PathStone Group

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Line Balancing

Agenda

1. Line Balancing: What is it ?
2. Line Balancing purpose and benefits
3. Objectives of Line Balancing
4. Steps in Solving Line Balancing
5. Line Balancing Techniques
6. Takeaways

Introduction

What is it ?

Line balancing is a method used to **stabilize** all the work content across all the stations or processes.

Introduction

Purpose and Benefits

- We can achieve a reduction in the **waiting time** or **disturbing even flow**.
- It also helps to make sure operators are not **overburdened (Muri)**.

Introduction

Purpose and Benefits

- Successful line balancing requires assuring that **every line segment's production** quota can be met within the time frame using the available production capacity.
- The intent of Line balancing is to **match the output rate to the production plan.**
- The job is divided into small portion called "**job element".**

Line Balancing

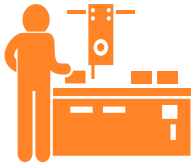
Objectives of Line Balancing:

Workload

Manage the **workloads** among assemblers.

Bottleneck

Recognize the location of **bottleneck**.



Workstations

Decide **number of workstations**.

Cost

Decrease production **cost**.

Idle Time

Assigning task to each workstation in such a way that there is **little idle time**.

Line Balancing

Line balancing operates under two circumstances:

1

Precedence Constraint: Products cannot progress to other station if it does not complete a necessary task at that station. It should not be across other station because certain part needs to be performed before other activities.

2

Cycle time Restriction: Cycle time is maximum time for products spend in every workstation. Different workstation has different cycle time.

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Steps in Solving Line Balancing:

1. Precedent Diagram
2. Determining Cycle Time
3. Assigning Tasks to Workstation
4. Calculating an Efficiency Line

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A food company is planning to manufacture 5,000 meal sets a week. The company has set up a production line with 9 work elements and allocated 40 hours a week to this manufacture.

Secrets of Airline Catering Kitchens Serving 100,000 Meals Per Day (skift.com)

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Precedent Diagram:

Precedence diagram needs to be drawn to show a relationship between workstations. Certain process begins when the previous process was done.

HINT: Develop the Process Map first, then the precedent diagram

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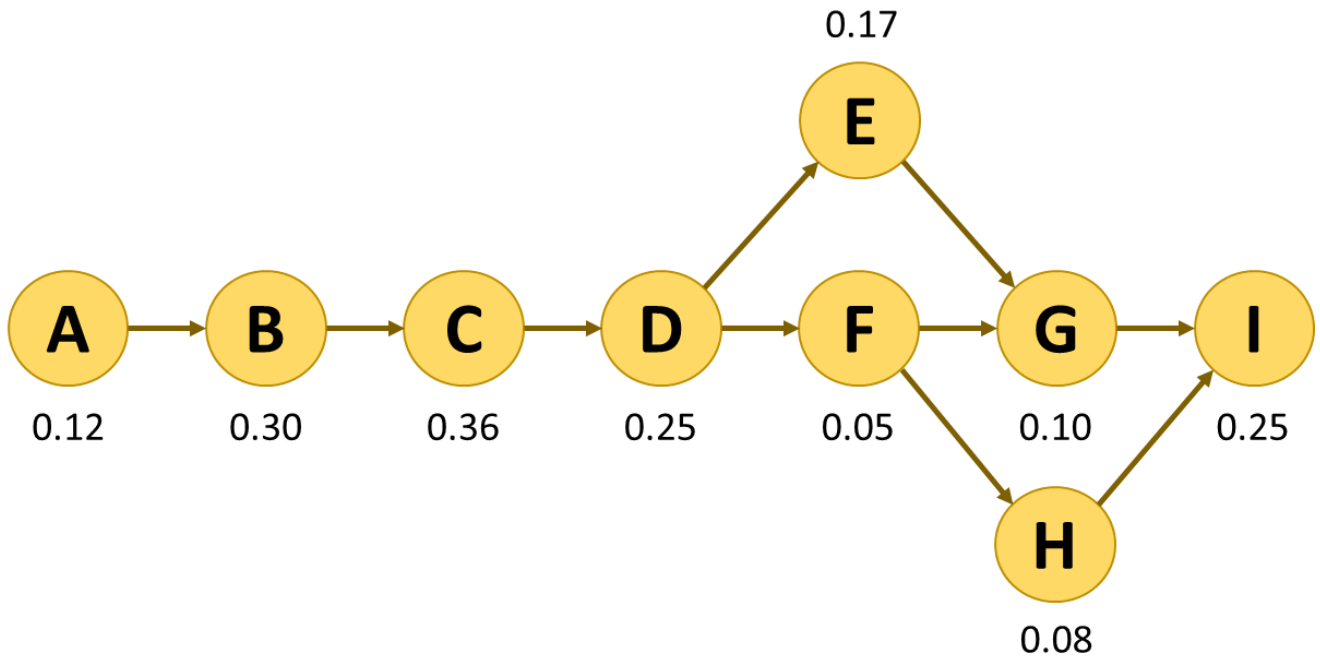
Process job elements and precedent diagram.

Job Element	Description	Takt time (min)
A	Load kettle	0.12
B	Mix blend	0.30
C	Add salad dressing	0.36
D	Place in container	0.25
E	Close container	0.17
F	Hand label master box	0.05
G	Place on labeler machine	0.10
H	Label container	0.08
I	Load and close master box	0.25

Total time = 1.68 min



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Determine Cycle Time:

Cycle time is longest time allowed at each station. This can be expressed by this formula:

$$\textbf{Cycle time } (CT) = \frac{Available\ time}{Desired\ output}$$

also,

$$CT = \frac{1}{Run\ rate}$$

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Determine Cycle Time:

$$\boldsymbol{CT} = \frac{40\ hours\ x\ 60\ min}{5{,}000\ sets} = 0.48\ min$$

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Assigning Tasks to Workstation:

The tasks distributions should be taken after completing a time cycle. It is good to allocate tasks to workstation in the order of longest task times.

$$\textbf{Number of work stations } (WS) = \frac{\sum Task\ time}{Desired\ actual\ time}$$

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Assigning Tasks to Workstation:

$$\boldsymbol{WS} = \frac{1.68\ \text{min}\ \ (Total\ work\ content)}{0.48\ \text{min}(Required\ cycle\ time)} = 3.5\ stages$$

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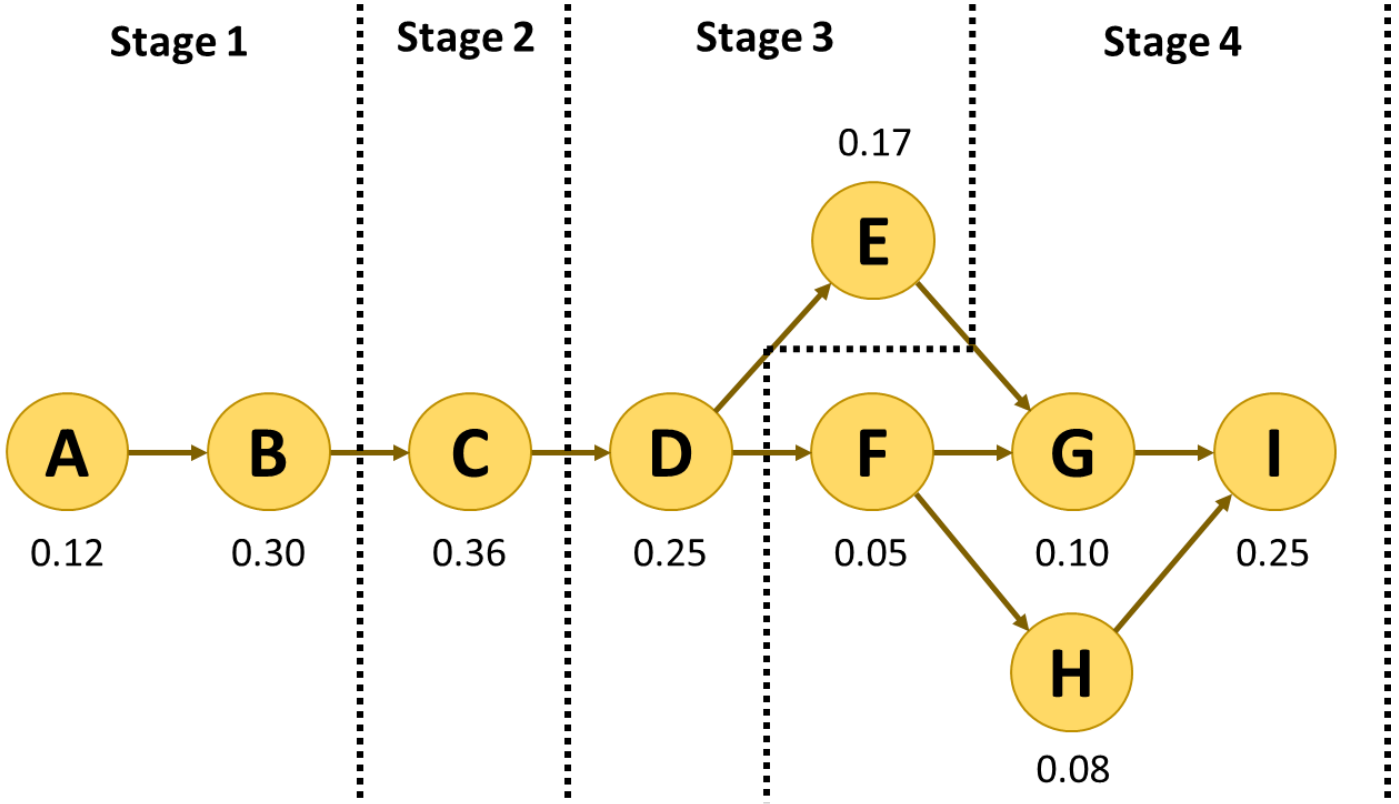
Allocation of Stages.

Assigning Tasks to Workstation:



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Calculating an Efficiency Line:

This is done to find effectiveness of the line. The formula is given by:

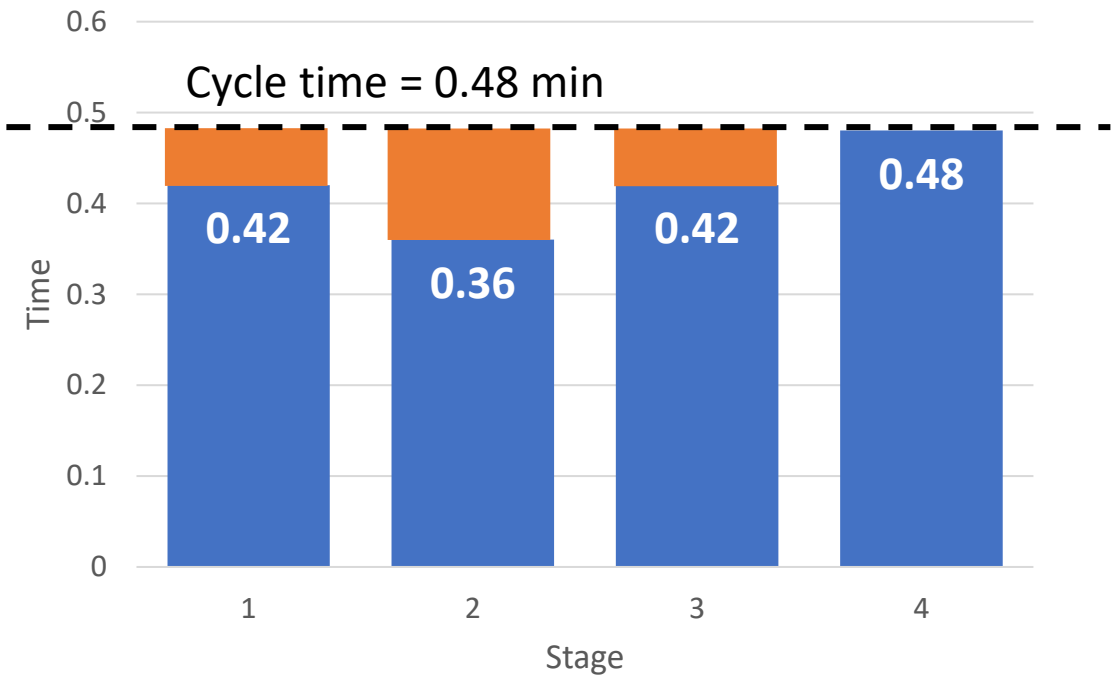
$$\textbf{\textit{Line efficiency}} = \frac{\sum Task\ time}{WS\ x\ Desired\ CT}$$

Then, a line balance is the **modification of the capacity** of a line ladder to a particular model mix. The capacity of the line hierarchy is **established by the number of tasks** and the **number of individual capacities** in the line segments.

Line Balancing

Yamazumi Chart.

Calculating an Efficiency Line:



$$Idle\ time = (0.48 - 0.42) + (0.48 - 0.36) + (0.48 - 0.42)$$

$$= 0.24\ min$$

$$Percentage\ Idle\ time = \frac{0.24}{4\ x\ 0.48} = 12.5\%$$

Work allocated to Stage activity

Idle time

Line Balancing

Production flow analysis

Concentrate on either the process or product aspects of cell layout. If cell designers choose to concentrate on processes, they could use cluster analysis to find which processes group naturally together.

Line Balancing

Detailed design in product layout

Rather than **'where to place what'**, product layout is concerned more with **'what to place where'**. Locations are frequently decided upon and then work tasks are allocated to each location.

The main product layout decisions are as follows:

- What cycle time is needed?
- How many stages are needed?
- How should the task-time variation be dealt with?
- How should the layout be balanced?

Line Balancing

Task-time variation

The flow is never constant. Each station's allocation of work might on average take x amount of minutes, but almost certainly the time will vary each time a part is processed.

If necessary to introduce more resources into the operation to compensate for the loss of efficiency resulting from work-time variation.

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Balancing work-time allocation

One of the most important design decisions in product layout is that of line balancing.

The effectiveness of the line-balancing activity is measured by balancing loss. This is the time wasted through the unequal allocation of work as a percentage of the total time invested in processing the product or service.

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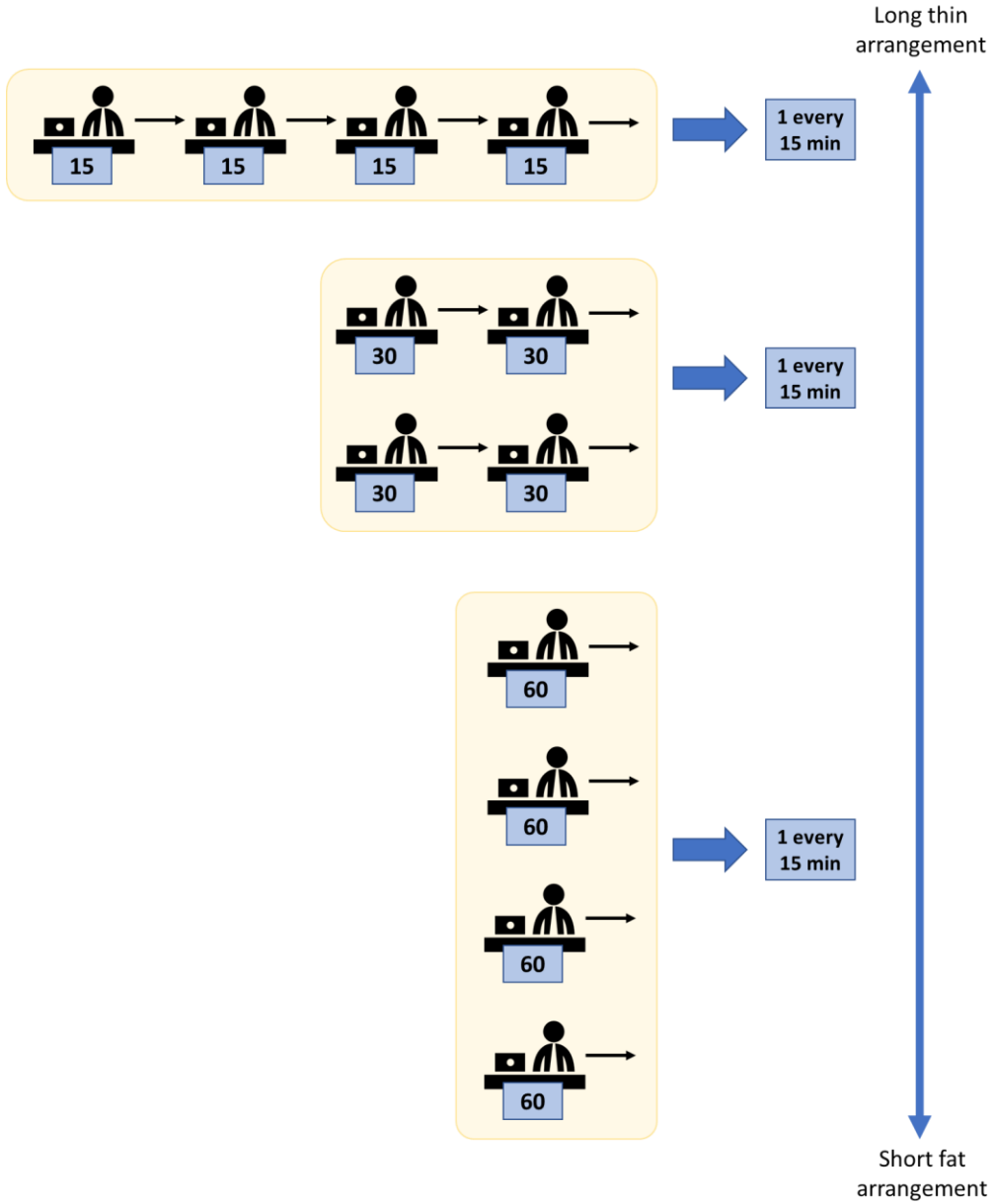
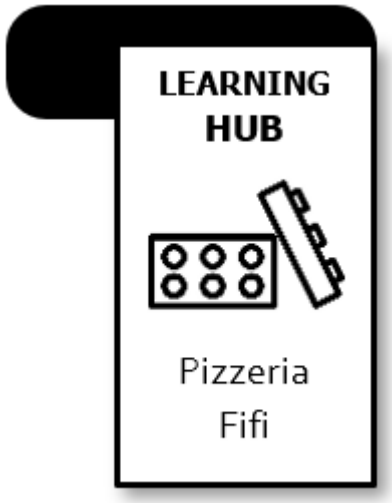
Balancing work-time allocation

Rearranging the stages

We may not arrange all the stages necessary to fulfill the layout in a sequential '**single line**'.

Product or service layout stage arrangement from **thin long** to **long fat** alternatives





Pizzeria FiFi

1. Have 2 people at dough mix
2. Optimize ovens
3. Use a cutter machine

	Task 1	Task 2	Task 3	Task 4	Task 5		
Demand (pizza/hr)	10	10	10	10	10		
Takt time (min/pizza)	1.2	1.2	1.2	1.2	1.2	**6**	min per pizza
Before							
Takt time (min/kg)	2.3	0.4	1.4	1.7	1.3	**7.1**	**10** pizza/hr
After							
Takt time (min/kg)	1	0.8	1	1.2	1.2	**5.2**	**10** pizza/hr

Line Balancing Workbook - Yamazumi Chart -

TOOLBOX

Line Balancing Workbook (Yamazumi Chart)

Project: Bulk Packaging: Line Balancing, labour cost reduction

Required Run Rate: 2.10 pouch/min — UOM for item: pouch
Takt Time: 0.48 min — UOM for time: min

	Process Step	Operator	Cycle Time (min)	Idle Time (min)	Task Utilization
1	Machine Loading	Loader	0.01	0.47	2%
2	Inspection and Repack	Checkweigher	0.09	0.39	18%
3	Zip Locking (x2)	Zipper	0.02	0.46	4%
4	CRA Labeling (x1)	CRA Stamper	0.05	0.43	11%
5	Boxing and Palletizing	Palletizer	0.19	0.29	39%
6	0	0	-		0%
7	0	0	-		0%
8	0	0	-		0%
9	0	0	-		0%
10	0	0	-		0%
11	0	0	-		0%
12	0	0	-		0%
13	0	0	-		0%
14	0	0	-		0%
15	0	0	-		0%

Metric	Value	UOM
Work Time Available		
Work Days/week	5.0	Days/week
Shifts/day	2.0	Shifts/day
Hours/shift	8.5	Hours/shift
Overtime	-	Mins/shift
Meals	30.0	Mins/shift
Break minutes/shift	30.0	Mins/shift
Changeovers	-	Mins/shift
Planned Downtime	-	Mins/shift
Unavailable Time	20.0	Mins/shift
Work Time Available	860.0	Mins/day

Schedule Demand		
Demand per Week	105,000	pouch
Demand per Shift	10,500	**pouch**

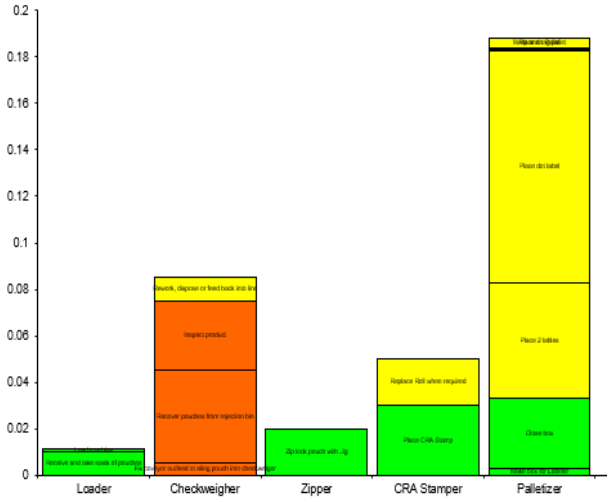
Target Cylce Time (Takt Time Target)	
2.46	**Seconds**
0.04	**Minutes**
0.00	**Hours**

Pulse (Pitch)		
Batch Size	200	**pouch**
Pulse (Pitch)	0	**Hours**

The First Bottleneck is: Boxing and Palletizing 39%

Process Lead Time: 0.35
Optimal Crew (or Stations): 1
Line Efficiency: 74%
Idle Time (min): 2.03 — 85%

Checkweigher	Color	Zip Locking (x2)	Zipper	Color	CRA Labeling (x1)	CRA Stamper	Color	Boxing and Palletizing	Palletizer	Color
0.005	R	Zip lock pouch with Jig	0.02	G	Place CRA Stamp	0.03	G	Make box for Labeler	0.003	G
0.04	R				Replace Roll when required	0.02	Y	Close box	0.03	G
0.03	Y							Place 2 lables	0.05	G
0.01	Y							Place dot label	0.1	Y
								Place on Pallet	0.001	Y
								Wrap and tag pallet	0.004	Y



Takeaways

- Develop a Process Observation analysis to understand the AS-IS process.
- Develop a Process Map to support a better approach to Line Balancing.
- Combine Line Balancing with Added Value Analysis and focus in eliminating or minimizing NVA/ENVA tasks before line balancing.
- Yamazumi Charts are an excellent visual tool to identify the unbalances.

Thank You

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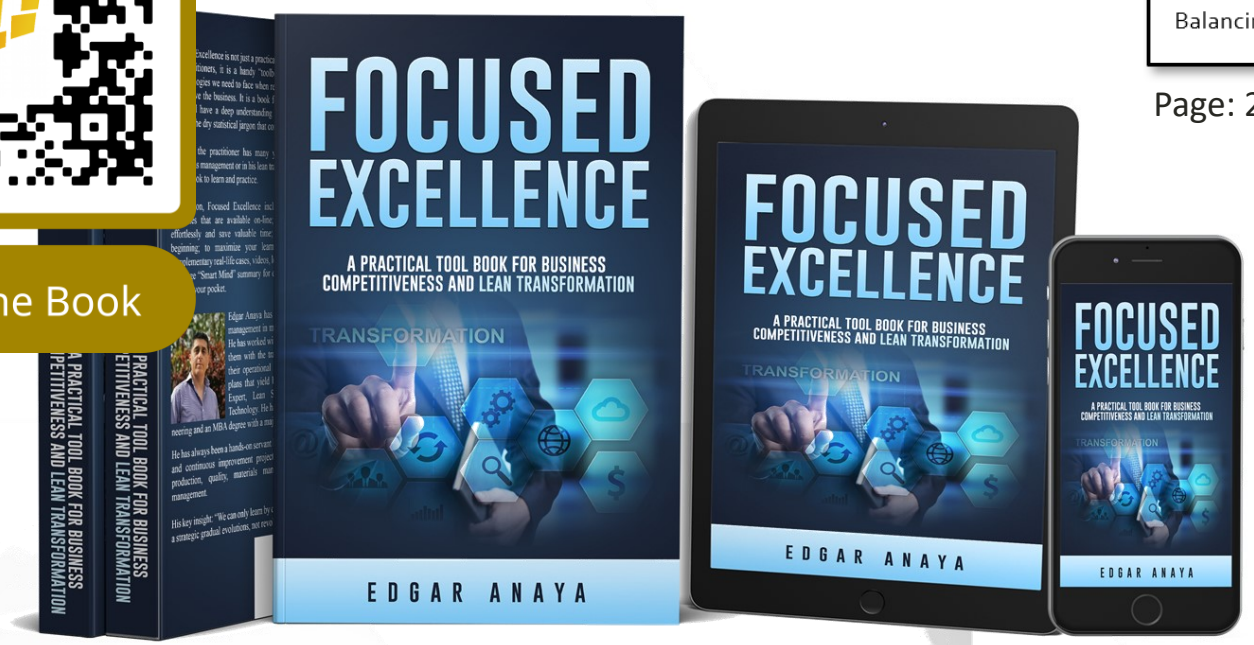

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edgar@pathstonegroup.com

Reference: Focused Excellence by Edgar Anaya

A Practical Tool Book for **Business Competitiveness** and **Lean Transformation**