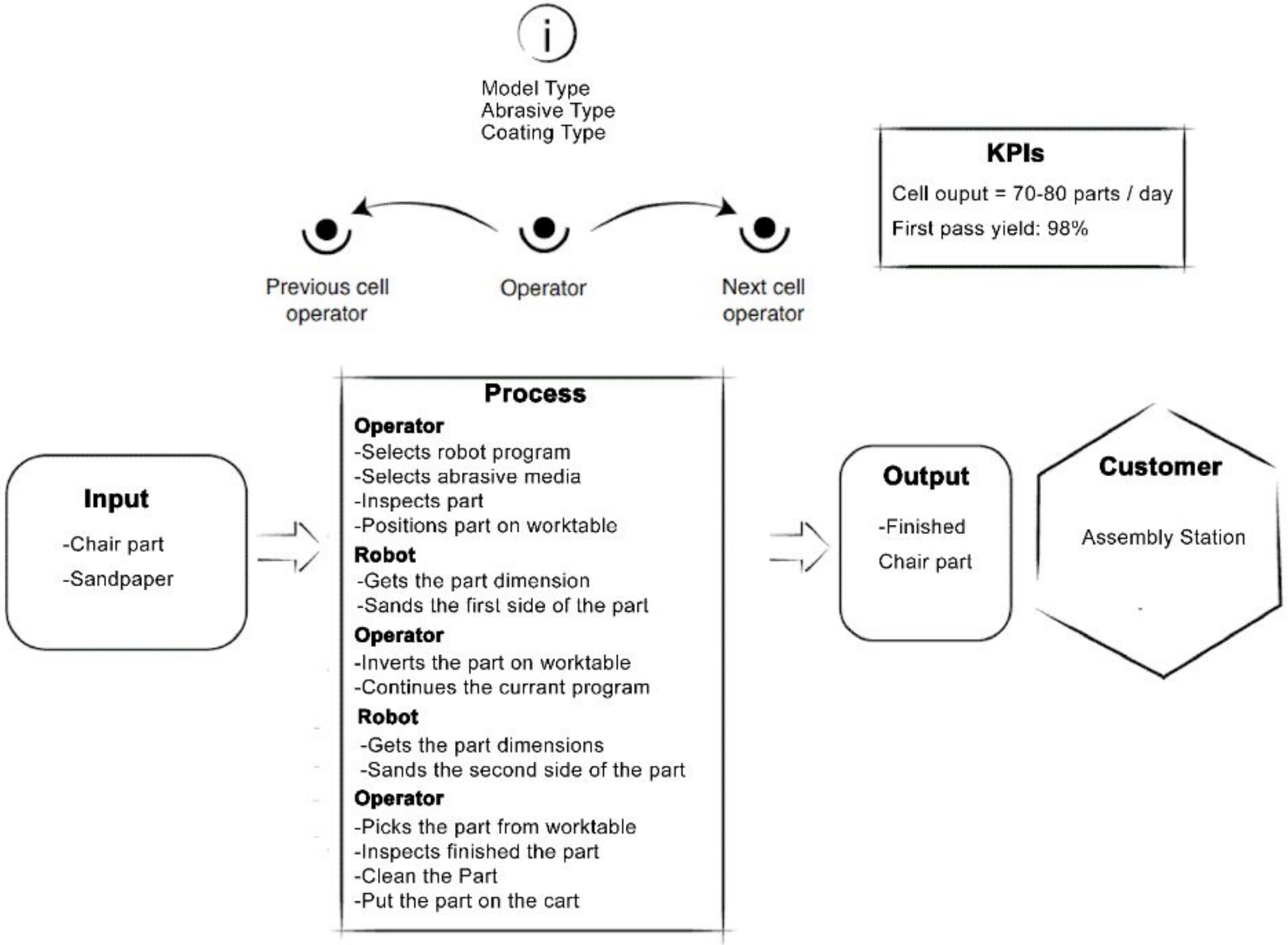
The KPI is the number of wooden chairs sanded per day. The target number is up to 70-80 parts per day. This will be validated at startup.

We are also targeting a first pass yield (FPY) of 98%.

How will the KPI be measured?

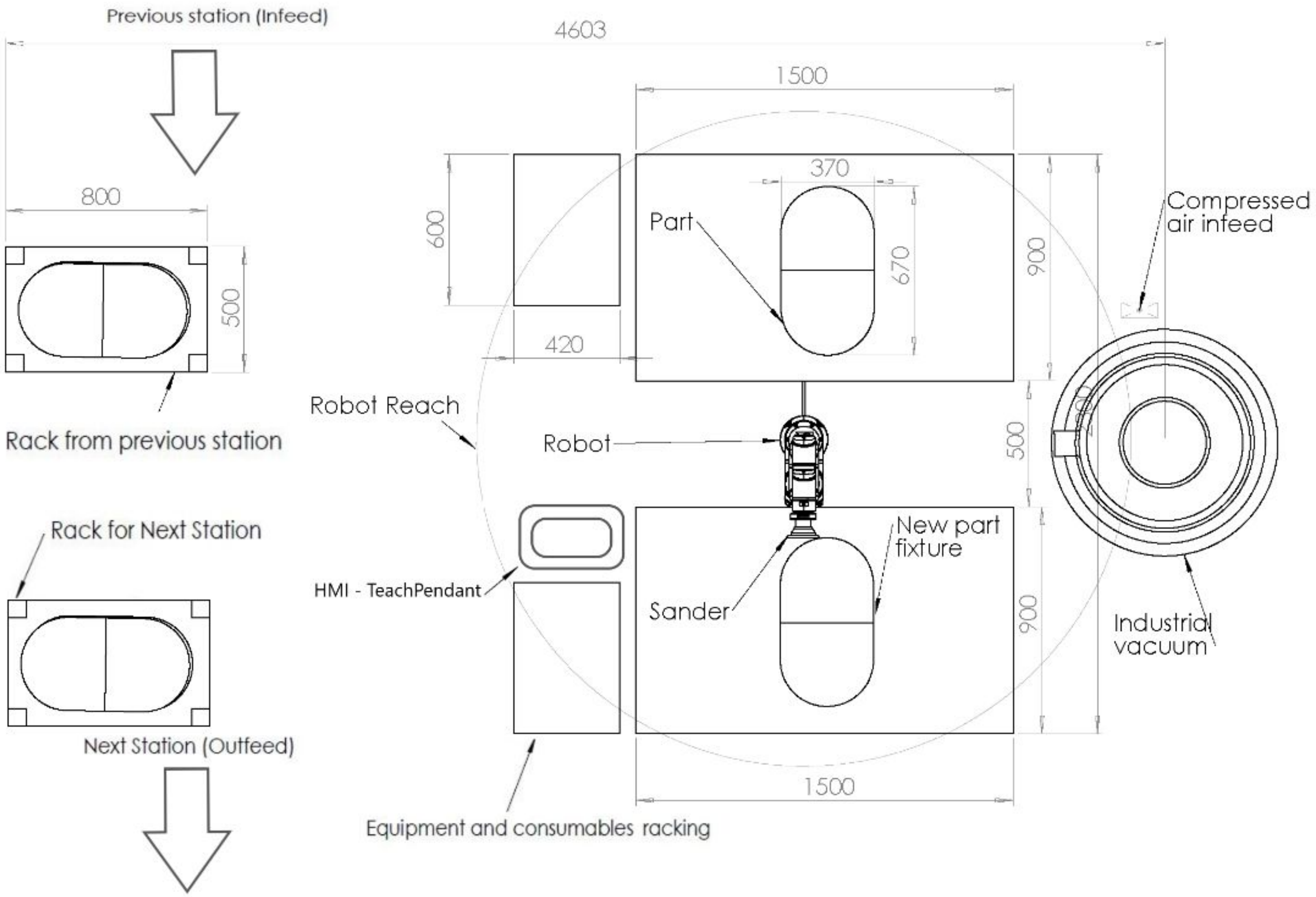
Using a counter in the robot's program.

Robotic Map



Value-added time (s)	270
Non value-added time (s)	70
TOTAL (s)	340

Robotic Layout



Manual/Robotic Comparison - Overview

Task map comparison	
1. Identify customer	Can we provide what our customer originally needed, or should we add an intermediary step?
2. Define output	Are we raising or lowering the amount of value provided to the customer's cell?
3. Define input	Do we need to change how the parts are presented?
4. Define process	Are we improving the process? Reducing the number of non-value-added operations?
5. Document information flow	Do we need to change the input or output information? Do we generate new information that can be useful elsewhere?
6. Measure KPI	How does the robot cell affect the KPIs themselves? Do the KPIs need to be tracked differently?
Layout comparison	
	Will you need to add, modify or move equipment in this cell, or in neighboring cells?

Manual/Robotic Comparison

	Same	Different
1. Identify customer	The customer of the robotic cell is the same as the customer of the manual cell.	N/A
2. Define output	The parts provided to the robot cell and to the manual cell are the same. All the parts will still be produced. The exit will also be the same.	N/A
3. Define input	The parts provided at the cell input will be the same. The operator will be able to pick the complete range of input parts.	N/A

Manual/Robotic Comparison

	Same	Different
4. Define process	Some steps will be the same for the operator (picking the part, inspecting, sanding the edges, inspecting and placing)	The steps taken by the robot to sand correspond to the ones previously done by the manual operator. The manual operator will still do some manipulations inside the cell to insert the parts in the holding devices. Total cycle time is a little bit less per part. The operator will be able to prepare a second part on the work table during the sanding process of the first part.
5. Document flow of information	N/A	Digital communication will need to be set up between the robot, tool and vacuum. The operator will need to select the dimensions of the part in the robot controller when starting the program. Robot will communicate the state with the operator with a three-color tower light (Run, Pause, Error).

Manual/Robotic Comparison

	Same	Different
6. Measure KPI	FPY should stay constant	Production capacity should go from 50 to 70/80 parts per day at best. Counter in robot program will be used to measure.
7. Layout	N/A	The work tables will stay at the same place. The robot will be placed between the tables on a pedestal and will be able to sand on both work tables. The table currently used by the operator will need to be moved, giving room to the robot. The input and output racks stay the same. Marks on the ground will be added to identify the robot's workspace. The operator will be able to reach the work tables from the peripheral of the cobot cell and stay out of reach of the robot.

Finalizing Robotic Cell Design: Overview

Items	Description
Calculate ROI	Payback period: ((Cost of project)/(Monthly gains from project)) + Time from start of project to production ROI: Monthly gains X (12 months - project time) / project cost Calculate 12 months in, and 24 months in
De-risk the project	Identify and analyze unknowns, plan for validation or plan B
Part listing	What will you need for this project?
Freeze the MVRC	You've got a minimum viable cell design ready to move to the Integrate phase!

Finalizing Robotic Cell Design: ROI

Gross margin per item produced:	$30
Working days per month:	20
Robotic cell cost:	$95,000

	Manual	Robotic	Change
Daily production, after FPY	49	68	+19
Daily gross margin produced	$1,470	$2,040	+$570
Monthly gross margin produced	$29,400	$40,800	+$11,400

Finalizing Cell Design: Payback Period

$$\frac{\text{Cost of robot cell}}{\text{Monthly gains}} + \text{Months spent on Design, Integrate phases}$$

$$\frac{\$95{,}000}{\$11{,}400} + \textbf{2}\text{ months spent on Design, Integrate phases}$$

8.3 + 2 = **10.3 months payback period**

Finalizing Cell Design: ROI over 12 months

$$\frac{\left(\text{Target period} - \text{Months spent on Design, Integrate phases}\right) \times \text{Gains per month}}{\text{Cost of robot cell}}$$

$$\frac{\left(12 - 2 = 10\right) \times \$11{,}400}{\$95{,}000}$$

$$\frac{\$114{,}000}{\$95{,}000} =$$

120% ROI after 1 year

Finalizing Cell Design: ROI over 24 months

$$\frac{(\text{Target period} - \text{Months spent on Design, Integrate phases}) \times \text{Gains per month}}{\text{Cost of robot cell}}$$

$$\frac{(24 - 2 = 22) \times \$11{,}400}{\$95{,}000}$$

$$\frac{\$250{,}800}{\$95{,}000} =$$

264% ROI
after 2 years

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Finalizing Robotic Cell Design - De-Risking

Question	Hypothesis	Confidence level	Impact on cell	Validation plan	Time and $ to validate it?
Will the robot be able to sand with a good FPY?	Yes	Medium	Critical	Ask for a proof of concept	Robot vendor can take 2 days to validate. Collaborating with partner to test the sanding process.
Will it be simple enough for the operator to enter the part dimensions when a changeover occurs?	Yes	High	Critical	Demo from partner	2-hour demo
Can we achieve the 70 parts/hour target?	Yes	Medium	Critical	Test with the proof of concept	Simulate the operator's task at the same as the Robot during the POC.
Will the part fixture work?	Yes	High	Critical	Build a prototype	3 weeks, and around 500$.

Finalizing Robotic Cell Design - Bill of Materials

- 1 x UR10 collaborative robot
- 2 x Stand for UR10
- 1 x Robotiq Surface Finishing Kit
- 2 x New Fixture System
- 1 x New Sander
- 1 x Cable Management Device
- 2 x Tower Light (optional)
- 1 x Electrical Hardware (relays, etc.)

Signals Exchange Summary - Robot Communication

#	Information	From	To	Description
CO4	Sander	Robot controller	Valve	Start/Stop the pneumatic tool
CO5	vacuum_cleaner	Robot controller	Relay	Start/Stop the vacuum cleaner

#	Information	From	To	Description
Do0*	Robot is sanding part 1	Robot controller	Tower light 1 - Green	The robot is sanding part on work table 1
Do1	Robot is waiting on part 1	Robot controller	Tower light 1 - Orange	The robot is waiting for a part on work table 1
Do2	Robot error worktable 1	Robot controller	Tower light 1 - Red	The robot is in error on work table 1
Do3	Robot is sanding on part 2	Robot controller	Tower light 2 - Green	The robot is sanding part on work table 2
Do4	Robot is waiting on part 2	Robot controller	Tower light 2 - Orange	The robot is waiting for a part on work table 2
Do5	Robot error on worktable 2	Robot controller	Tower light 2 - Red	The robot is in error on work table 2

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*Two tower lights can be used in this project to clarify the steps and indicate that operator assistance is required. Please note that this will not be presented in the Integration phase tutorial video.

Freeze the Robotic Cell Design!

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