

# BATHTUB KINGS

MSE 980 Project

# ABOUT US

Who are we?

A team of engineers with the ultimate goal of completely automating the bathtub manufacturing industry

# PROBLEM

LACK OF  
VISIBILITY



Don't know the current state of your products, equipment, or people

ASSET TRACKING



Trouble accounting for factory assets

PRODUCTIVITY



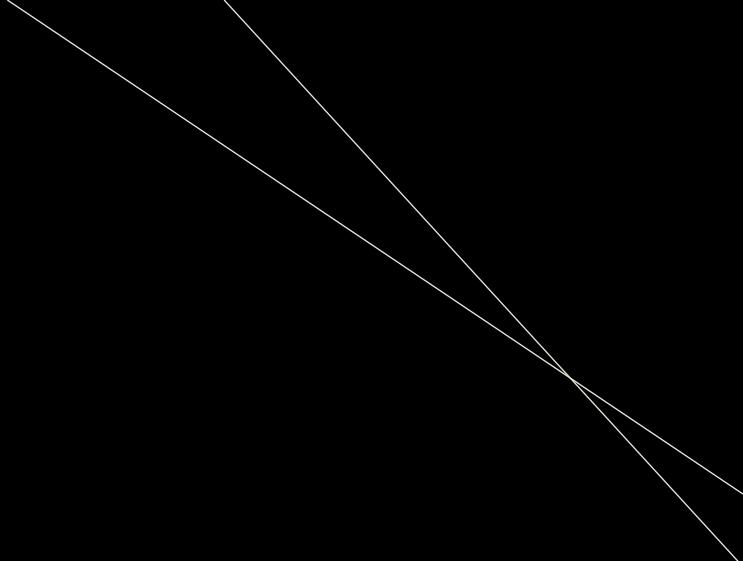
Lack of ability to improve factory KPIs any further

SAFETY



How can we keep track of what happened to who and when?

# SOLUTION?



## A factory RTLS integration

Implementing an RTLS solution will allow you to  
stay on top of all your products, assets, and  
people.

# MAJOR RTLS TECHNOLOGY VENDORS

Ultra Wide Band



GPS



RFID



Wi-Fi



Camera and Machine Vision



Bluetooth Low Energy



# COMPARISON BETWEEN RTLS TECHNOLOGIES

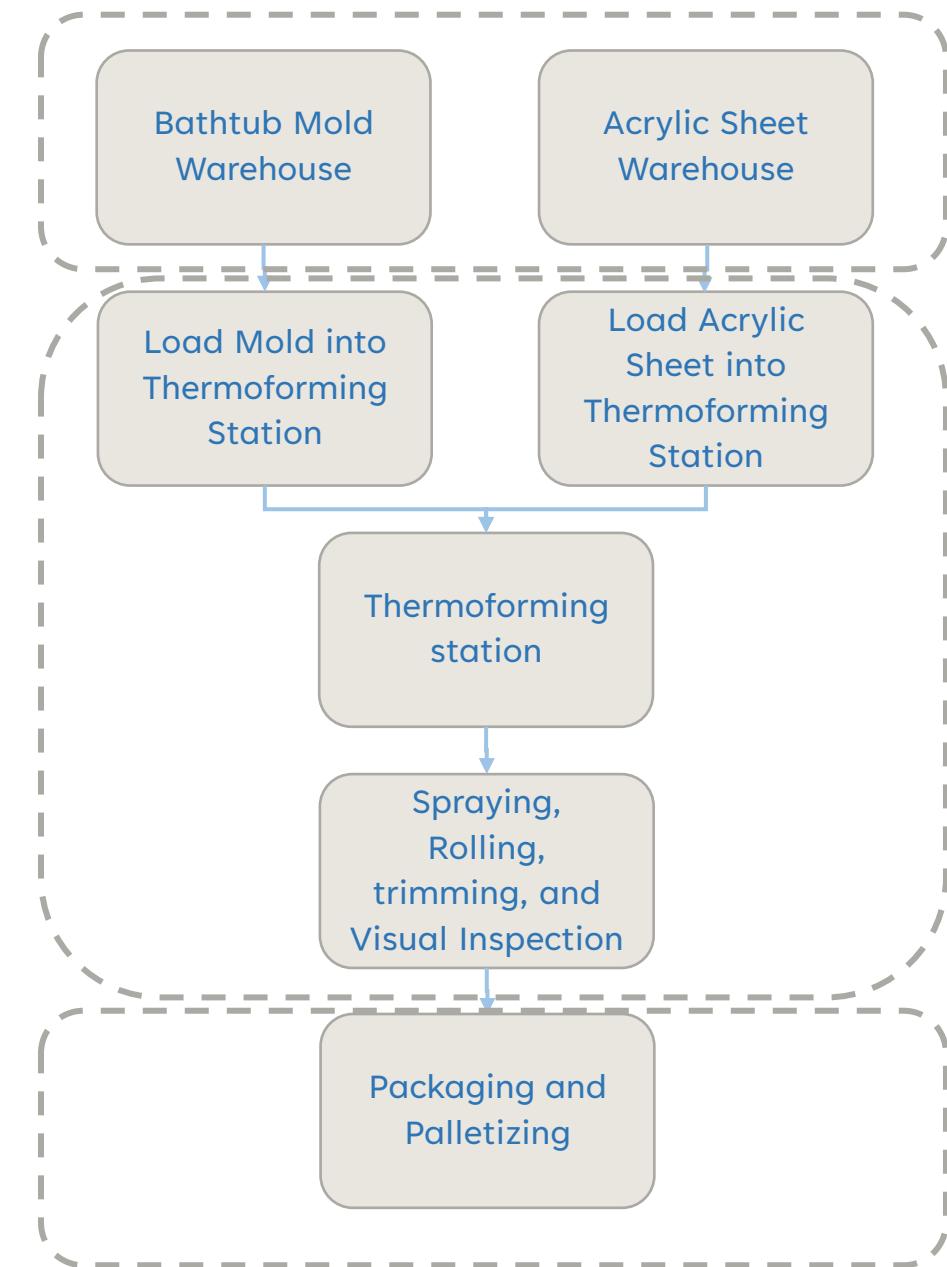
	UWB	RFID (passive/active)	BLE	WiFi	Camera	GPS
Accuracy	10-50cm	1m/up to 10m	1-5m	5-15m	1cm- 50cm	1-10m
Power Cons.	10-100mW	None/1-100mW	1-50mW	10-100mW	100-500mW	50-200mW
Range	0-50m	0.5-1m/up to 5m	0-100m	0-500m	1-10m	10-100m (outdoors)
Bandwidth	500 MHz	125 – 134 kHz (low), 13.56 MHz (high), 860 – 956 MHz (ultra-high)	2 MHz	2.4 GHz or 5 GHz	~1-2 Mbps	11 - 15 MHz
Price	Medium-High	Medium-Low	Low	Medium	High	High (charged per month)
Installation/Maintenance	Medium	Medium-Low	Medium	Medium-Low	High	Low
Ruggedness	Medium-High (resistant to interference)	Medium-High	Medium	Medium	Medium-Low	High
Localization	Time of Flight (ToF), Angle of Arrival (AoA)	None/ Triangulation, RSSI (Received Signal Strength Indication)	RSSI (Most Common), Triangulation, Angle of Arrival (AoA)	RSSI, Triangulation	Computer Vision, Image Processing	Trilateration based on satellite signals

# SYSTEM OVERVIEW

Final  
Dispatching  
Warehouse

Acrylic/Mold  
Warehouses

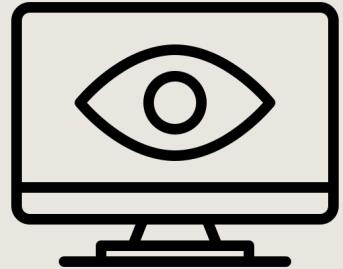
Production  
Floor



# WHICH RTLS TECHNOLOGIES TO CONSIDER?

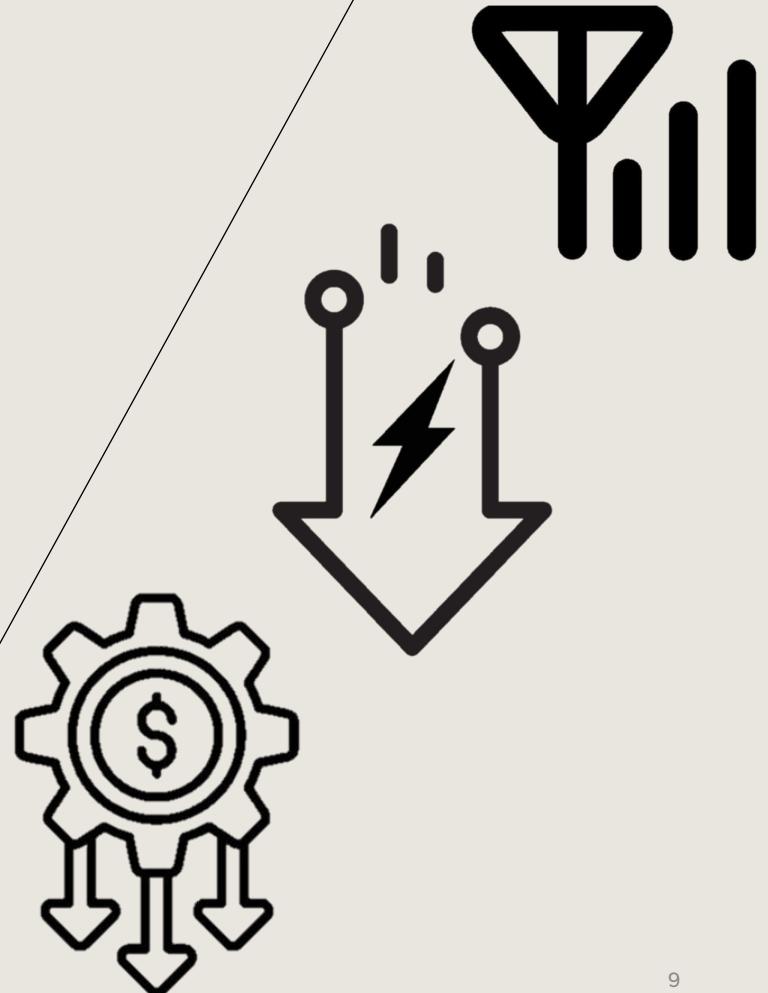
Since budget is always a major constraint, it's better to implement technologies that directly benefit or improve particular parts of the production line.

- we can use passive **RFID tags** to keep track of which bathtub mold is currently in use
- For the acrylic sheets we can use QR codes and **computer vision** to detect which sheet type (size, color, thickness, texture, etc) is currently in use,
- To keep track of moving objects (such as forklifts or autonomous robots) or temporary stationary objects (such as pallets), or workers, we can use **Ultra-Wideband** technology, as it provides better tracking of objects in motion compared to passive RFID or camera.
- Once the item is packaged and ready to be shipped, we can use GPS for tracking outside the warehouse.



# WHAT RTLS FEATURES TO CONSIDER?

- **Range** important for adequate coverage
- **Low Power Consumption**, to run for extended periods of times without having to replace batteries or recharge
- **Low Installation/Maintenance costs**
- Accuracy is less important, as warehouses have small floor area relative to the range the technologies can cover, thus accuracy degradation will not be a problem



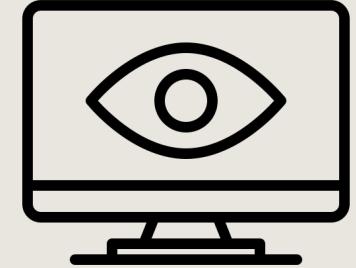
# WHICH RTLS TECHNOLOGIES TO APPLY?



Using the same RTLS technologies everywhere is not optimum, since stationary and moving objects require different asset tracking technologies

We can however use the following

- Passive RFID tags for Bathtub Mold tracking (Mold Warehouse)
- Computer vision for QR codes on the acrylic sheets (Acrylic Sheet Warehouse)
- Computer vision to detect sheet type (Production Floor)
- Ultrawide Band for tub cart tracking (Production Floor)
- Ultrawide Band for moving assets such as forklifts, autonomous robots, personnel, etc.
- GPS for shipment (Final Dispatchment)



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- [1] Rácz-Szabó, A., Ruppert, T., Bántay, L., Löcklin, A., Jakab, L., & Abonyi, J. (2020). Real-time locating system in production management. *Sensors*, 20(23), 6766.
- [2] Thiede, S., Sullivan, B., Damgrave, R., & Lutters, E. (2021). Real-time locating systems (RTLS) in future factories: technology review, morphology and application potentials. *Procedia CIRP*, 104, 671-676.
- [3] Thiede, S., Ghafoorpoor, P., Sullivan, B. P., Bienia, S., Demes, M., & Dröder, K. (2022). Potentials and technical implications of tag based and AI enabled optical real-time location systems (RTLS) for manufacturing use cases. *CIRP Annals*, 71(1), 401-404.

# VENDOR RECOMMENDATIONS

- RFID for Mold Warehouse



- Camera with QR Code for Acrylic Sheet Warehouse

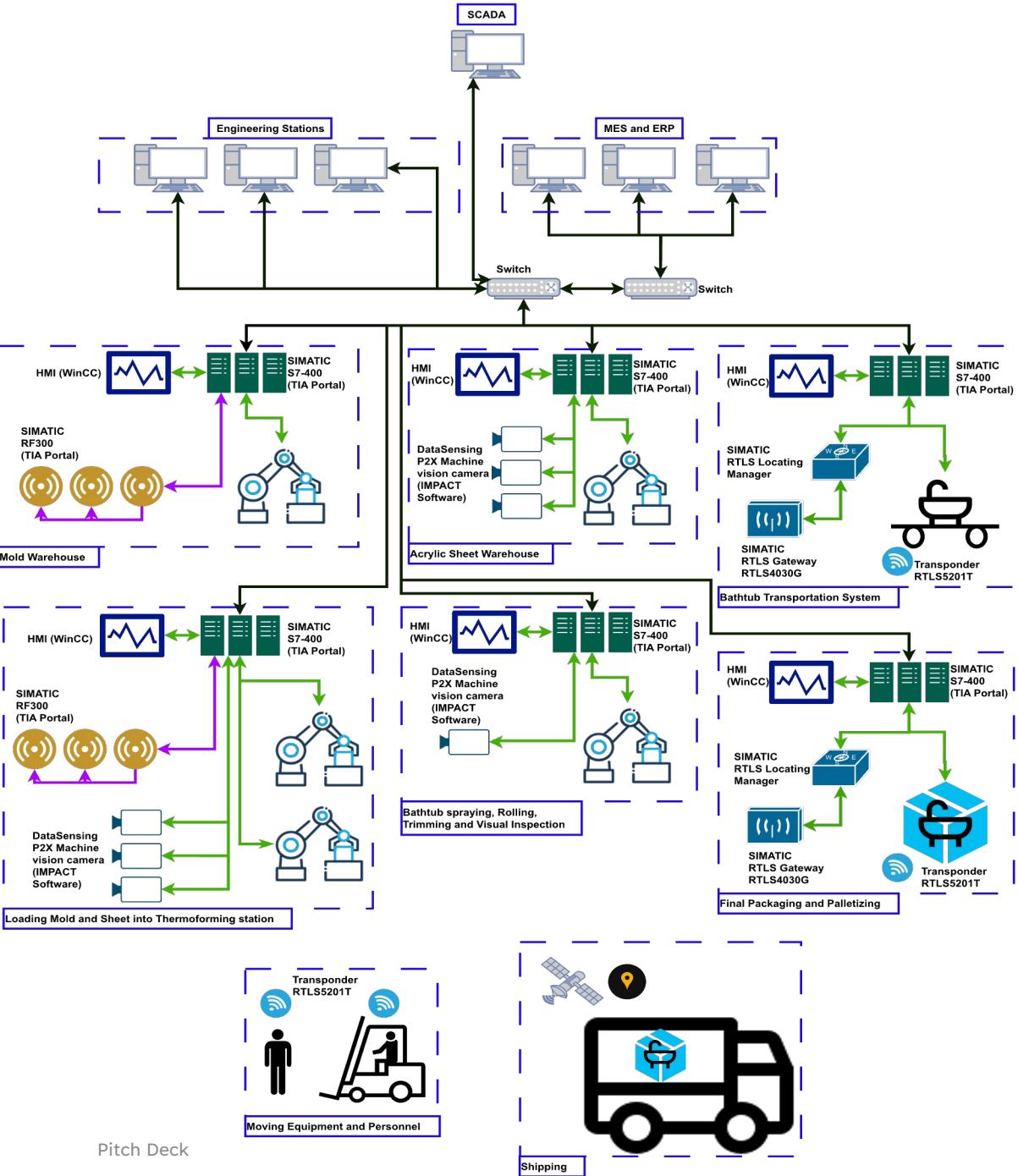
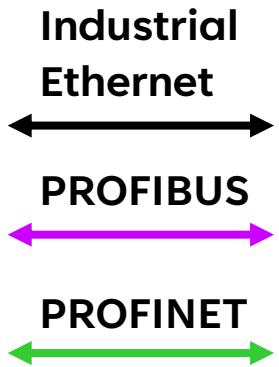


- UWB for Production Floor

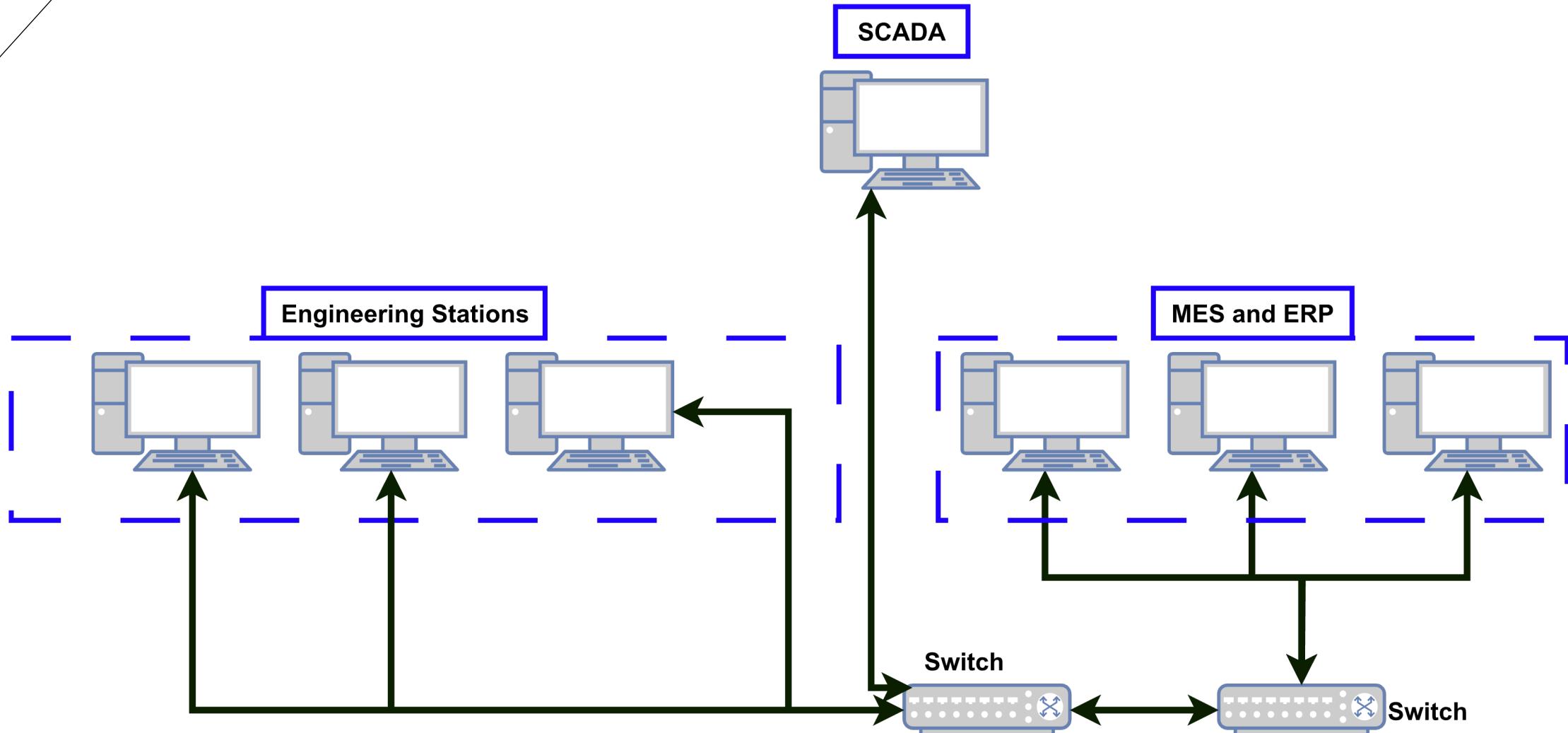


Vendors highlighted in green are selected in the network diagram

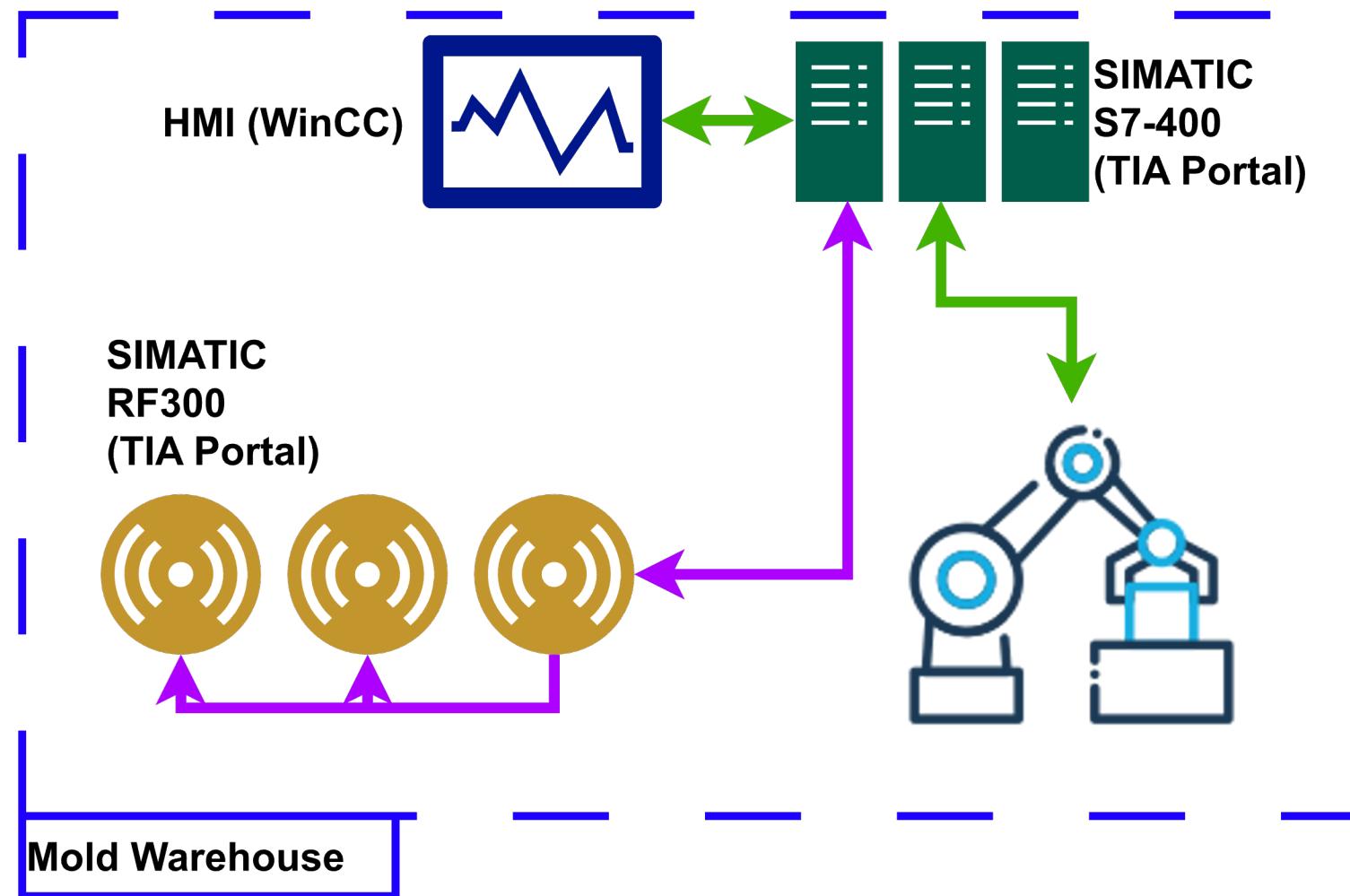
# NETWORK DIAGRAM



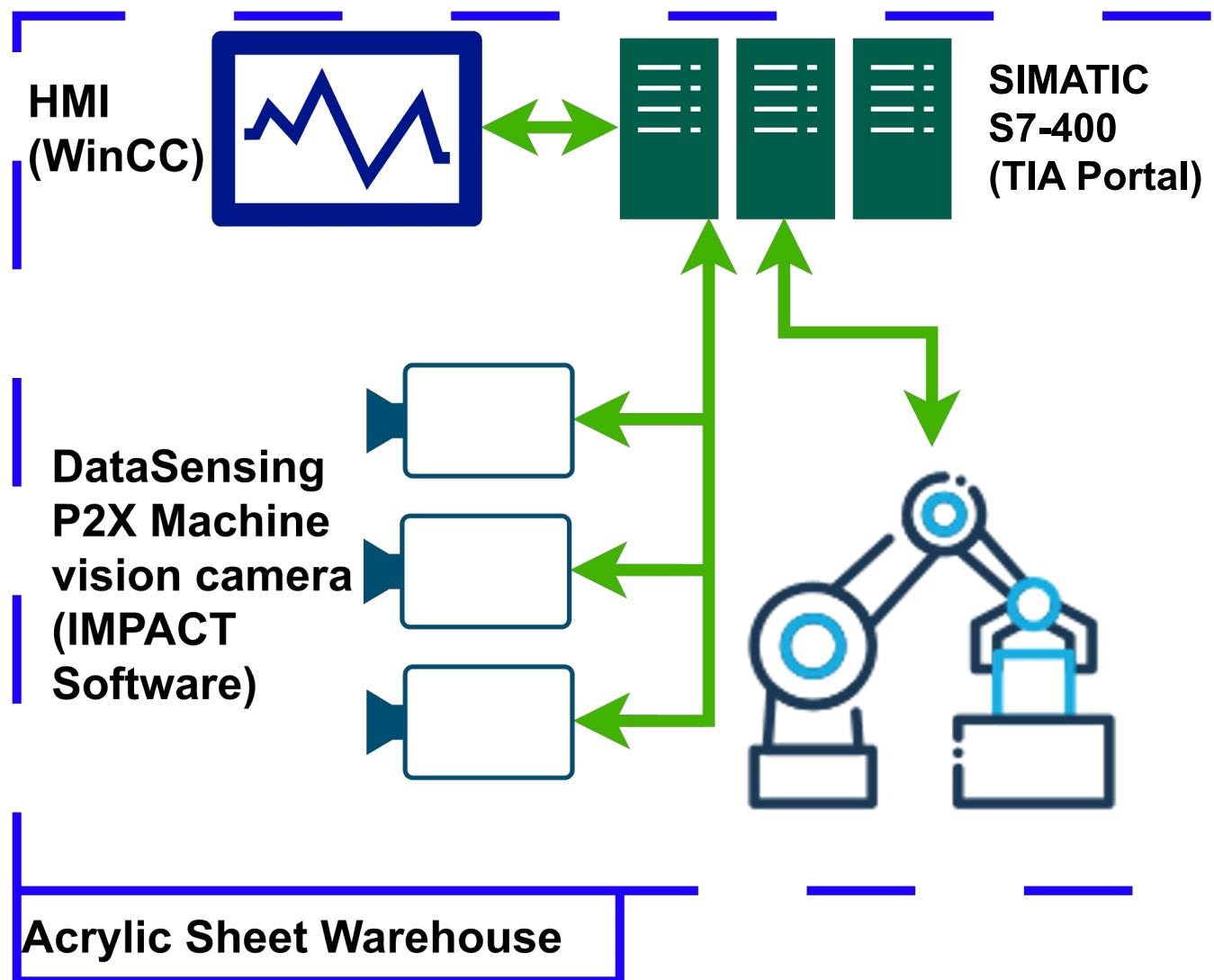
# SCADA, ENGINEERING, MES AND ERP STATIONS



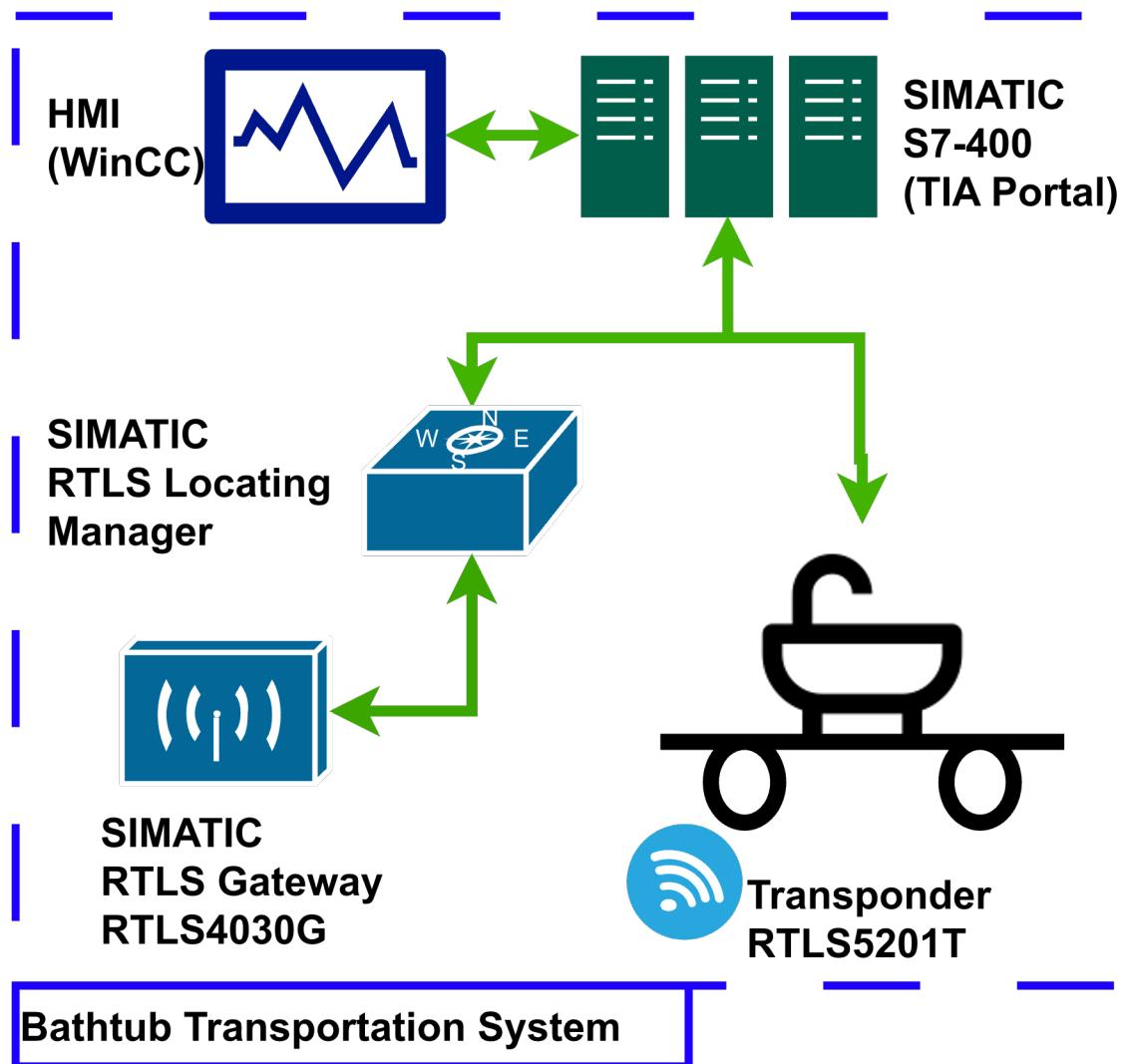
# MOLD WAREHOUSE DIAGRAM



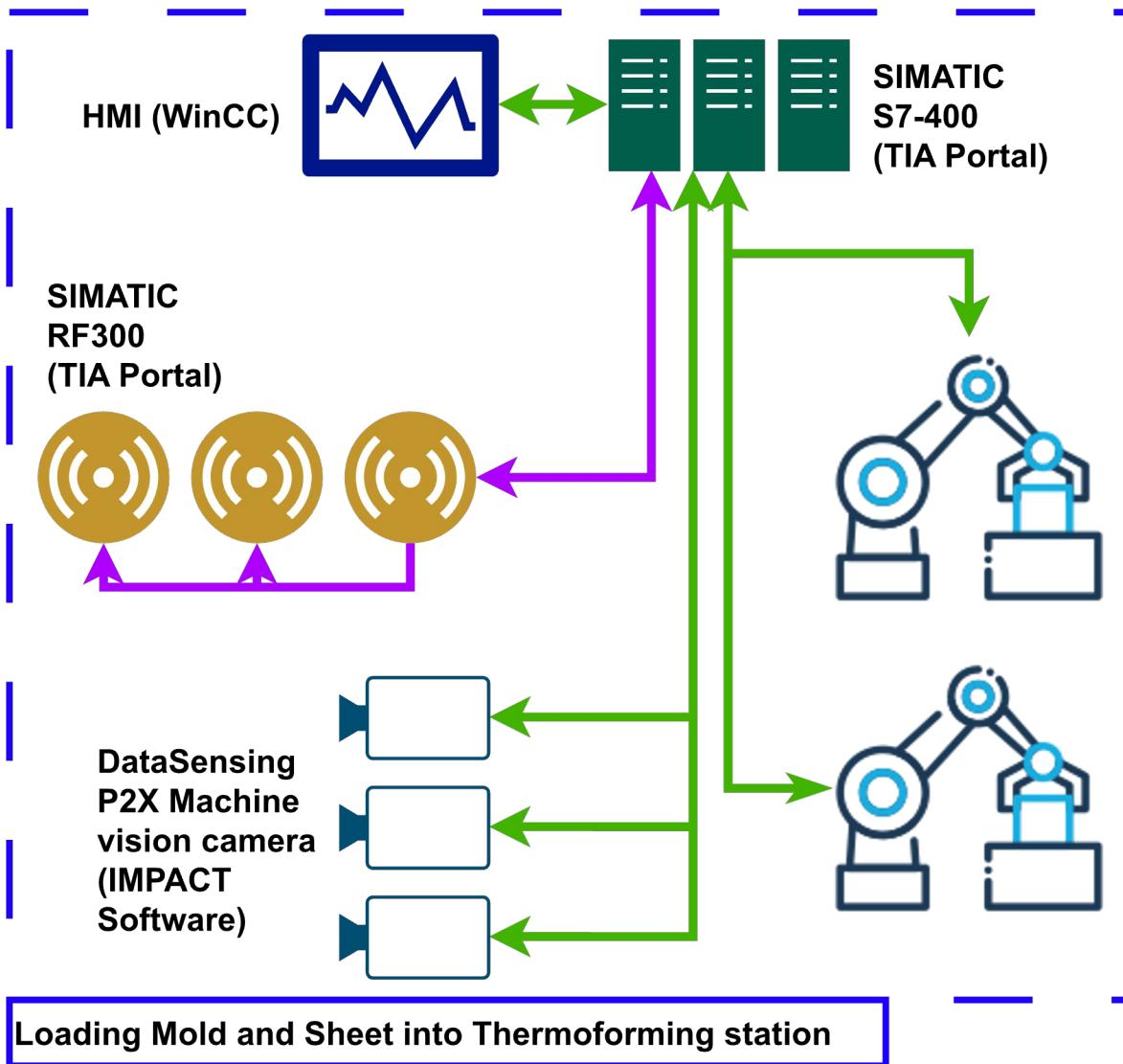
# ACRYLIC SHEET WAREHOUSE DIAGRAM



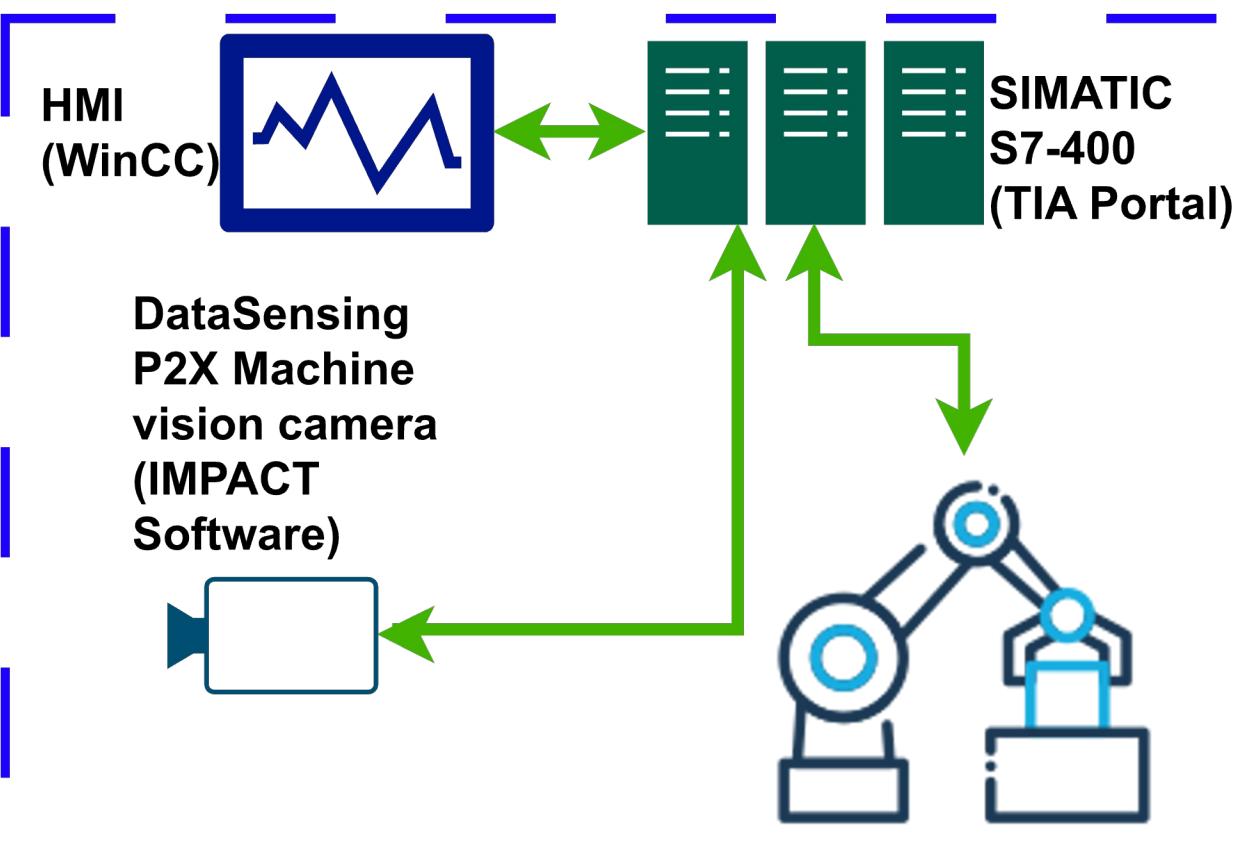
# BATHTUB TRANSFER SYSTEM DIAGRAM



# THERMOFORMING STATION DIAGRAM

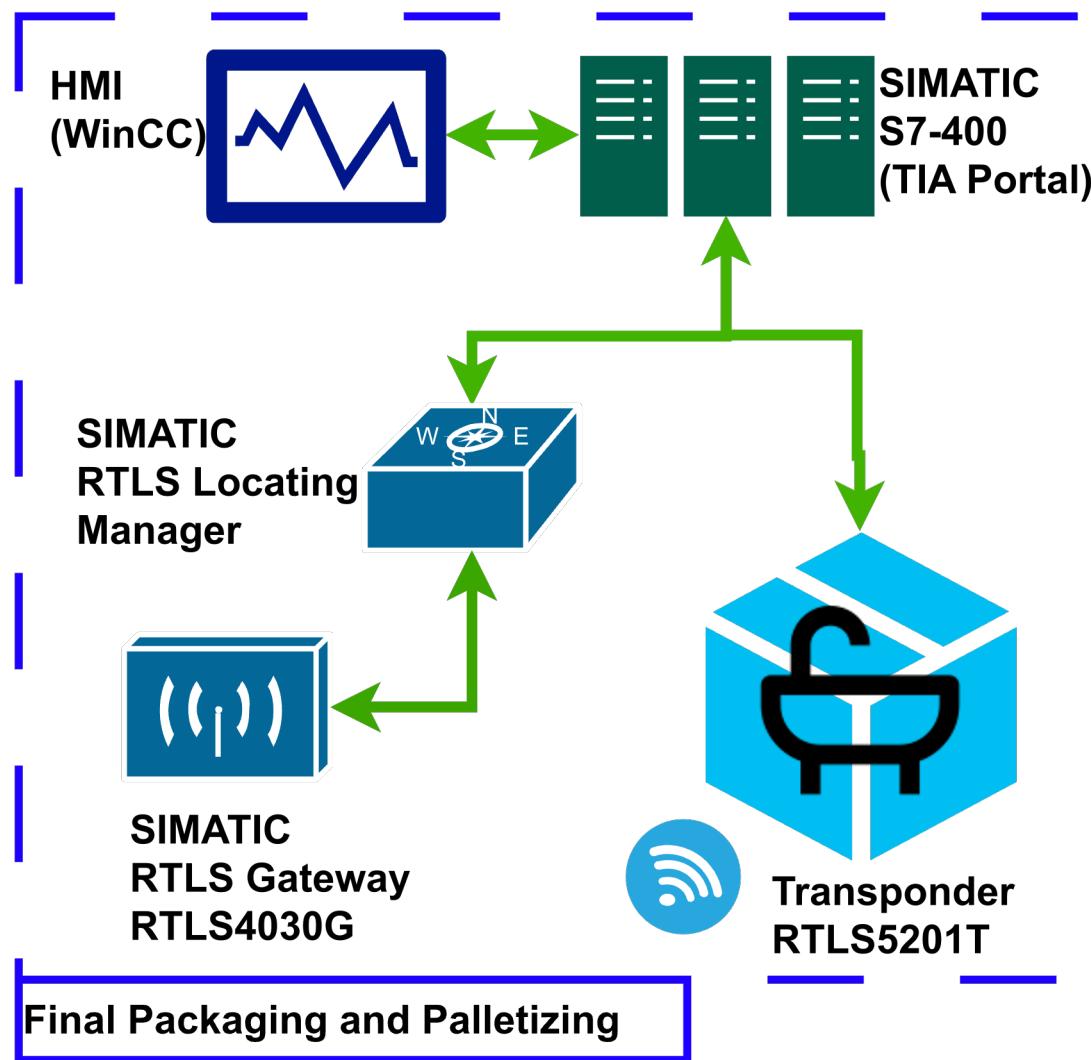


# SPRAYING, ROLLING, TRIMMING AND INSPECTION DIAGRAM

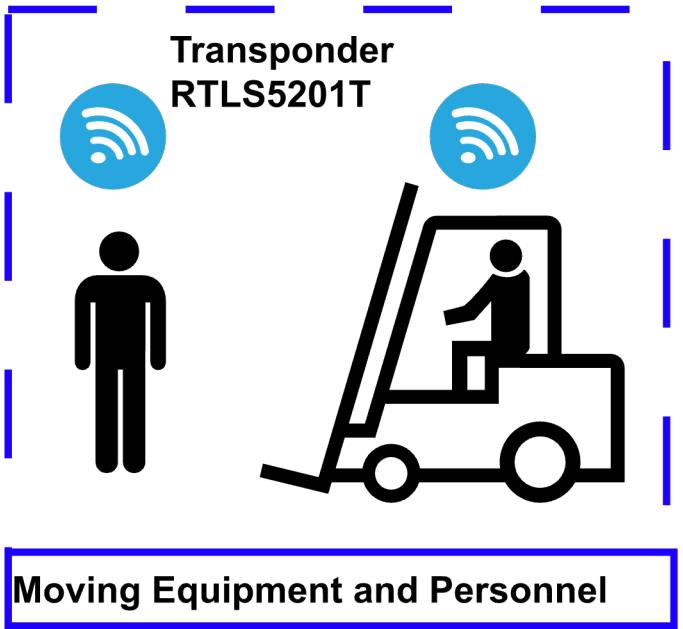


**Bathtub spraying, Rolling,  
Trimming and Visual Inspection**

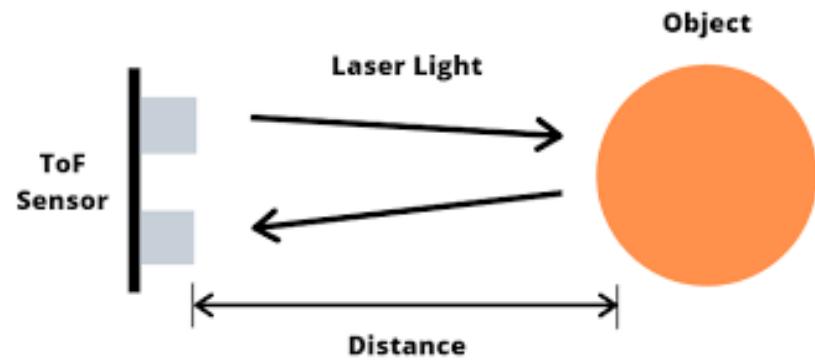
# PACKAGING AND PALLETIZING DIAGRAM



# MOVING ASSETS AND FINAL SHIPPING

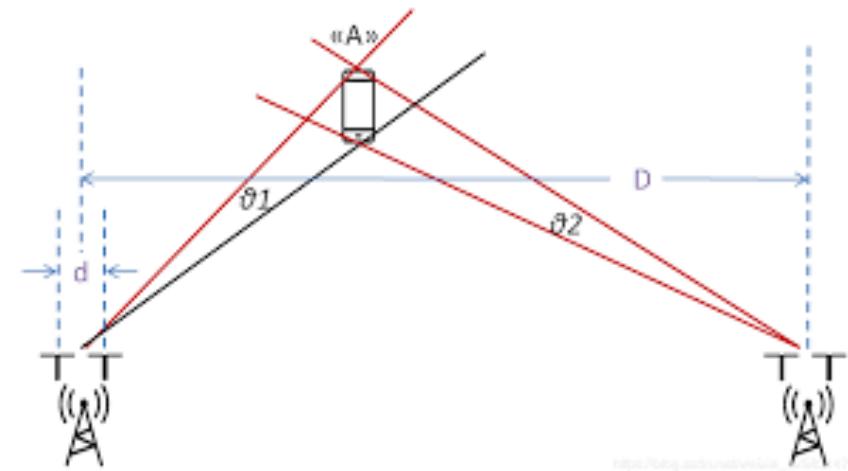


# UWB LOCALIZATION METHODS



**Time of Flight (ToF)**

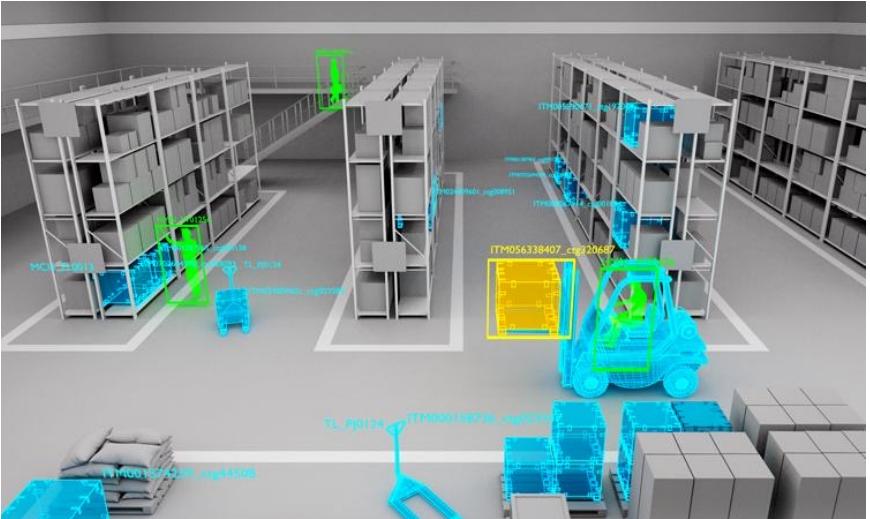
measures signal travel time to determine distance between source and target, used in radar, ultrasonics, and 3D imaging



**Angle of Arrival (AoA)**

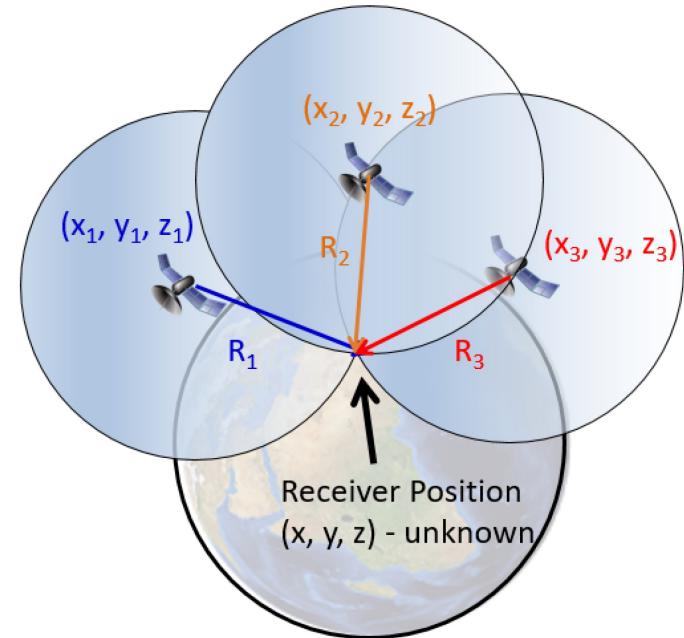
determines the direction from which a signal arrives at a sensor array. It's used to find the angle or direction of a signal source relative to the sensor

# CAMERA/GPS LOCALIZATION METHODS



## Computer vision and Image processing

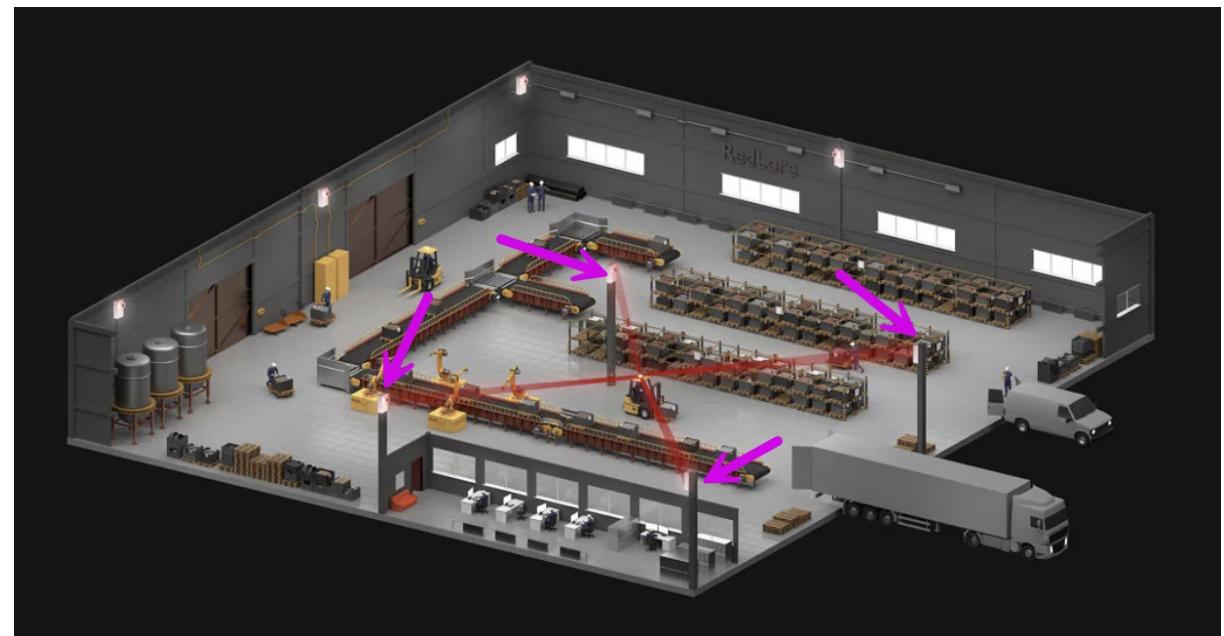
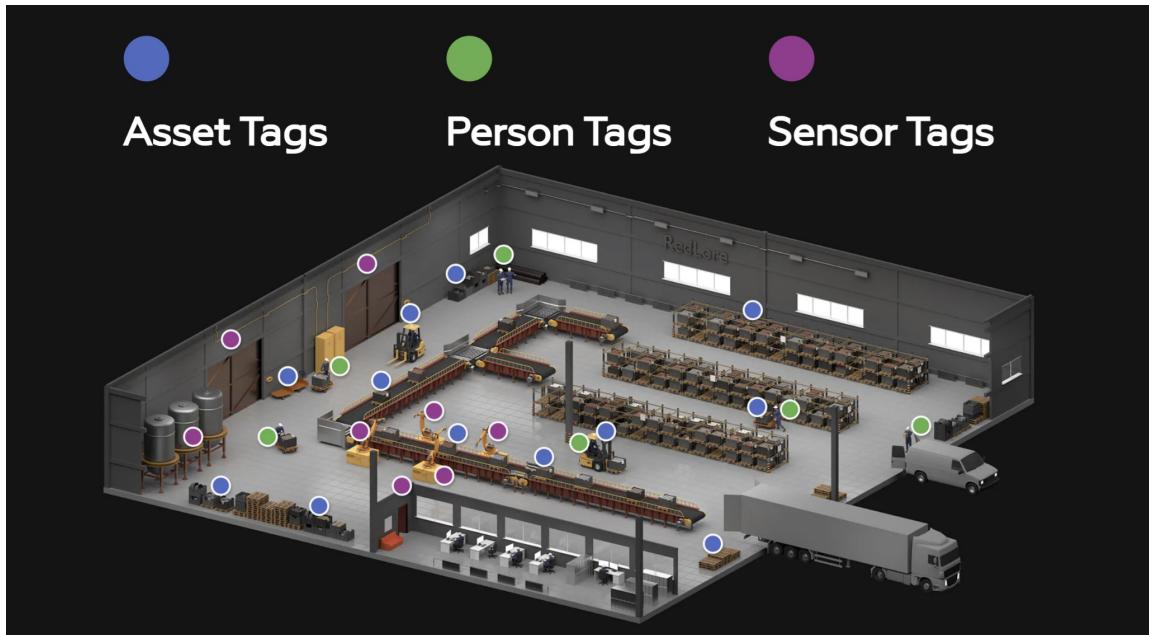
computer vision utilizes visual data to determine the position or location of objects or devices in a given environment. It involves feature extraction, image matching, and mapping to estimate the spatial coordinates of objects relative to a reference point



## Trilateration based on satellite signals

determining a location by measuring distances from at least three satellites using signals like GPS. The intersection of these distance measurements allows pinpointing the receiver's location

# FACTORY EXAMPLE (UWB)



# WHAT CAN RTLS BRING TO YOUR FACTORY?



## - **Efficiency**

- Reduction in time spent searching for items
- Identify and decrease bottlenecks

## - **Throughput**

- Predictive Analysis on RTLS data and to find root causes and alleviate

## - **Productivity**

- Optimize resource allocation so the right tool is readily available
- Track progress at key locations so problem areas can be identified

## - **Transparency**

- Provide assurance of the state of your factory to stakeholders
- Drilldown into the transaction history of each asset - what happened and when

## - **Safety**

- Respond quickly to emergencies when they happen
- Monitor the state of equipment in real-time to determine safety hazards and maintenance required



## DRIVING FORCES BEHIND RTLS INTEGRATION

There are many driving forces that helped thrust RTLS Technologies into bathtub manufacturing and manufacturing in general

- Efficiency Enhancement - **Asset Optimization**
- Cost Savings - **Resource Management**
- Quality Control - **Real-Time Monitoring**
- Workforce Productivity - **Task Optimization**
- Safety and Compliance - **Emergency Response and Regulatory Compliance**
- Data-Driven Decision Making - **Analytics and Insights**
- Customer Satisfaction - **Timely Deliveries**
- Technology Integration - **Industry 4.0**
- Competitive Advantage - **Innovation and Differentiation**

# CALCULATING RETURN ON INVESTMENT (ROI)

Calculating the Return on Investment (ROI) for deploying Robots or Cobots in manufacturing lines involves considering both the costs and benefits over a specific period.

$$ROI = \frac{\text{Net Benefit} - \text{Costs}}{\text{Cost}} \times 100$$

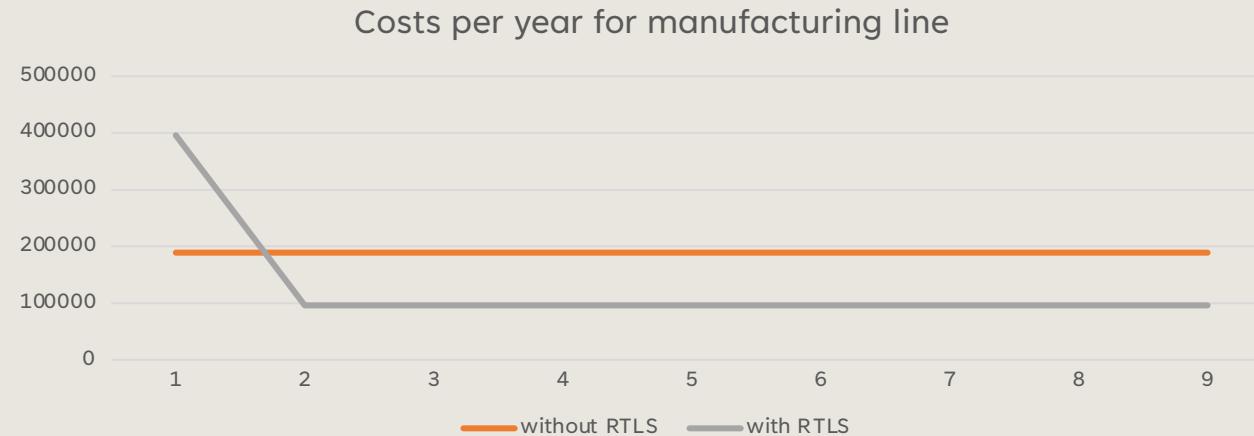
The most important aspect of ROI for manufacturing lines is the savings they incur while also increasing throughput

# CALCULATING RETURN ON INVESTMENT (ROI)

without RTLS	\$
# of items	1000
Item price	200
cost of manual tracking	200
# tracking workers	50
losses	1000
total	189000

year	1	2	3	4	5	6	7	8	9
	189000	189000	189000	189000	189000	189000	189000	189000	189000
	396000	96000	96000	96000	96000	96000	96000	96000	96000
difference	-207000	93000	93000	93000	93000	93000	93000	93000	93000
break even	279000 at year 4								

with RTLS	\$
initial investment	300000
# of items	1000
Item price	200
cost of manual tracking	200
# tracking workers	20
system maintenance	100000
total year 1	396000
total subsequent years	96000



From this simple calculation we can see that using robots and cutting the asset tracking workforce will result in savings of near \$100k per year after breaking even. This doesn't take into account the increased throughput which increases sales



THANK YOU

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- [Ze 3] <https://ieeexplore.ieee.org/document/9090691>
- [Ze 4] <https://www.sciencedirect.com/science/article/pii/S1570870522001962#:~:text=The%20existing%20BLE%2Dbased%20localization,the%20transmitter%20and%20the%20receiver>
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