CONSTRUCTION MANUFACTURING FUNDAMENTALS

ARE YOU READY OF A MINDSET SHIFT?

BUILDING. REDEFINED.

INDUSTRIALIZED CONSTRUCTION

WHAT IS IT?

The application of manufacturing principles and systems to the built environment

Manufacturing & Construction

Stable site
Predefined production flows
Controlled environment

Create and maintain flow
Continuous improvements
Product-centric
Plan to delivery date

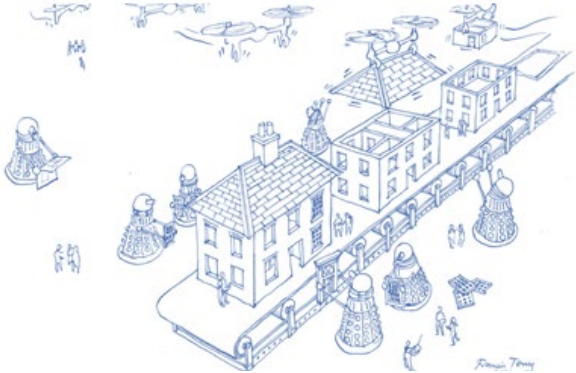
Changing sites
Project-specific production flows
Exposed and changing environment

Plan flow through parade of trades
Constant transformation
Project-centric
Forecast planning

So, if they gave birth...

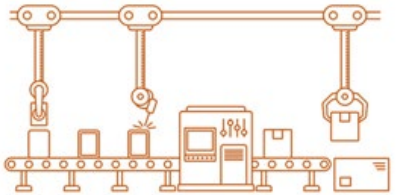
Construction:

- Project-specific production resources, no factory
- New products avoided due to risk
- Efficiency internally in project
- Product never fully predefined



Industrialized Construction:

- 100% factory loading
- Product development to handle market attraction
- Continuously work on cost reduction and efficiency
- Large investment in factory
- Products can seldom be fully predefined



Manufacturing:

- 100% factory loading
- Product development to handle market attraction
- Continuously work on cost reductions and efficiency
- Large investment in factory
- Limited options for customization

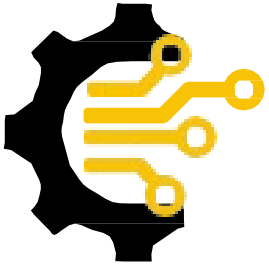
ABOUT US

ABOUT ICG

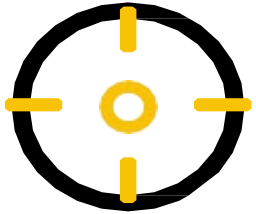
Our Mission: Accelerate the shift from best-in-class traditional construction to revolutionary industrialized construction.

ICMA SM

MATURITY ASSESSMEN T & BENCHMARKING



CONSTRUCTION MANUFACTURING SOLUTIONS



ADVISORY + FACILITATION

WHY YOU SHOULD CARE

50%

FASTER

70%

FEWER WORKERS ONSITE

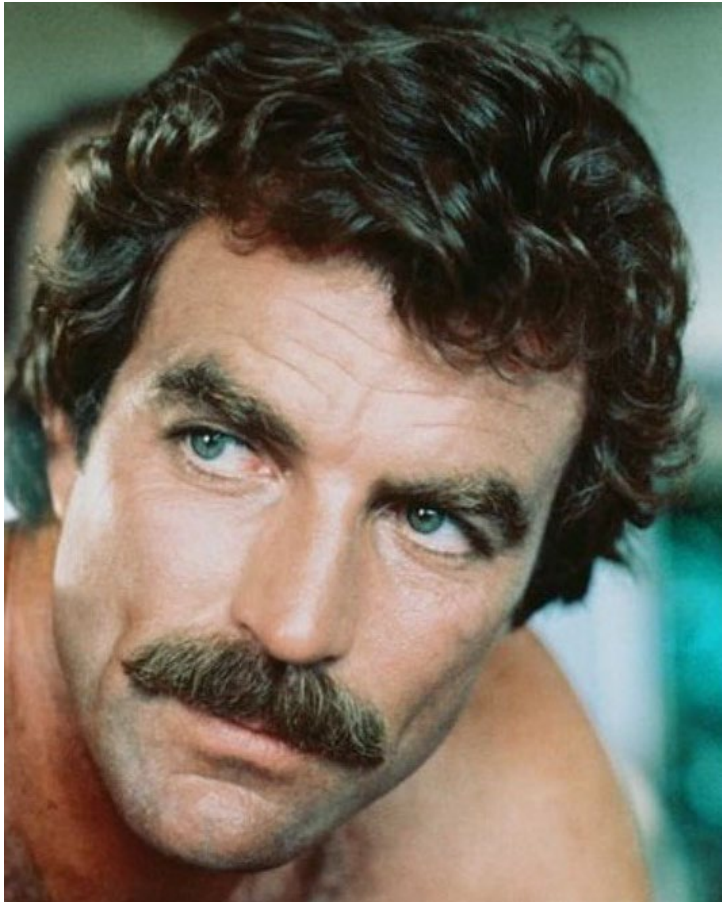
70%

FEWER DELIVERIES

50%

CO_2

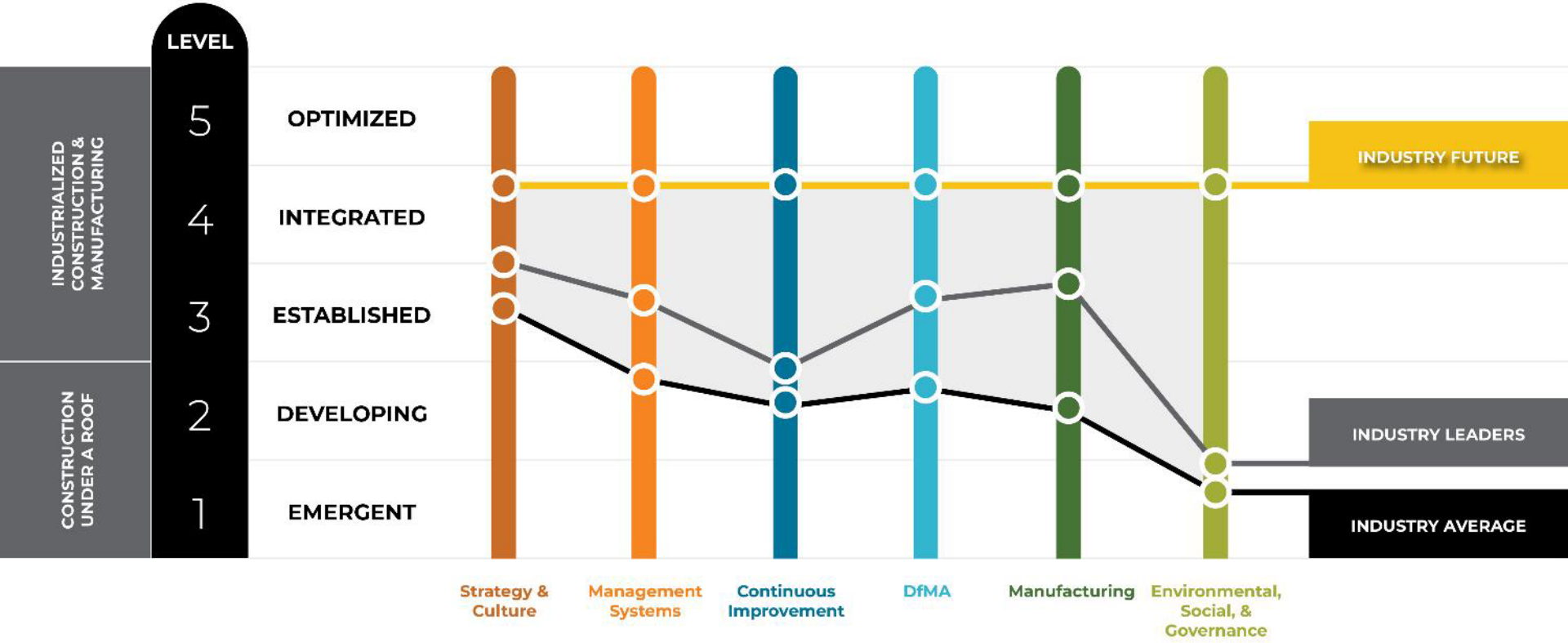
CARBON REDUCTION



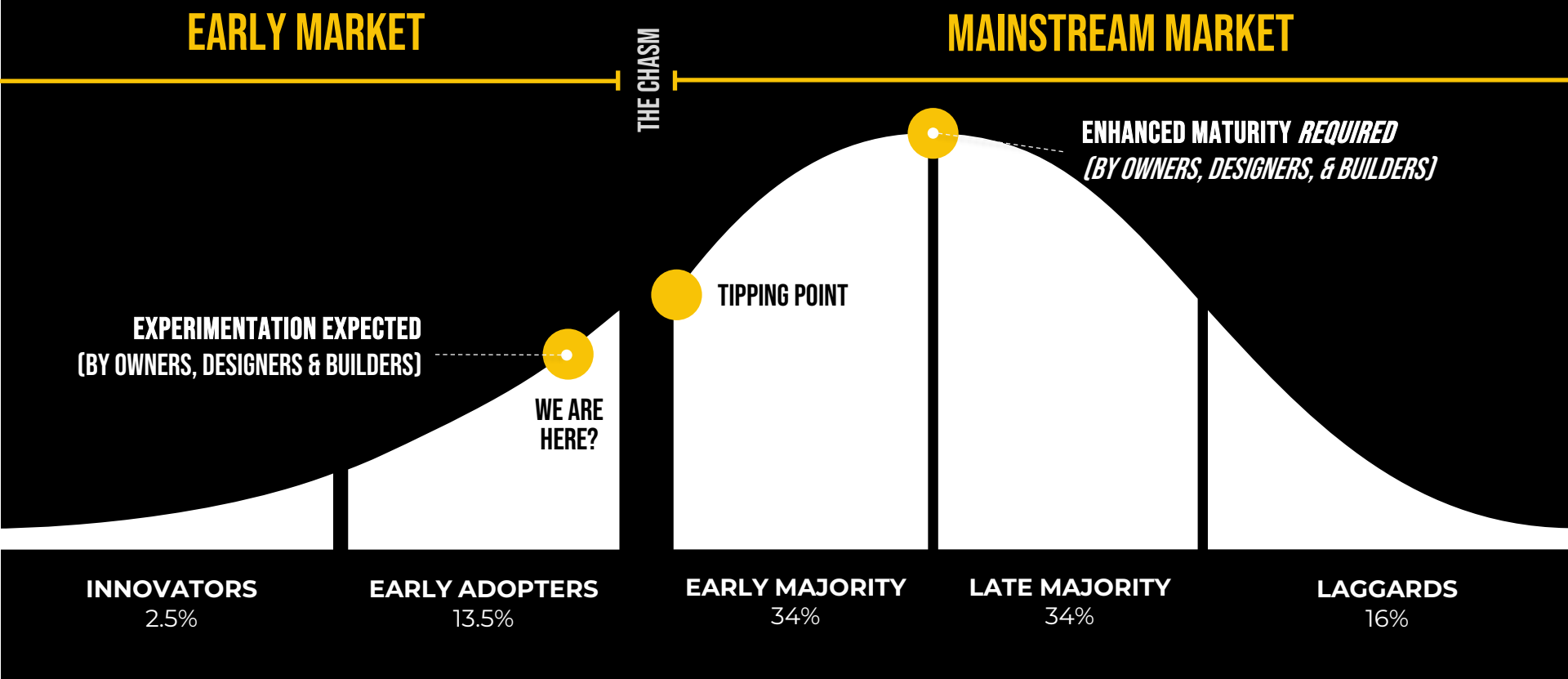
Source: Google images

Industrialized Construction (IC) Maturity: A Data-Driven Benchmark

Where are we as an industry?



INDUSTRIALIZED CONSTRUCTION ADOPTION OF INNOVATION



WHY WE NEED BENCHMARKS ASSESSMENTS & STANDARDS

The most magnificent scheme in the world will be worthless if your perception of the current condition is in error.

SHIGEO SHINGO

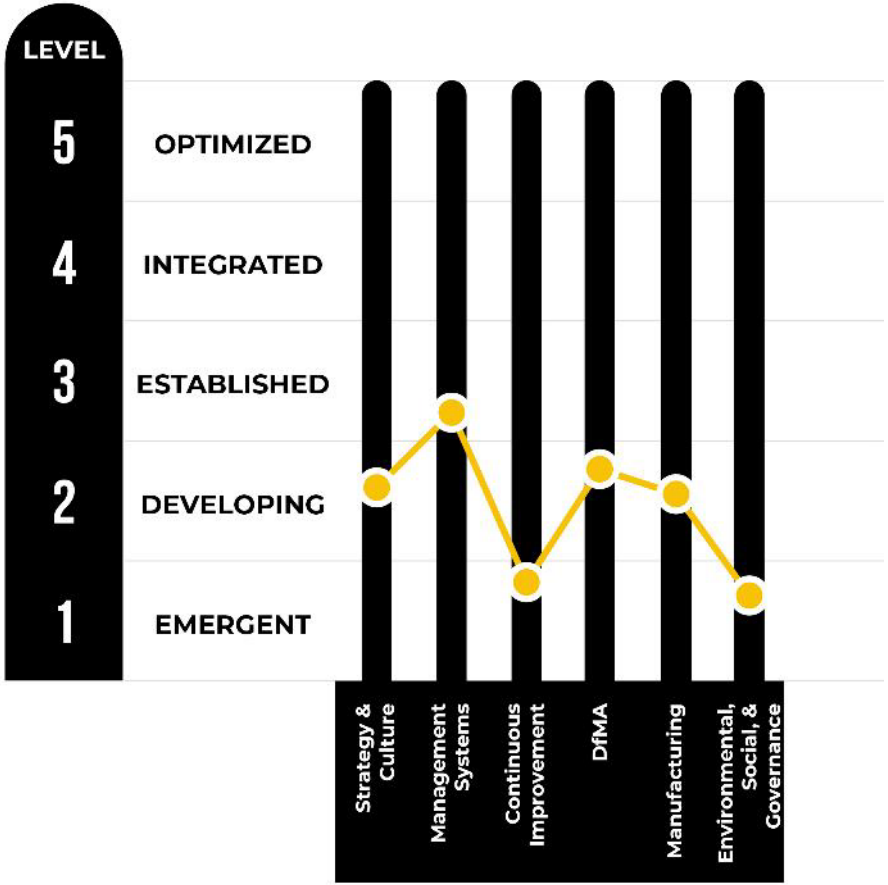
A FRAMEWORK TO UNDERSTAND CAPABILITIES

ICMA SM

INDUSTRIALIZED CONSTRUCTION MATURITY ASSESSMENT

Data-Driven Performance Assessment

6 Disciplines
70 Topics
5 Levels of Performance



STRATEGY & CULTURE

- Coherent strategy
- Cascading Strategy
- Focus on customer value
- Speed of learning

MANAGEMENT SYSTEMS

- Manage in value streams
- Dashboards
- Developing skills of future
- Mgmt. at front line

CONTINUOUS IMPROVEMENT

- Problem Solving Methods
- Process Stability
- Knowledge Transfer
- Foster Innovation

DATA & DESIGN

- Early Integration
- Path to Productization
- Feedback Loops
- Digital Twin
- Product Development / Prototyping

MANUFACTURING MINDSET

- Production Demand (Takt) & Control
- Capacity & Load Leveling
- Standard Work
- Visual Controls & Mgmt.
- Product Line Simulation

ENVIRONMENTAL, SOCIAL, & GOVERNANCE

- Carbon emissions tracking
- Embodied Carbon tracking
- Scrap reduction
- Workforce inclusion

ICMA SM

6 DISCIPLINES

70 TOPICS

INDUSTRIALIZED CONSTRUCTION PROJECT MATURITY

OPTIMIZED
???????

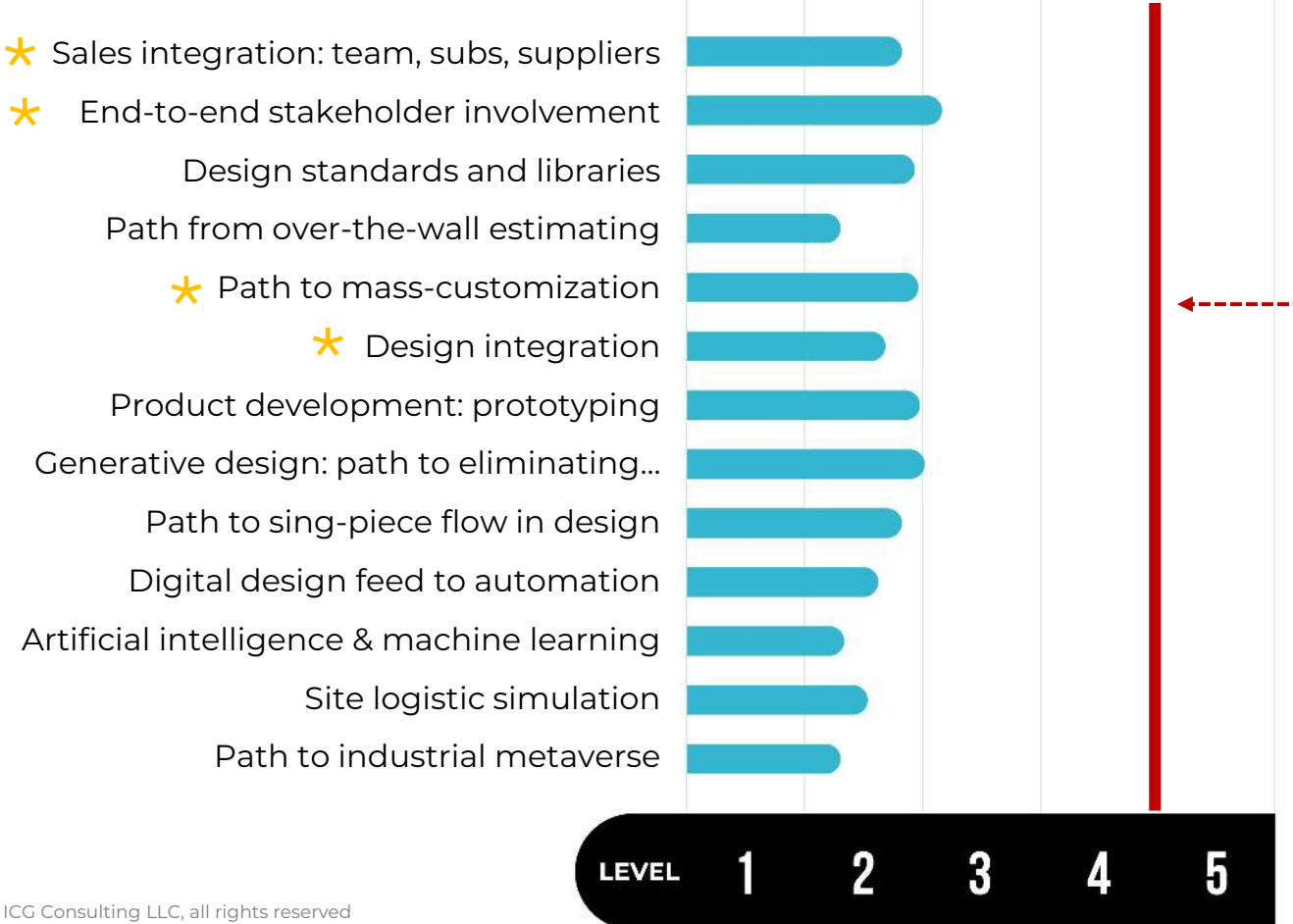
INTEGRATED
TRANSFORMATIVE BUSINESS RESULTS

STABILITY
IMPROVED PROJECT OUTCOMES (SQCD)

DEVELOPING
INCONSISTENT RESULTS

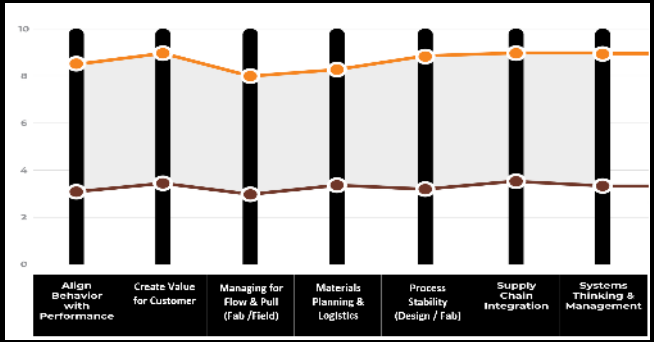
EMERGING
UNIMPROVED / WORSE RESULTS

DIGGING IN TO UNCOVER ACTIONABLE INSIGHTS FOR FACTORIES AND OWNERS



Target for project or program performance

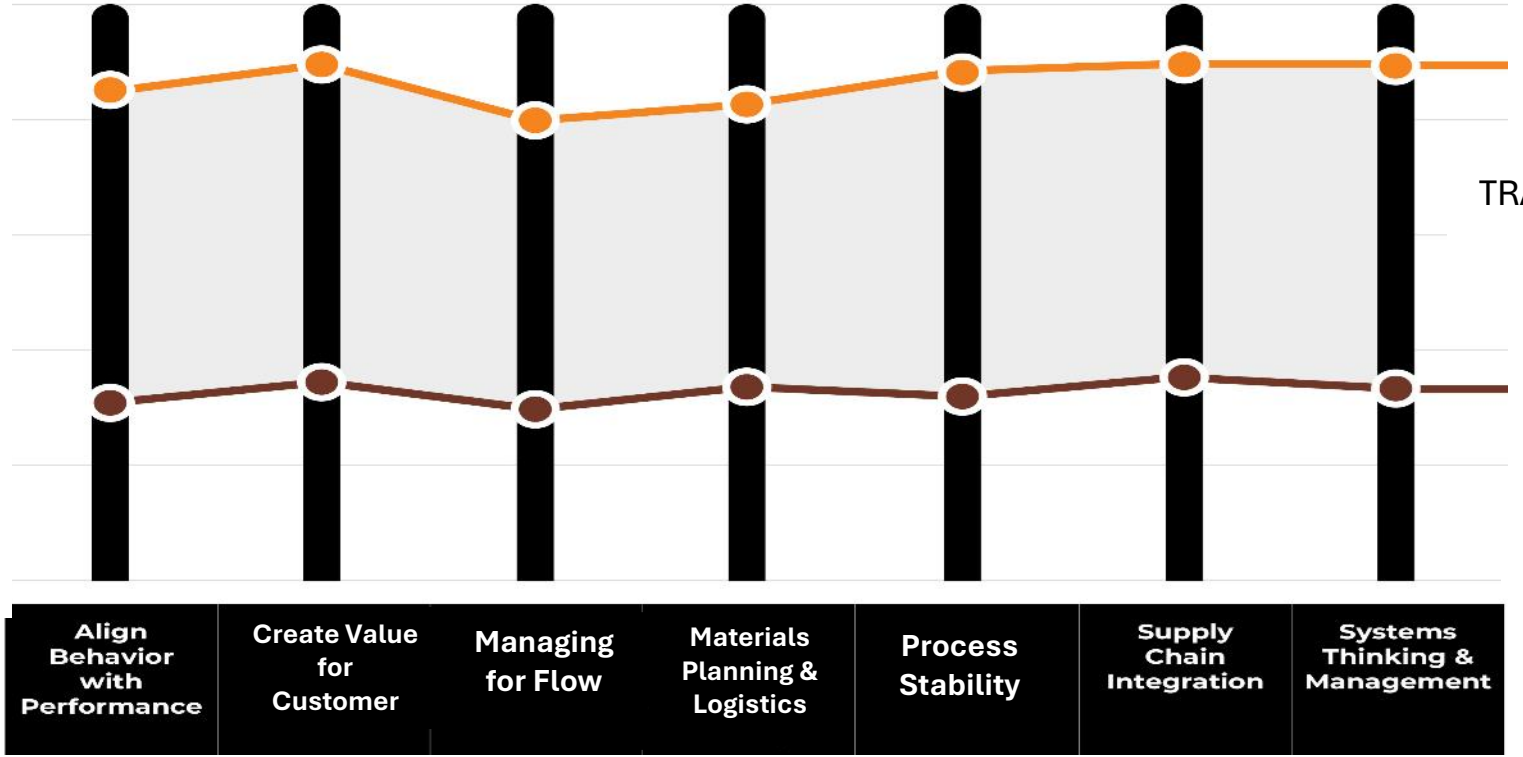
COMPARATIVE INSIGHTS TO MAKE A MORE INFORMED DECISION



FACTORY TOUR ESSENTIALS

HOW YOU CAN LOOK FOR CORE COMPETENCIES THAT DELIVER BETTER PERFORMANCE

CORE COMPETENCIES DELIVERING BETTER PERFORMANCE



TOP PERFORMER

TRANSFORMATIVE RESULTS

INDUSTRY AVERAGE

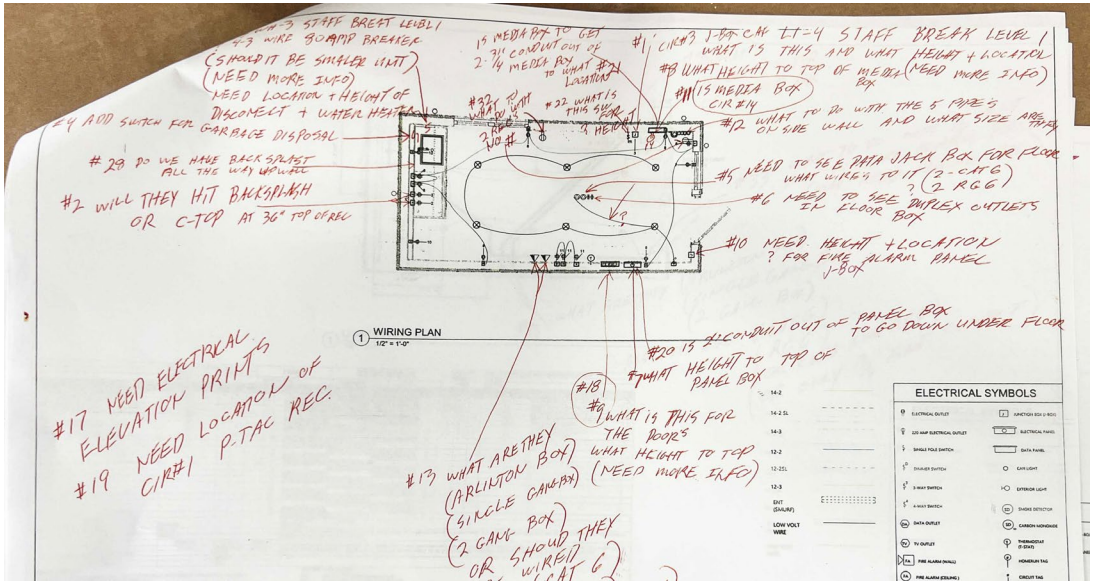
INCONSISTENT RESULTS

Q: Are people WAITING?

- Information
- Material

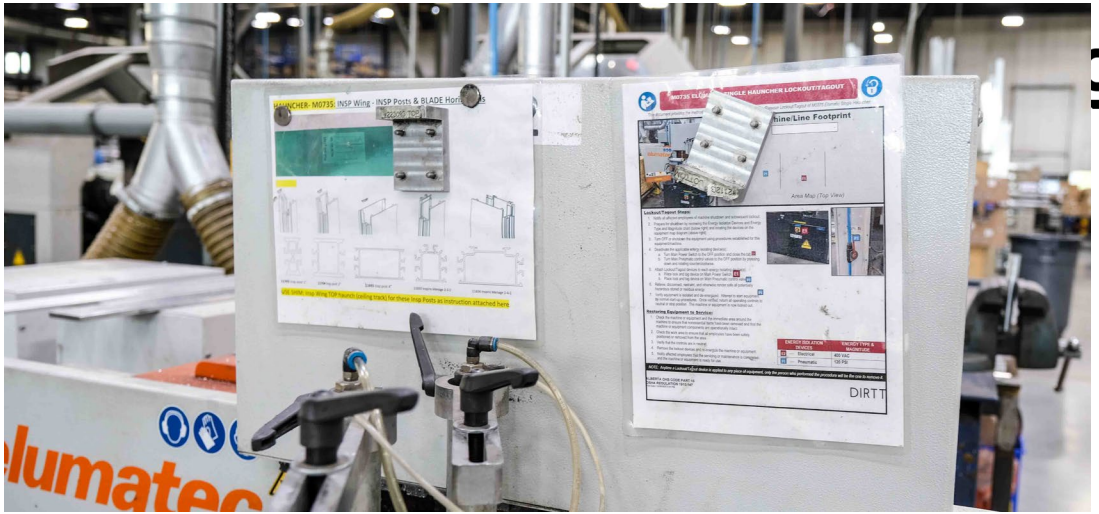
Do you see work instruction with handwriting on them?

Yes = Problem



The equivalent of 19 RFIs

Q: Are work instructions visible?



Unburdened Work

Q: Available lifting devices?

Q: Work at the right height?

Q: Consumables part of workstation?

CAN WE SEE PEFORMANCE ?

DAILY MANAGEMENT (LEARNING!) SYSTEM

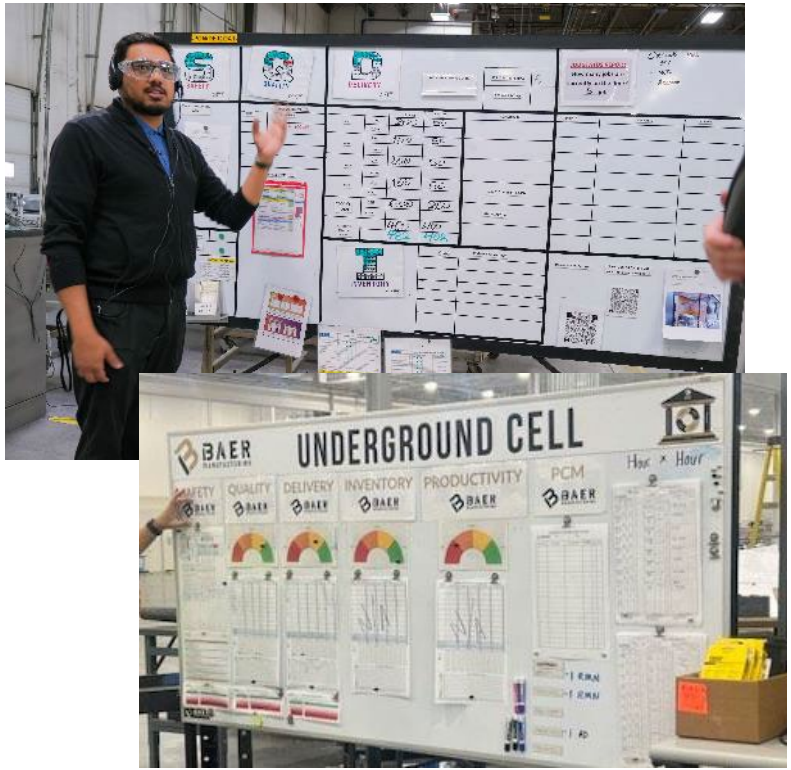


Photo Credits: DIRTT and BAER Manufacturing

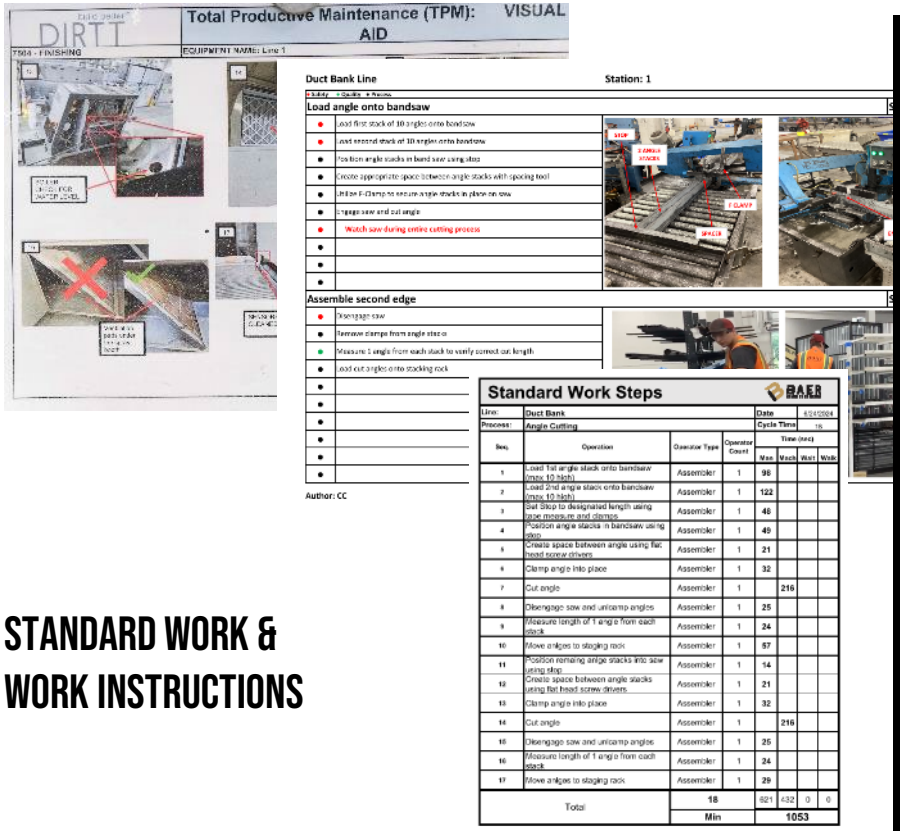
Safety-Quality-Delivery-Inventory

Q: How fast do you learn? Ideal answer is hour-by-hour!

Q: Are you seeing trends?

Q: What is off track today? **Why?**

HOW DO PEOPLE KNOW HOW TO PERFORM THE WORK?



STANDARD WORK & WORK INSTRUCTIONS

Q: How do people learn to perform the work?

Standard work ☑

Tribal knowledge ✕

Photo Credits: DIRTT and BAER Manufacturing

ADOPTION OF MANUFACTURING TOOLING FOR SAFETY

Q: In what ways have you adopted tooling in the name of worker safety?

Q: How have you used tooling or processes to improve the hierarchy of safety controls?

AN EXAMPLE OF ASSESSOR CRITERIA

Level 1: There is no daily management of resources.

Level 2: There is **no reflection on the previous days results** to shape the activities of the day. The organization conducts meetings at the start of a shift.

Level 3: The organization conducts meetings at the start of a shift, have **hourly tracking in place.** The organization tracks and acts on Safety, Quality, Cost, Delivery at the plant level and discussion of goals and S, Q, C, D at the floor level/by department.

Level 4: **Each KPI is active and visible. DMS systematically runs** health & safety, 5S, internal vs. external quality with defect paretos, productivity trends and downtime paretos, actual vs. planned costs trends, and human development goals and status. All visible and any out-of-standard behavior is root-caused, and counter measured at the floor and the same for the plant level.

Level 5: **mutual, automated visibility**

CONSIDER MEDALLION SYSTEM

A POWERFUL ASSET FOR OWNERS AND INTEGRATORS

WHERE ARE WE AS AN INDUSTRY?

TOP PERFORMER STRENGTHS

- IC / Manufacturing roles
- Strategic partnerships
- Product strategy
- End-to-end stakeholder involvement
- Manufacturing Tooling

INDUSTRY-WIDE CONSISTENT GAPS

- Use of standard work
- Structured problem solving
- Manage plant by projects vs products
- Production control / visibility
- Traditional estimating

A CONSTRUCTION MANUFACTURING SYSTEM...

IS BUILT UPON THE 5 OPERATING PRINCIPLES OF LEAN

1. Identify Value in-the-eye of the Customer
2. Operate in Value Streams
3. Achieve Flow of Work Processes
4. Establish Systems that can React to “Pull”
5. Relentless Pursuit of Perfection

CORE COMPETENCIES MUST BE DEVELOPED

THE MINDSET SHI(F)T IS NOT TO BE TAKEN LIGHTLY

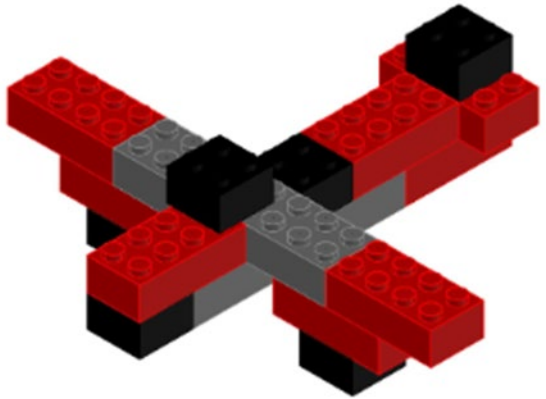
1. Align Behavior with Performance
2. Think & Manage Systematically
3. See & Solve Problems (Identification, Notification, Resolution)
4. Factory data system
5. An Operator Led Environment (an improved respect for people enviro)

GLOSSARY

TERM	DEFINITION
REWORK	any improperly constructed component, assembly, or airplane
SCRAP	any component or assembly with a vendor defect or design revision
STANDARD WORK	the steps, procedures, methods, and times required to complete a process
WORK INSTRUCTIONS	to define and illustrate the tasks, tools, equipment, and built in quality checks required to complete a process
TIME MOTION STUDIES	study used to understand process duration and operator utilization
LINESIDE REPLENISHMENT	calculated quantities of materials presented at point of install for use by labor at regular intervals based on usage
YAMAZUMI	work balancing charting is a tool that aids in the visualization of bottle necks and overworked operators or processes
HEIJUNKA	The reduction of waste in a mfg. process by reducing large fluctuations (unevenness) in production demand & product type

APPLYING LEAN MANUFACTURING PRINCIPLE & MINDSET

LEGO AIRPLANE SIMULATION



YOUR MARKET: AIRPLANE MANUFACTURING

- Airplane production is a tough business!
- Offshore manufacturing is increasing
- Margins are shrinking
- Customers are getting more demanding
- You have no money to hire staff or buy more capacity
- Operate your plant efficiently or you'll face trouble!

ROLES AND OBJECTIVES

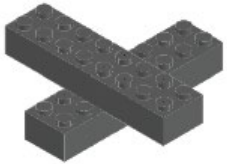
WORKERS	INSPECTOR	DATA CAPTURE
4 people	1 person	1 person
Build the components/ assemblies	Perform quality control	Tabulate production results

DEMAND: 12 Planes Per Shift

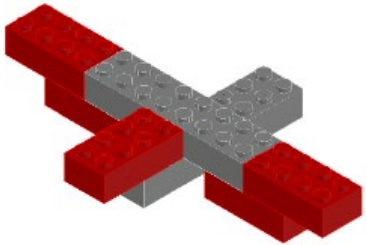
SHIFT: 6 Minutes

PRACTICE

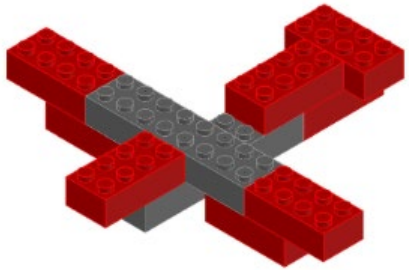
- Read work instructions for your individual station
- Examine the sample plane
- Any questions?



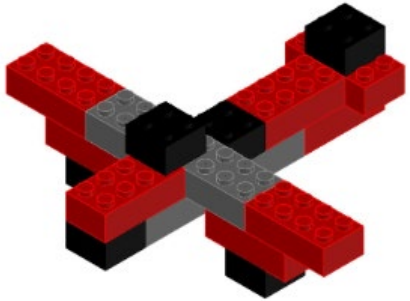
Station 1



Station 2



Station 3



Station 4

PHASE 1

Traditional production

- Aircrafts are assembled in a typical batch process
- **No prebuilding** or kitting is performed
- Each worker is responsible to complete their own tasks (only their own – no help!)
- **Work hard!** You are rewarded for your individual performance!

PHASE 1: CAN WE MAKE IT BETTER?

TOOLS AND LEARNING

- 8 Wastes
- Value stream mapping

LEARNING: EIGHT WASTES DOWNTIME

Defects: Efforts caused by rework, scrap, incorrect info

Overproduction: Producing more than is needed or too early

Waiting: Idle time waiting for resources, materials, or information

Non-Utilized Talent/Resources: Underutilized employee skills & expertise

Transportation: Unnecessary movement of products and materials

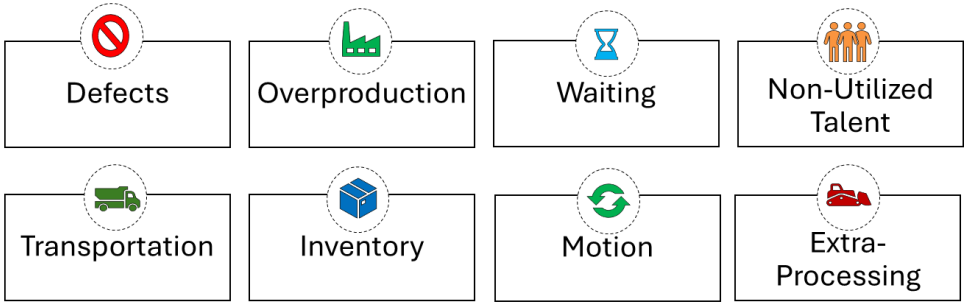
Inventory: Holding excess materials, WIP, or finished goods

Motion: Excess movement by people (walking most common)

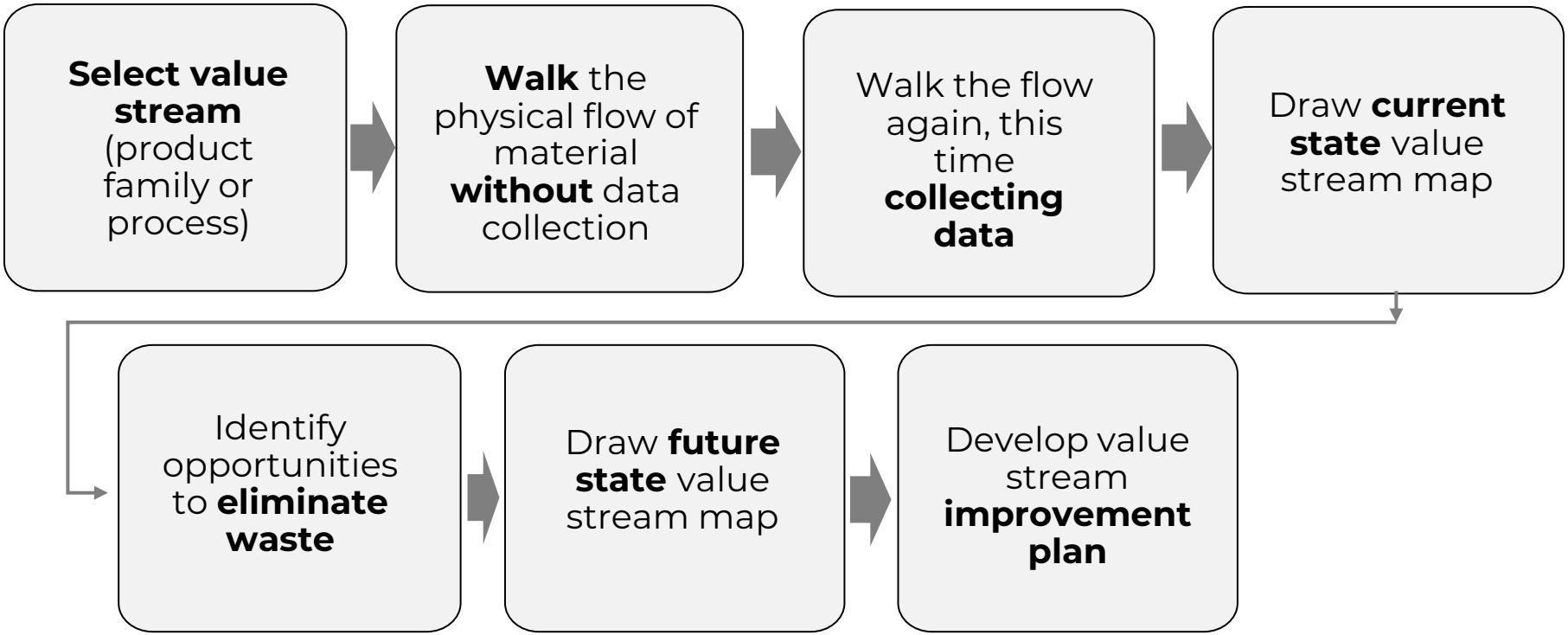
Extra-Processing: More work/quality, added features than customer requires

PHASE 1: REFLECTIONS AND QUESTIONS

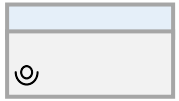
- Which of the 8 waste did you see in this exercise?
- Do any of these exist in your current project? Which are most common on your projects?



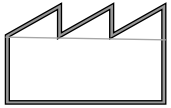
VALUE STREAM MAPPING

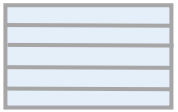


VALUE STREAM MAPPING (VSM)


Process


Production control


Customer/ supplier


Data box


External shipment

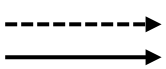

Production kanban


Inventory supermarket


Signal kanban


Inventory

Load leveling


Manual Info

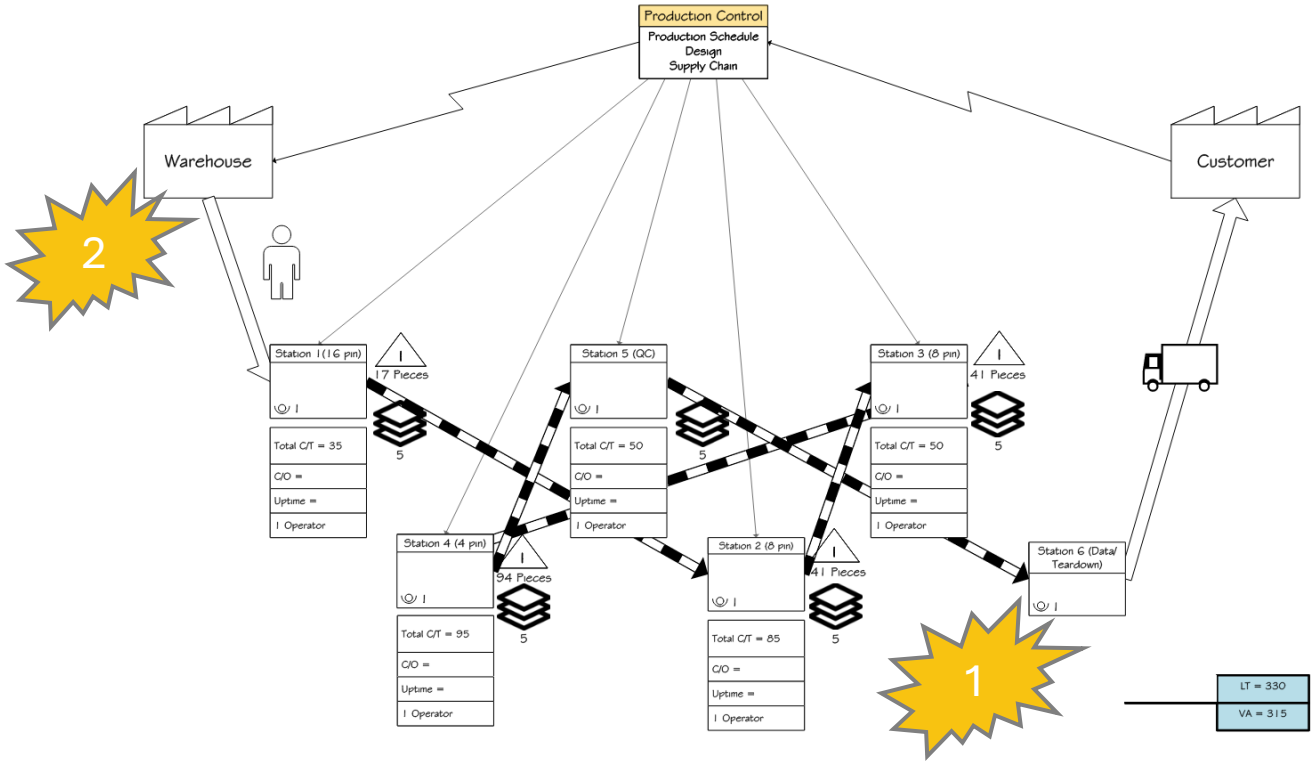

Electronic info


Batch / WIP


Push arrow


Material pull

PHASE 1 AIRPLANE: VSM W/ KAIZEN BURSTS



KAIZEN BURSTS

(Opportunities for Improvement):

1. Physical station layout
2. Lineside Replenishment

PHASE 2: REFLECTIONS & QUESTIONS

- How did resequencing the work and moving the material closer to point-of-use improve your throughput?
- Did we solve one problem, but add new waste? What wastes still exists?
- How much did layout change help? What about better materials staging?
- What are some changes you could make to your Fab Shop or Job Site (plant) layout or materials staging in real life?

PHASE 2 – CAN WE MAKE IT BETTER?

TOOLS AND LEARNING

- Push vs. pull systems

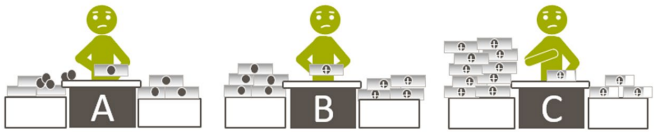
PUSH VS. PULL

PUSH SYSTEM:

Also known as a **make to stock manufacturing.**

Production is based on known forecasts with low fluctuation in demand.

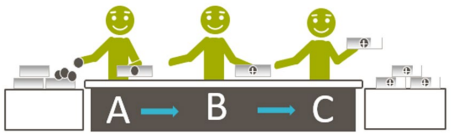
Once produced, **sub-assemblies and finished goods are PUSHED to the next station or point of use whether needed or not.**



PULL SYSTEM:

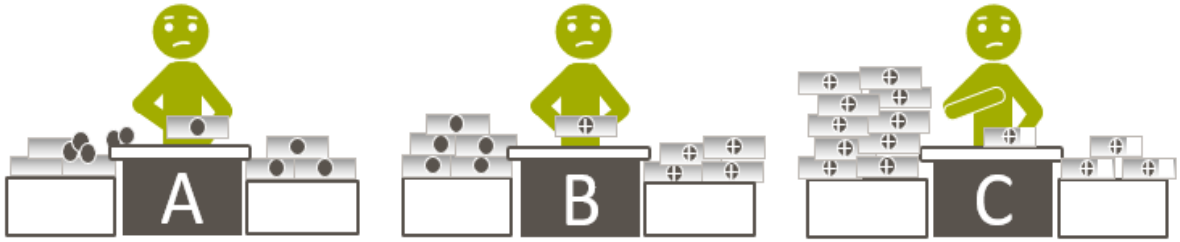
Also known as lean, single-piece flow, or just-in-time (JIT)

Production at one station only occurs when **initiated by a customer downstream.**



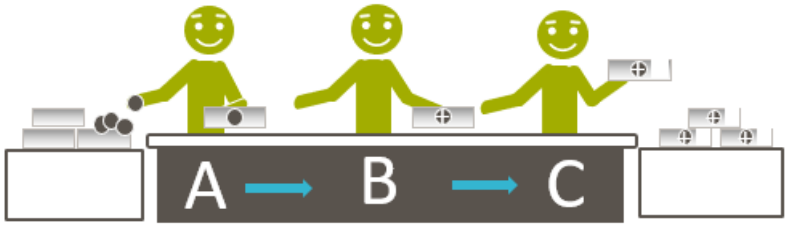
PUSH VS. PULL

BATCH & PUSH PROCESSING



Large lot productions, forecasted demand, high inventory, manufacturing waste, high efficiency with low system productivity

SINGLE PIECE FLOW "MAKE ONE, MOVE ONE"



Small lot production, based on customer demand, low inventory, low manufacturing waste, demand flexibility, high system productivity

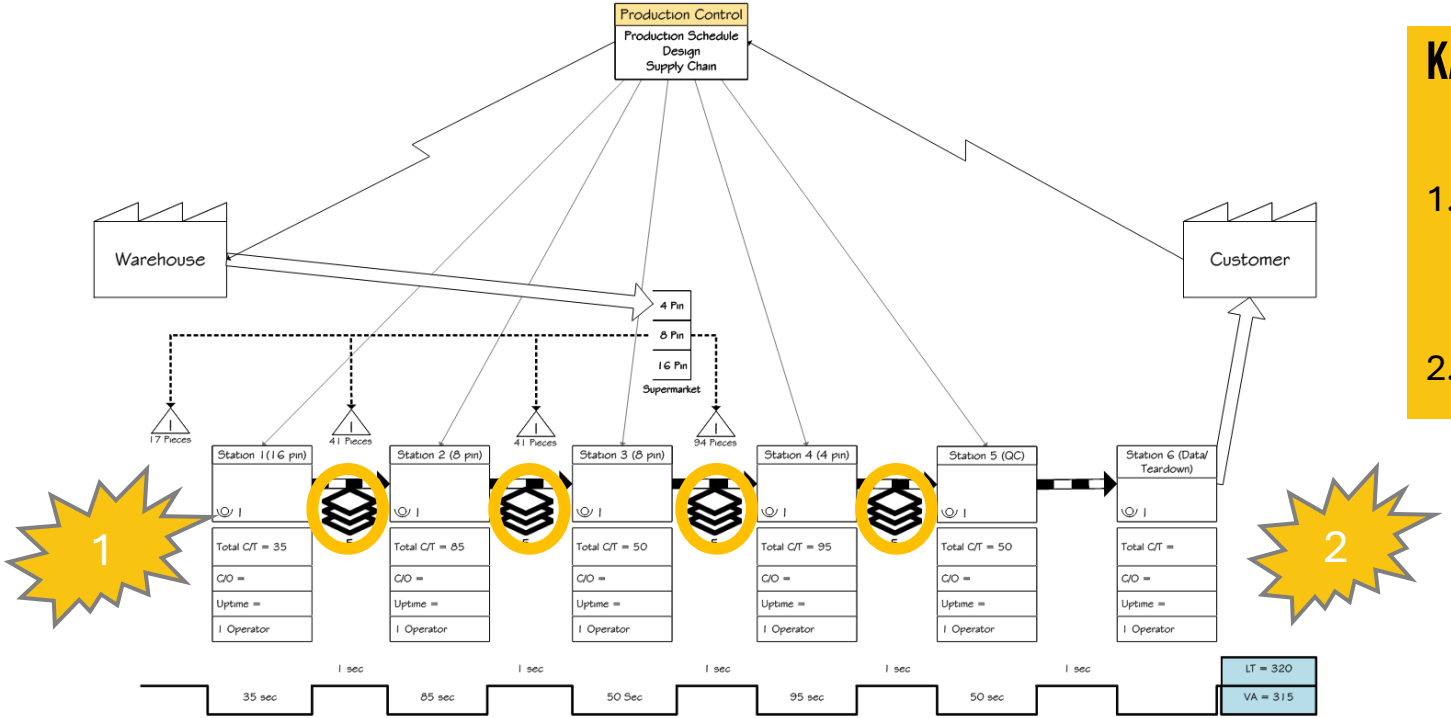
PUSH SYSTEMS

ADVANTAGES	DISADVANTAGES
» Goods can be produced based on demand forecast that is **stable** » Enables for longer term planning (not based on specific client demand)	» Uncertainty in demand, supply chain, and manufacturing process issues/changes » Long time to react to market changes » Lead times dependent on lot sizes » Quality problems » Higher inventory costs

PULL SYSTEMS

ADVANTAGES	DISADVANTAGES
» Reduces inventory » Inventory stored at point of use » Local ownership » Improved communication » Reveals quality problems » Efficiency gains	» Lack of flexibility and managing variability » Implementation time » Purchasing system integration » Sunset process » Multiple sourcing » Tight Integration with Suppliers

PHASE 2 AIRPLANE: VSM W/ KAIZEN BURSTS



KAIZEN BURSTS

1. Single piece flow / no more batching
2. Built in quality

PHASE 3 – CAN WE MAKE IT BETTER?

TOOLS AND LEARNING

- TAKT
- Cycle Time
- Workload Balance

MEASURING PRODUCTION: TAKT TIME VS. CYCLE TIME

WHAT IS TAKT? A manufacturing term used to describe production rate required to meet customer demand.

WHAT IS CYCLE TIME? Cycle Time measures the time it takes for a specific process or task to be completed.

- **TAKT** is stable (rate, beat, pulse)
- **CYCLE TIME** can vary

TESTABLE

TAKT TIME is a time value used to define the **PER- UNIT PRODUCTION RATE** required to meet customer demand.

$$\text{TAKT TIME} = \frac{\text{AVAILABLE PRODUCTION TIME PER DAY}}{\text{CUSTOMER DEMAND PER DAY}}$$

PHASE 3: REFLECTIONS AND QUESTIONS

- Did we meet demand? What is your current demand?
- How do you know if you are ahead or behind?

WHY IS TAKT IMPORTANT?

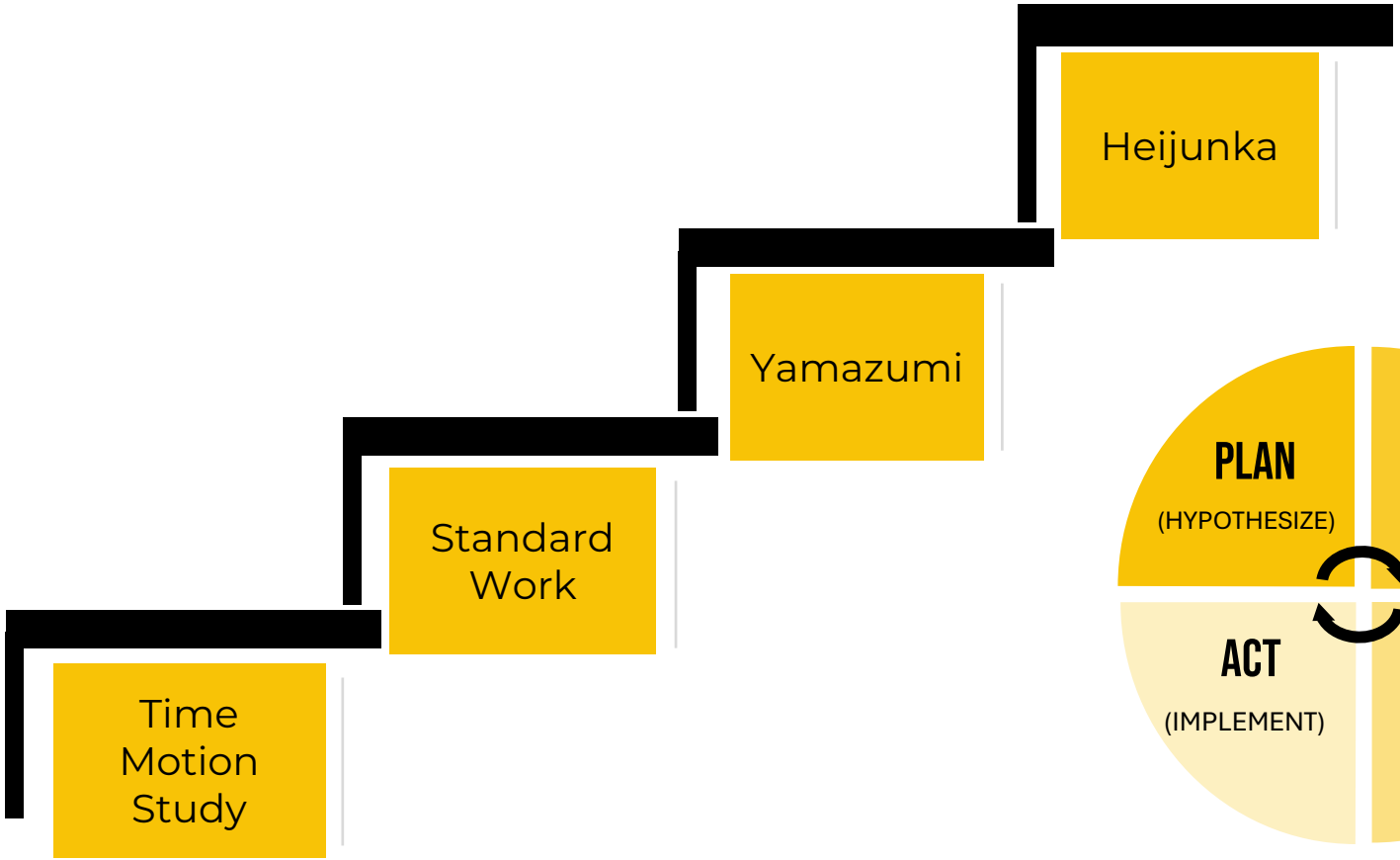
- Reduces waste (overproduction)
- Understanding capability of meeting customer demand
- Supports optimization of labor force when analyzed against cycle time
- Help establish and maintain single-piece flow

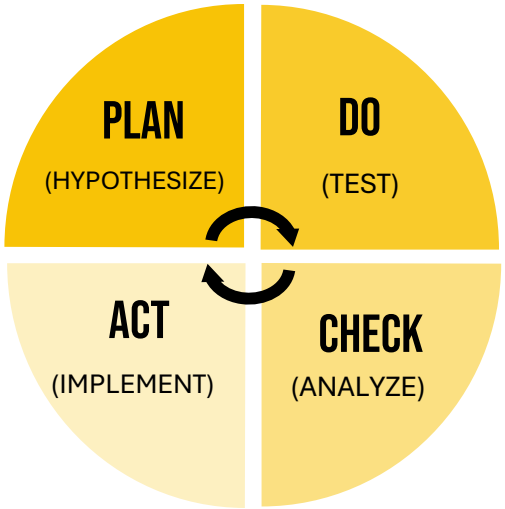
TAKT EXERCISE

$$\text{TAKT TIME} = \frac{\text{AVAILABLE PRODUCTION TIME PER DAY}}{\text{CUSTOMER DEMAND PER DAY}} \quad \frac{\text{360 SECONDS PER SHIFT}}{\text{12 PLANES PER SHIFT}} = \text{30 SECONDS}$$

- At what rate per station should you be completing an assembly?
- Why are you not able to meet this rate?
- Do you know your current Takt and/or cycle time in your actual system?

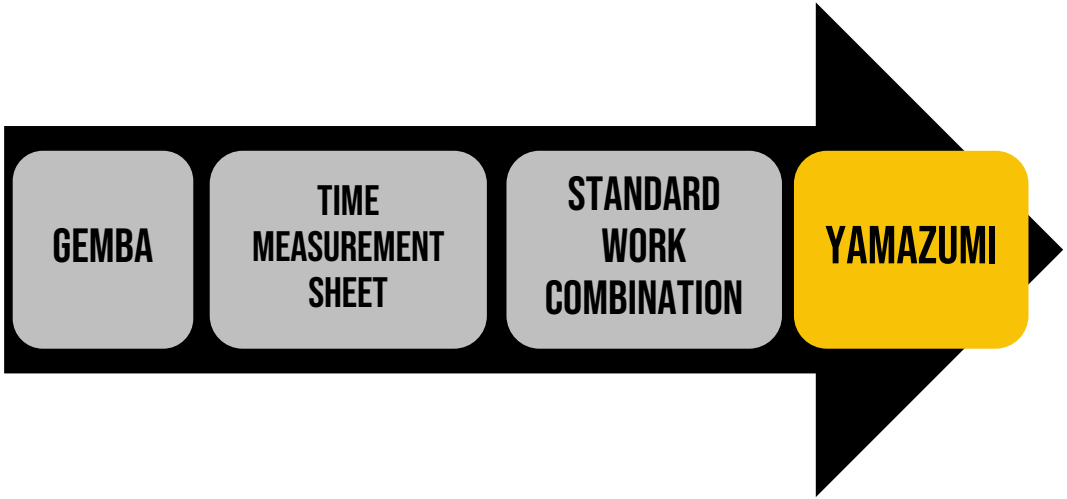
WORK BALANCING CONTINUOUS IMPROVEMENT





WHAT IS YAMAZUMI (TO STACK UP)

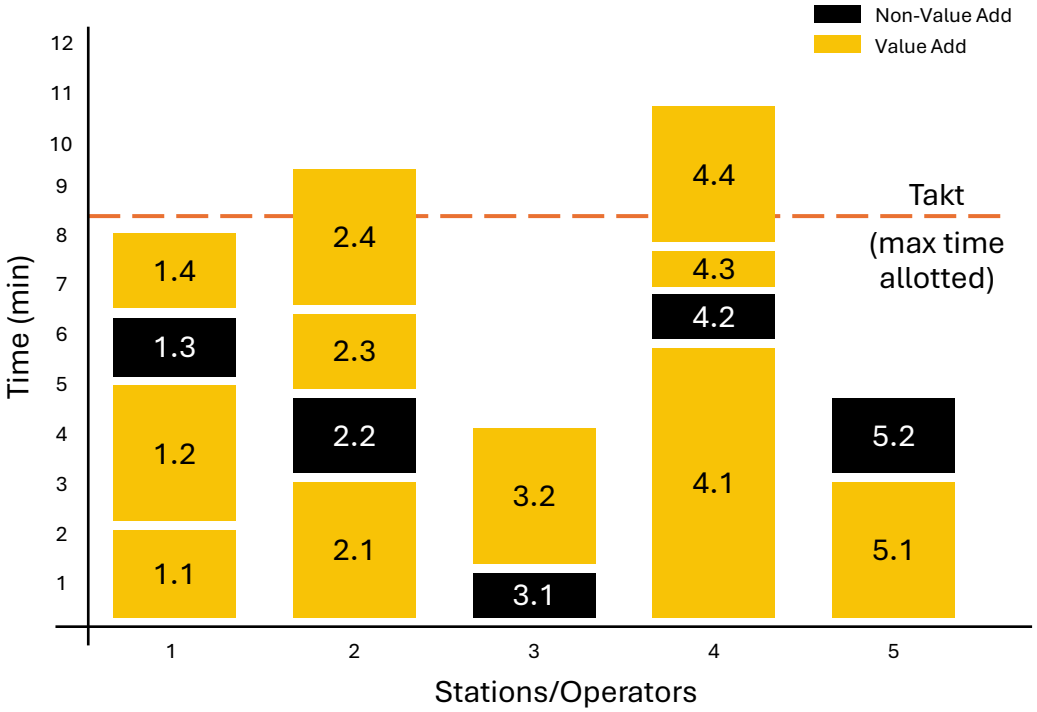
- Balance work (Station/Operator)
- Eliminate waste
- Line setup /improvements
- Achieve demand



Yamazumi charting is a tool that aids in the visualization of bottle necks and overworked operators or processes.

WORK BALANCING BY STATION/OPERATOR

Each block represents a defined task or an operator's assigned amount of work.



THE YAMAZUMI CHART

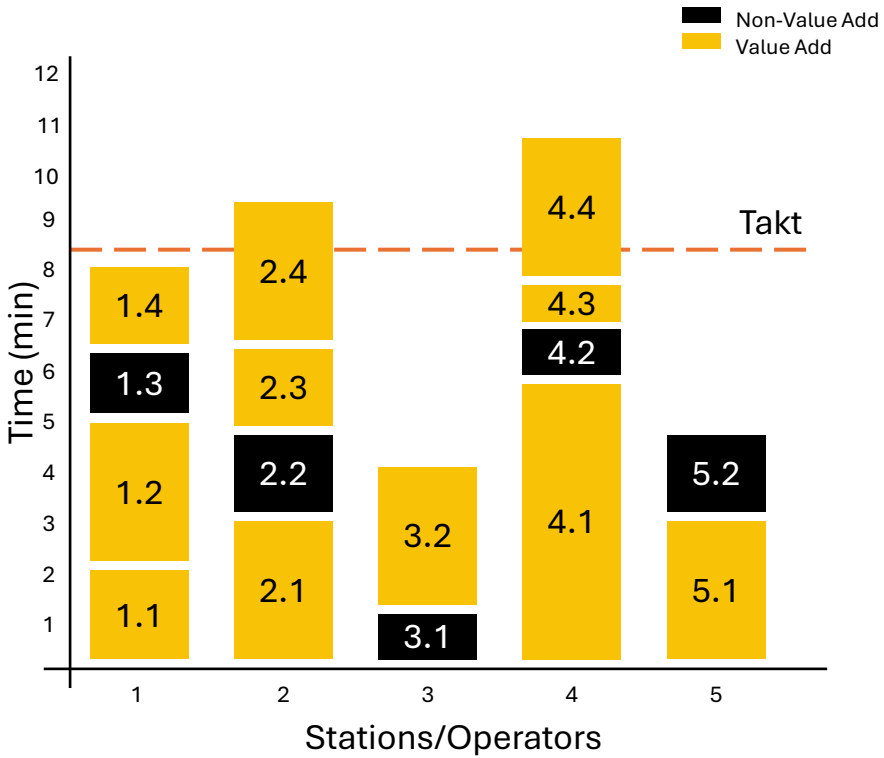
WORK BALANCING BY STATION/OPERATOR

WHAT TO LOOK FOR:

- Stations over Takt time
- Stations close to Takt time
- Stations significantly under Takt time
- Non-value-added tasks

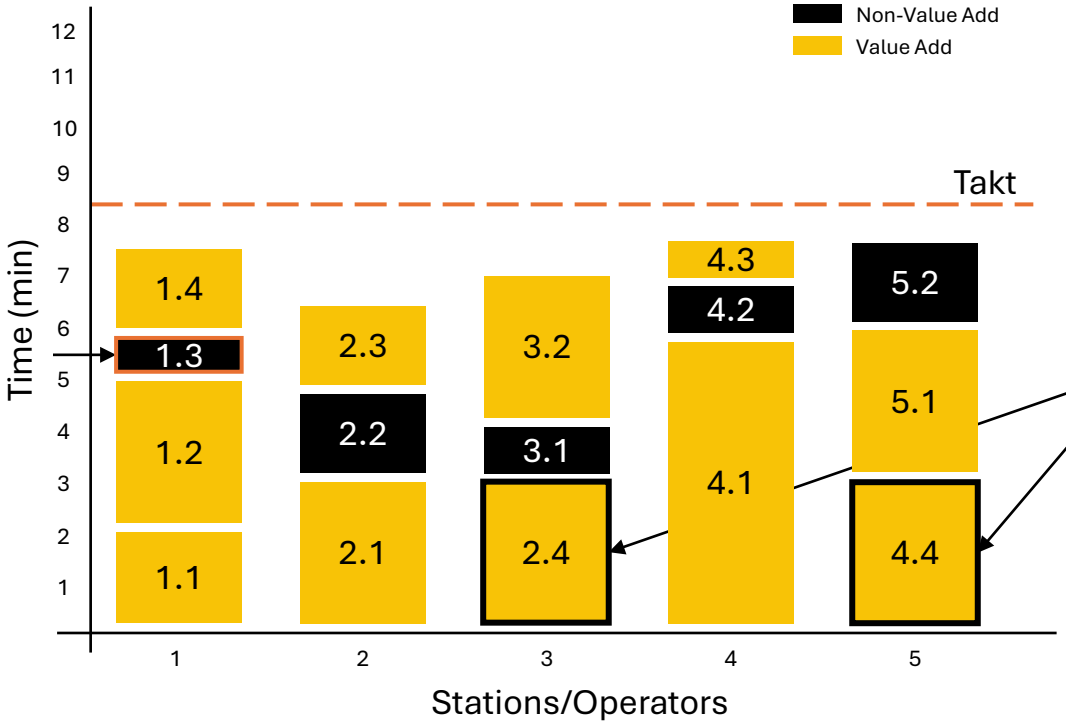
HOW TO MANAGE:

- Identify unnecessary processes that can be removed
- Work to eliminate non-value-added tasks
- Work to reduce task process times
- Identify areas where work content can be moved to other areas



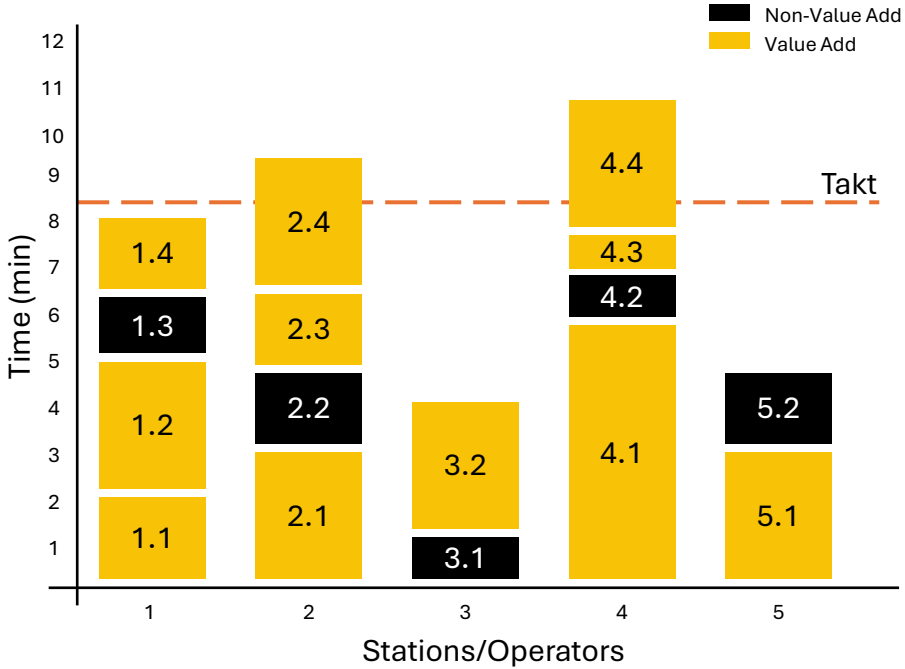
YAMAZUMI BY STATION/OPERATOR

Reduced waste in nonvalue added activity in block 1.3.

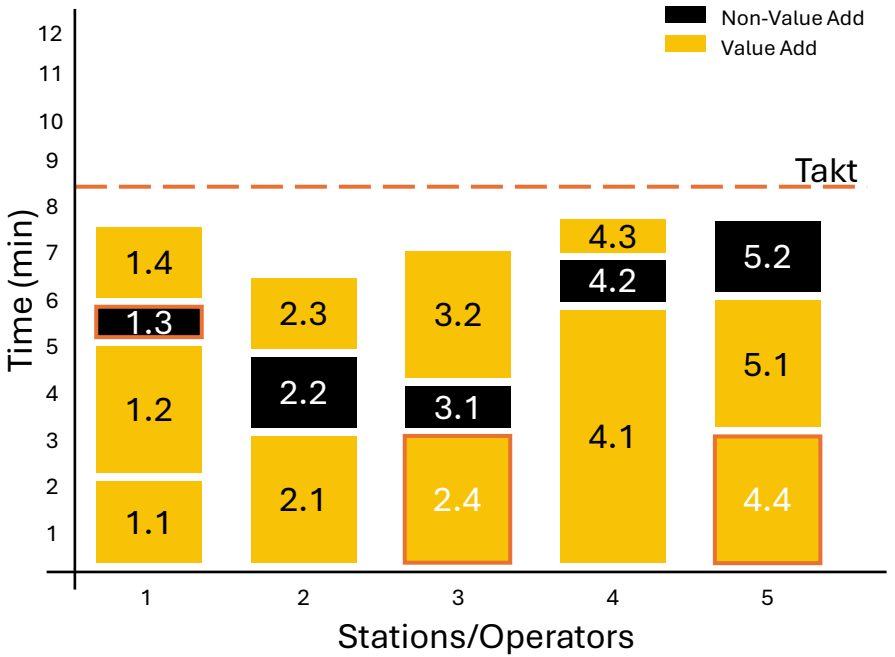


Reallocated value-added work from blocks 2.4 and 4.4

YAMAZUMI BY STATION/OPERATOR

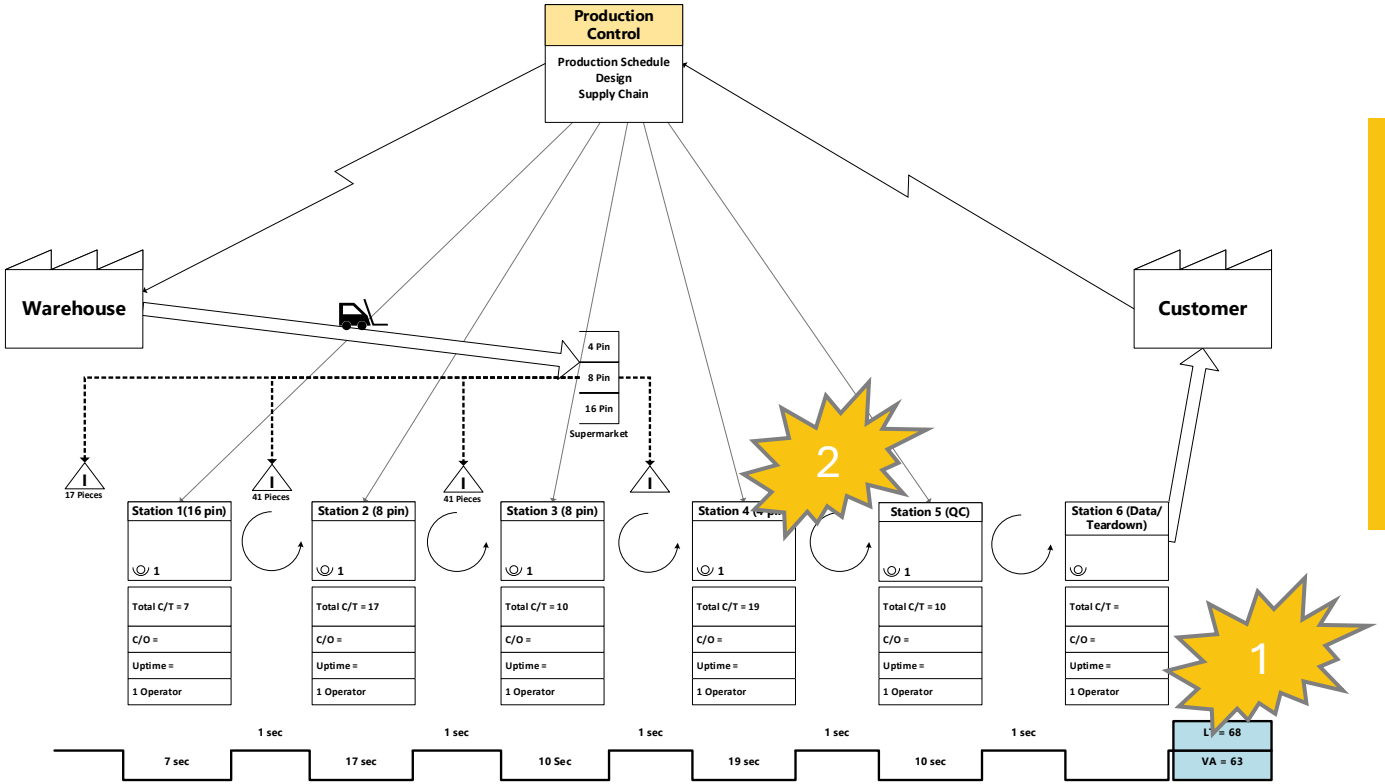


BEFORE WORK BALANCING



AFTER WORK BALANCING

PHASE 3 AIRPLANE: VSM W/ KAIZEN BURSTS



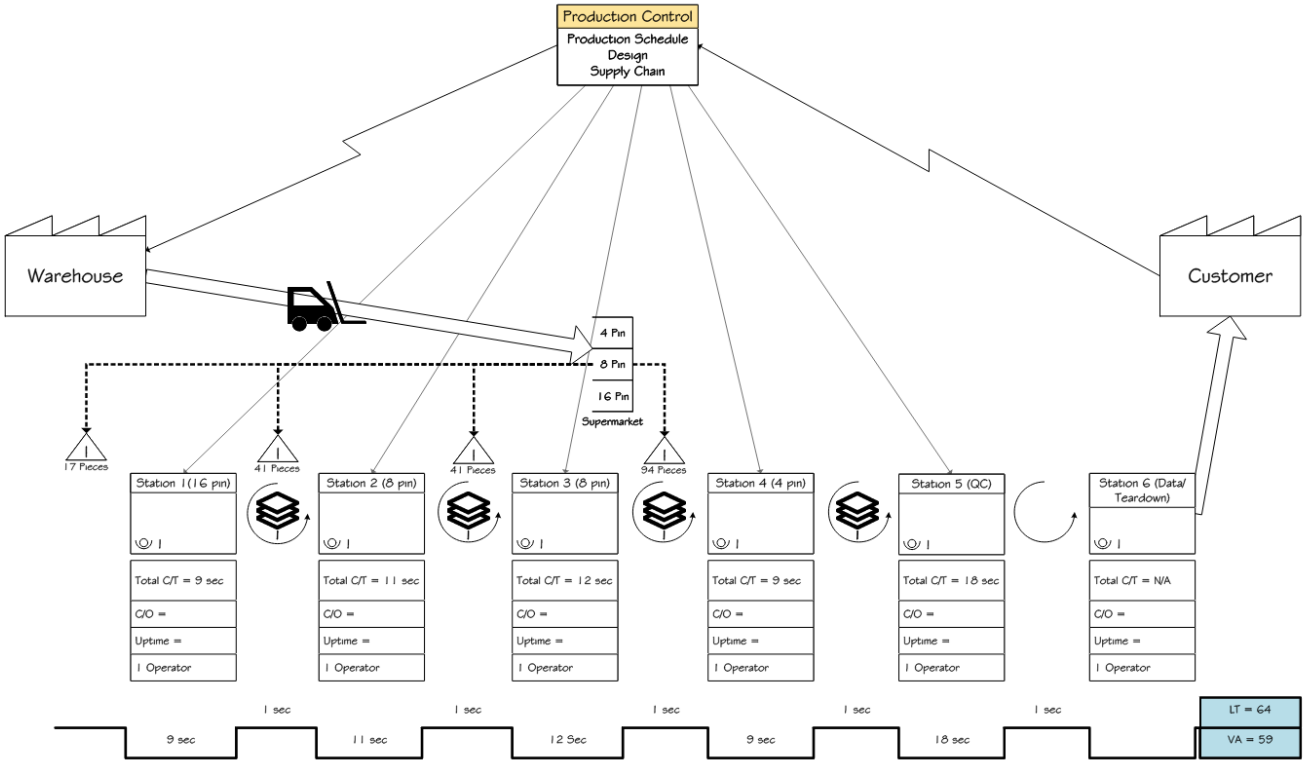
KAIZEN BURSTS

1. Takt vs Cycle Time
2. Workload balancing

PHASE 4: REFLECTIONS & QUESTIONS

- What are some value add and non-value add steps you identified?
- If you were asked to improve what should your target be? What steps would you take?
- Consider which improved: Quality, Cost, Delivery, Safety

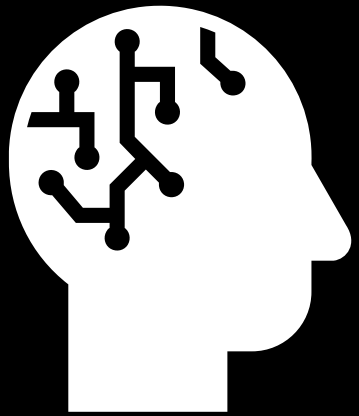
PHASE 4 VSM


Production Control
Production Schedule
Design
Supply Chain
Warehouse
Customer
4 Pin
8 Pin
16 Pin
Supermarket
17 Pieces
41 Pieces
41 Pieces
94 Pieces
Station 1 (16 pin)
Station 2 (8 pin)
Station 3 (8 pin)
Station 4 (4 pin)
Station 5 (QC)
Station 6 (Data/ Teardown)
Total C/T = 9 sec
C/O =
Uptime =
1 Operator
Total C/T = 11 sec
C/O =
Uptime =
1 Operator
Total C/T = 12 sec
C/O =
Uptime =
1 Operator
Total C/T = 9 sec
C/O =
Uptime =
1 Operator
Total C/T = 18 sec
C/O =
Uptime =
1 Operator
Total C/T = N/A
C/O =
Uptime =
1 Operator
1 sec
1 sec
1 sec
1 sec
1 sec
9 sec
11 sec
12 Sec
9 sec
18 sec
LT = 64
VA = 59

FINAL REFLECTIONS

- What did you learn in each phase? How did you feel?
  - Phase 1: Traditional
  - Phase 2: Cellular
  - Phase 3: Pull
  - Phase 4: Balanced
- What difference could this make in the real world? Is this at all realistic? Why? Why not? What would you expect to achieve?

CONVERSATION



SIMULATION MODEL
WHITE PAPER

CONTACT WITH ME