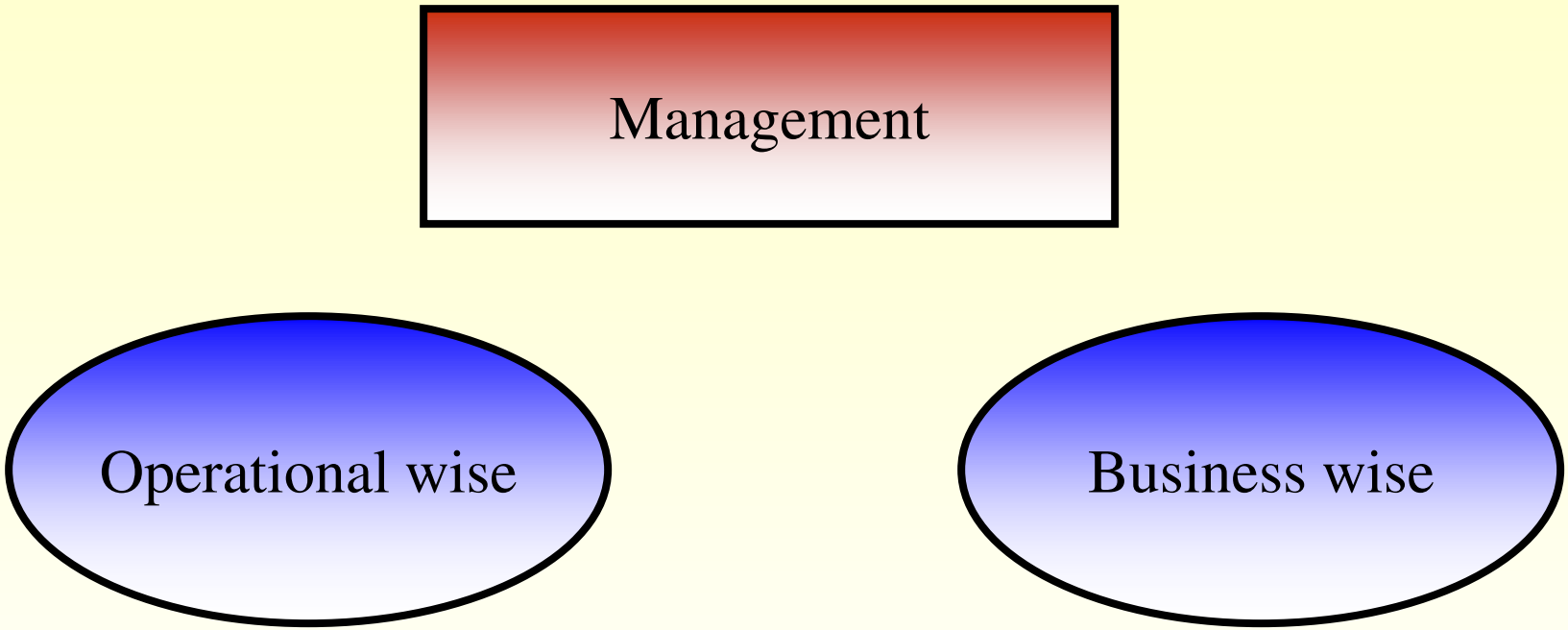
Overall Equipment Effectiveness

Awareness Session

Jan '21

Background



Asset Utilization and OEE indices show how the factory is being managed in the operational and business prospective

OEE Definition

OEE is an index which calculates the equipment operating state and judges if the equipment is utilized at its fullest.

دليل يقوم بحساب الحالة التشغيلية للمعدة أخذين فى الاعتبار ان المعدة مستخدمة بالحد الأقصى لها

OEE Calculation

Overall equipment efficiency

=

Availability x Performance rate x Quality Products Rate

It is calculated by multiplying together the equipment's .availability, performance rate and quality rate

An overall assessment in terms of the three attributes of time, speed and quality, it indicates the proportion of time for which the equipment is actually adding value.

OEE Calculation

Availability

indicates the extent downtime

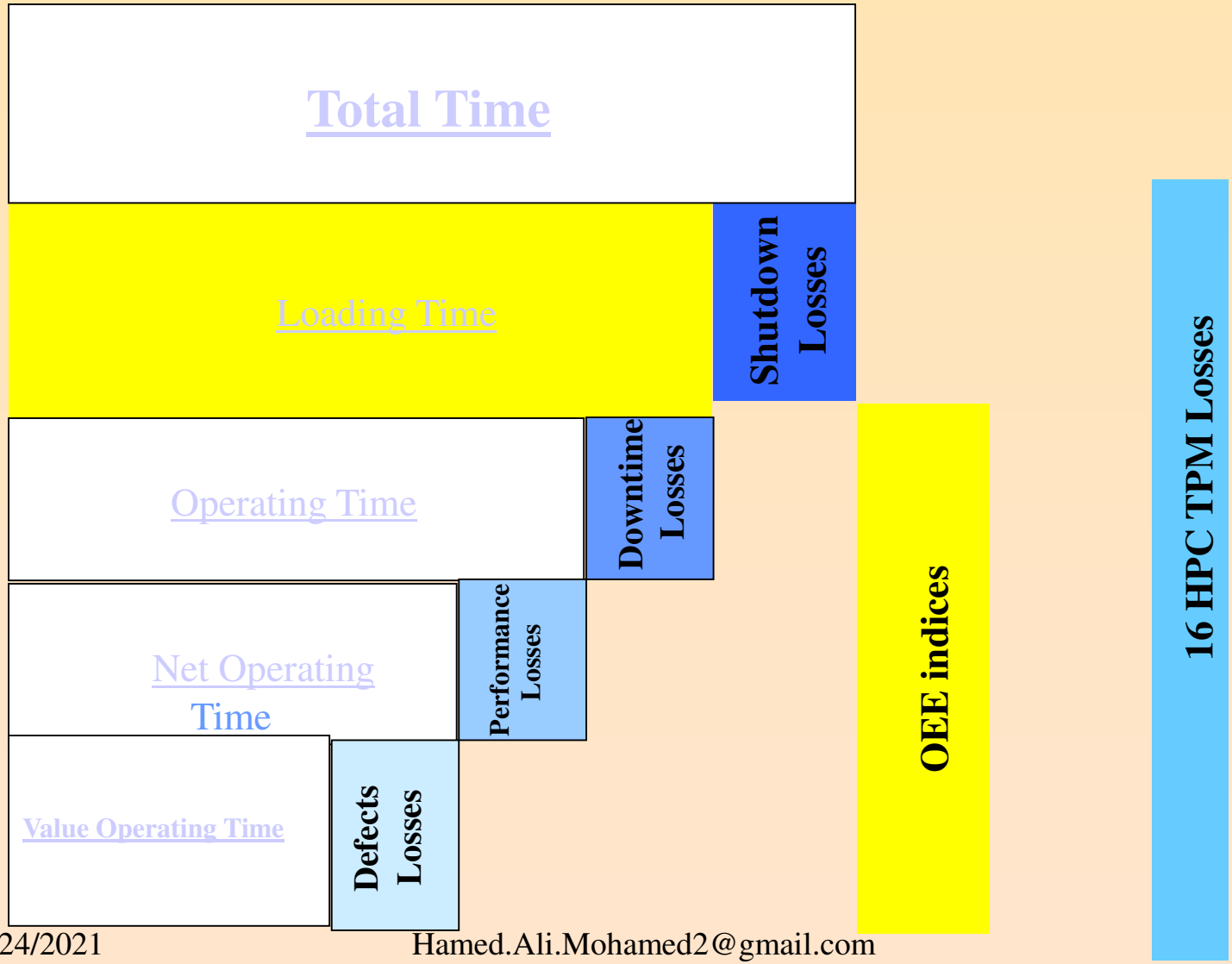
Performance Rate

indicates the scale performance losses

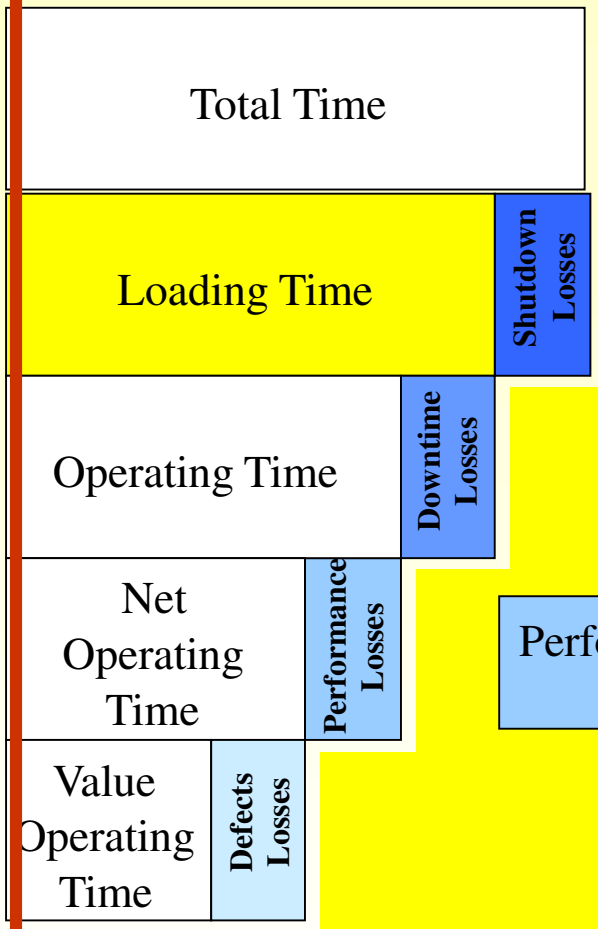
Quality Products Rate

indicates size of products defects losses

OEE Calculation



OEE Calculation



$$\text{Availability} = \frac{\text{Loading time - Downtime}}{\text{Loading Time}} \times 100$$

$$\text{Performance} = \frac{\text{Standard Cycle time x Products units Processed}}{\text{Operating Time}} \times 100$$

$$\text{Quality} = \frac{\text{Products units Processed - Defects units}}{\text{Products units Processed}} \times 100$$

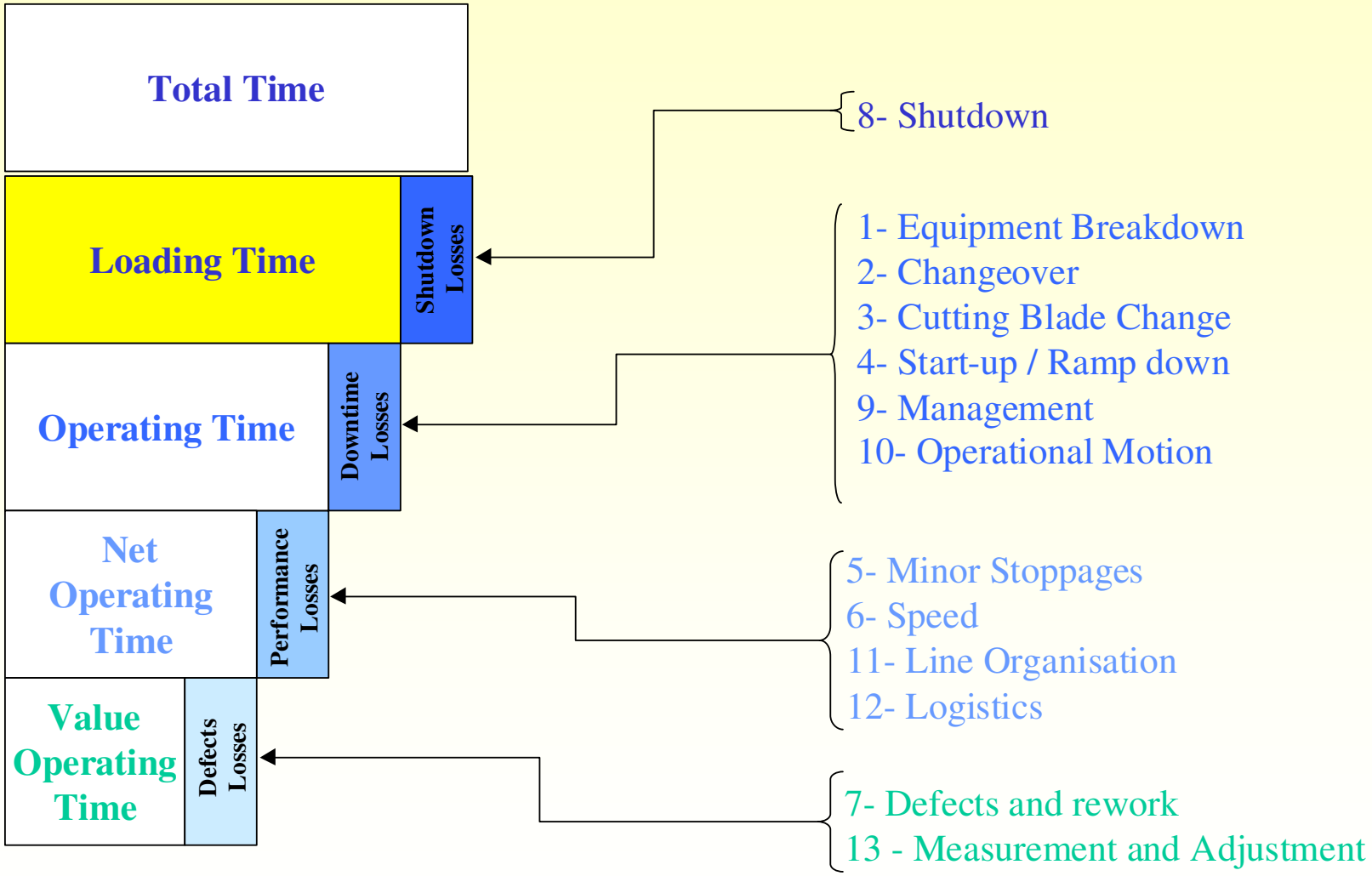
OEE: Availability x Performance x Quality

Notes: a) Standard Cycle Time: Based on Designed,Maximum Speed (as defined in losses definition)

b)Defects units: Include not only the waste but also the quantity of rework

c) OEE Calculation Area

16 Losses Classifications



14 - Energy

15 - Maintenance spare parts

16 - Yield

Losses Definition

- ***Equipment Breakdown***

  Unplanned equipment stoppage more than 10 minutes

- ***Minor Stoppage***

  Unplanned equipment stoppage less than 10 minutes

Losses Definition

- ***Change over***

  Time taken for a change over from last product at nominal speed and quality until the first product of the next run at nominal speed and quality.

- ***Cutting blade change***

  time taken to change items used in the process which have worn out, e.g. blades, reels, etc...

Losses Definition

- ***Start up / Shut down***

  Start up is total time taken to achieve nominal speed and quality.

  Start up time is measured after any planned stoppage not including change over.

  Shut down is total time taken to shut down the line and establish appropriate conditions for an effective start up.

Losses Definition

- ***Speed***

  Speed loss from running the line at a speed less than standard cycle time for a particular product.

- ***Defects and Rework***

  Time lost in producing non-conforming product or time to rework non-conforming product.

Losses Definition

- ***Shutdown***

  This is caused by stopping the equipment for periodic planned activity like maintenance or inspection or for legal inspection during the production stage.

  This also includes holidays, weekends, no plan, modifications, trials, etc...

Losses Definition

- ***Management***

  These are waiting time losses generated by management problems, e.g failure to provide materials, spare parts, waiting instructions, utilities, etc...

- ***Operational motion***

  Losses due to difference in skills levels or to inefficient layout.

Losses Definition

- ***Line organization***

  Losses due to shortage of operators, e.g. during the break.

- ***Logistics***

  Time wasted due to inefficient delivery of raw and packaging materials, product to the line and removal of finished product from the line.

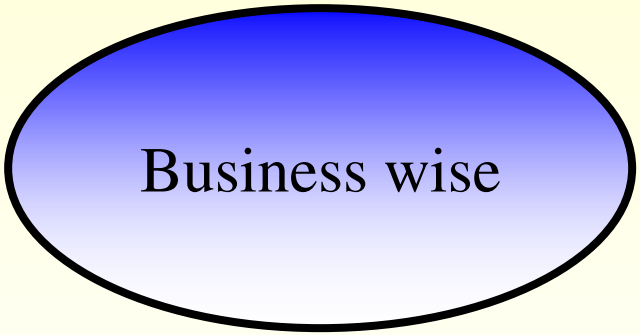
Losses Definition

- ***Measurement and adjustment***

  Frequent measurement and adjustment to prevent recurrence of problems, e.g. quality

  Routine and unexpected cleaning and sanitisation are also considered here.

Background



Overall Equipment Efficiency

Asset Utilization

Asset Utilization and OEE indices show how the factory is being managed in the operational and business prospective

Asset Utilization

- Definition

  An index which measures utilization of the lines taking into account the impact of the factory shutdown on availability.

- Calculation

  Asset Uitilisation = Loading time x 100 (%)/Total time

How efficiently is the line being utilized from business point of view

Capacity planning

TPM CoP Loss Tree

6th October 2002 Data Collection / Input

Home

To Open Losses booklet, use right button on your mouse and select "Document Object" - "O

Description	Units	1	2	3	4	5	6
Line Identifier		Norden 700	Norden 700	Norden 600	Norden 700	Norden 2000	Norden 400
Design Speed	Units / min	70	70	60	70	100	40
Volume Produced	000 Units	3,519	4,298	1,769	3,936	4,286	804
TOTAL TIME	**Hours**	2,064	2,064	2,064	2,064	2,064	2,064
SHUTDOWN LOSS		1,066	818	1,195	836	968	1,541
Holidays / Weekends / Factory Shutdown	Hrs / Year	360	360	360	360	360	360
No Production Orders	Hrs / Year	297	132	141	132	108	418
Planned Modifications	Hrs / Year	374	312	608	326	230	745
Planned Maintenance	Hrs / Year	0	0	2	0	254	0
Other Shutdown Losses (No water/electricity)	Hrs / Year	8	9	8	8	8	4
Other Shutdown Losses (making plant stoppage)	Hrs / Year	27	5	76	10	8	14
LOADING TIME	**Hours**	998	1,246	869	1,228	1,096	523
OPERATING TIME	**Hours**	835	1,046	606	991	798	396
DOWNTIME LOSS		164	200	264	237	299	127
Equipment Breakdown	Hrs / Year	119	157	218	192	263	109
Changeovers	Hrs / Year	12	2	28	19	0	8
Cutting Blade Change	Hrs / Year	1	2	3	3	18	3
Start-up / Ramp Down	Hrs / Year	32	40	16	23	18	8
Management	Hrs / Year						
Operational Motion	Hrs / Year	0	0	0	0	0	0
NET OPERATING TIME	**Hours**	811	1,005	530	964	741	356
PERFORMANCE LOSS		23	41	75	27	57	41
Minor Stoppages	Hrs / Year	21	34	20	25	35	41
Speed	Hrs / Year	0	0	50	0	13	0
Line Organisation	Hrs / Year	3	7	6	3	9	0
Logistics	Hrs / Year	0	0	0	0	0	0
VALUE OPERATING TIME		810	1,003	511	949	740	356
DEFECTS LOSS		2	2	19	15	1	0
Defects & Rework	Hrs / Year	2	2	19	15	1	0
Measurement & Adjustment	Hrs / Year	0	0	0	0	0	0

Description	Unit	1	2	3	4	5	6
Capacity Utilisation (Asset Utilisation)	%	48.4%	60.4%	42.1%	59.5%	53.1%	25.3%
Availability	%	83.6%	83.9%	69.7%	80.7%	72.8%	75.8%
Performance	%	100.4%	97.8%	81.1%	94.6%	89.6%	84.5%
Quality	%	99.8%	99.9%	96.4%	98.5%	99.9%	100.0%
Overall Equipment Efficiency	%	83.8%	82.0%	54.5%	75.2%	65.1%	64.0%

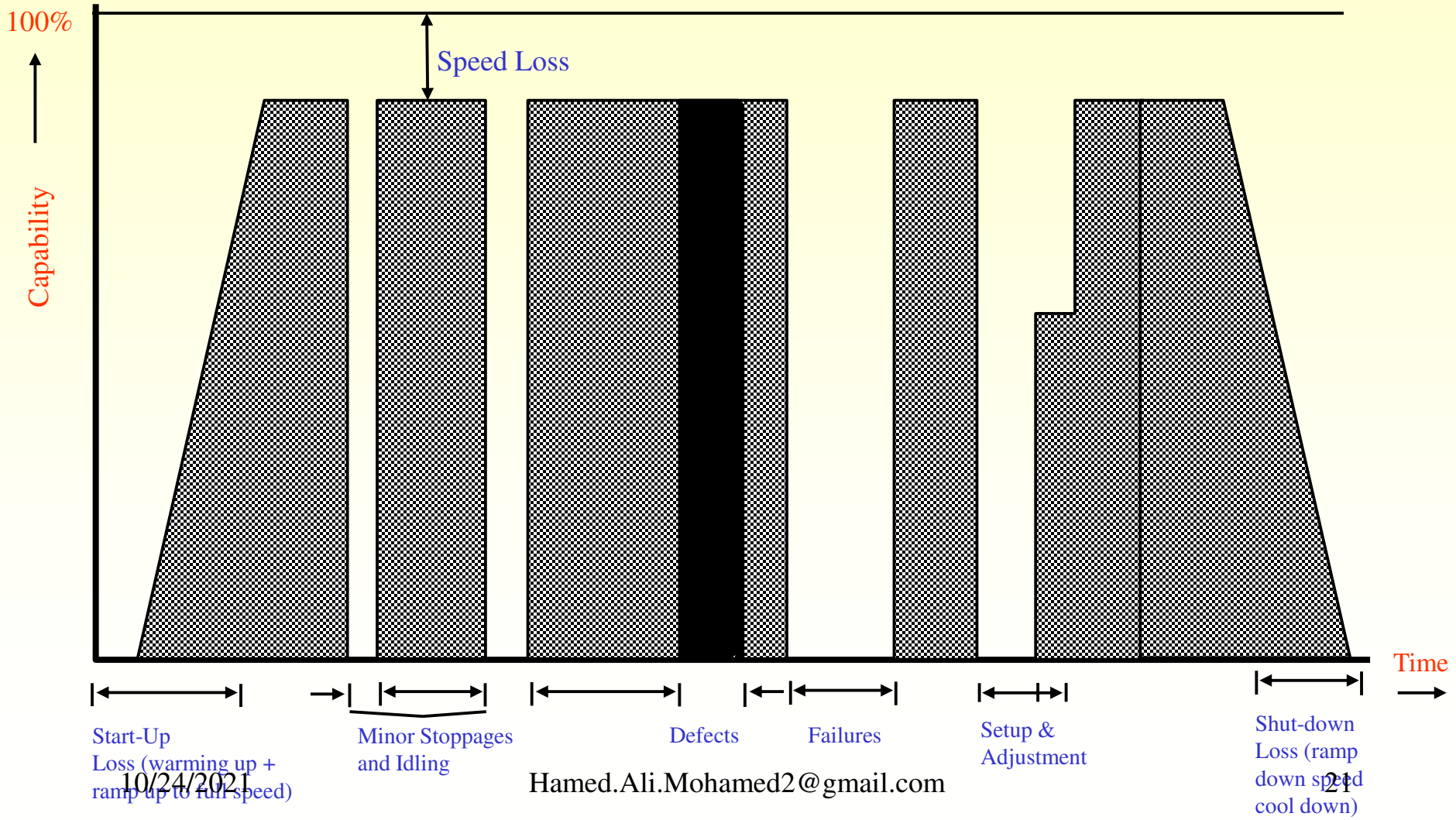
Loss Tree Check	1	2	3	4	5	6
Theoretical Value Operating Time (VOT) - based on Speed & Output	838	1,023	491	937	714	335
Difference reported VOT on loss Tree & Theoretical	-28	-20	20	12	26	21
Percentage Difference (based on 8760)	-1.4%	-1.0%	1.0%	0.6%	1.2%	1.0%

Red values - Negative times suggest rate factor wrong

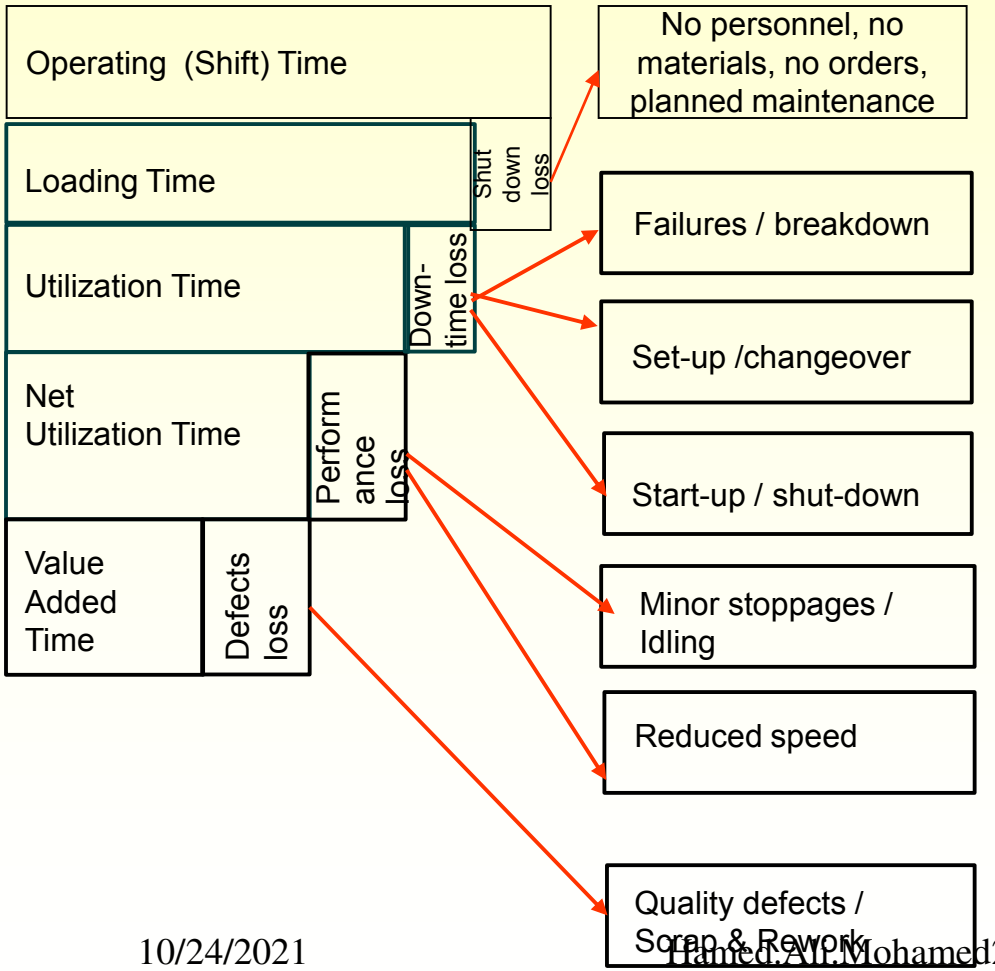
Blue values suggest speed loss / minor stops too small

The 6 big losses

The 6 big losses visualized



OEE Definitions



OEE = Value Added Time / Loading Time

=% efficiency of line in the loading time

Shut down losses such as planned maintenance / meals / rests have no effect on OEE!

Availability = Utilization Time / Loading Time

= % of loading time that line was running

Performance rate = Net Utilization Time / Utilization Time

= Actual Production / (Utilization Time * Std. speed)

= % of potential production that was made

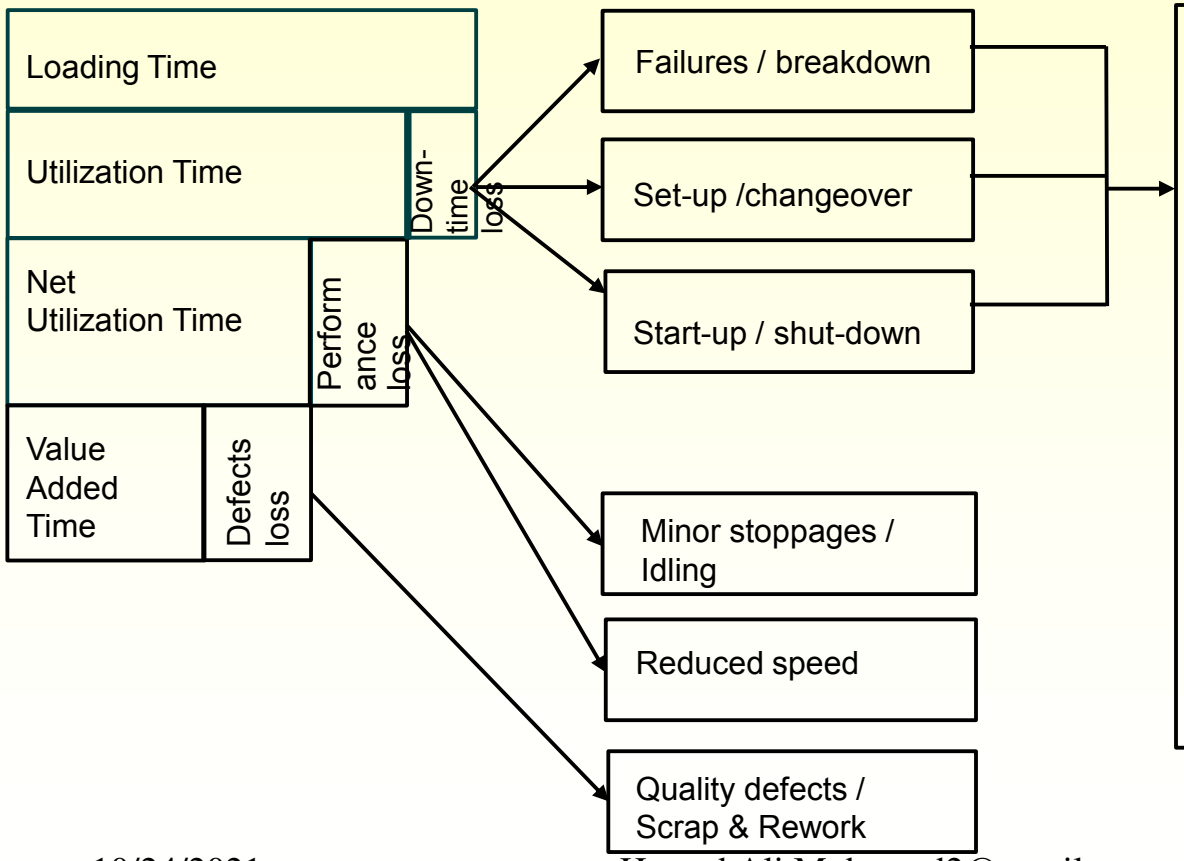
Quality rate = Value Added Time / Net Utilization Time

= Good Production / Actual Production

= % of actual production that can be sold

Availability

Equipment



6 Big losses

- Failures / breakdown
- Set-up /changeover
- Start-up / shut-down
- Minor stoppages / Idling
- Reduced speed
- Quality defects / Scrap & Rework

Calculation

Availability:

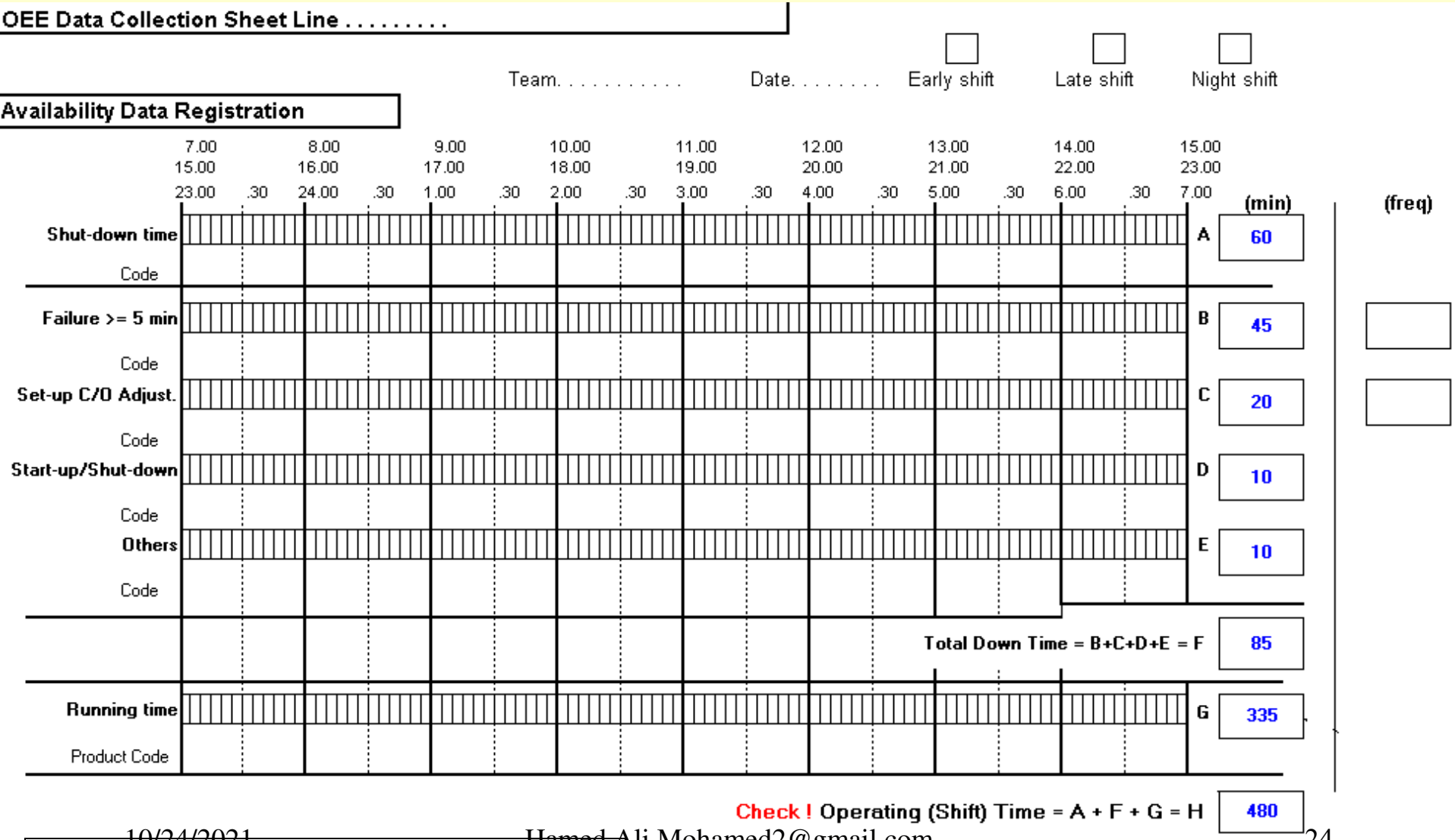
$$\text{Availability} = \frac{\text{loading time - downtime}}{\text{loading time}} \times 100\ \%$$

example:
available time = 8 hours=480 min
meal break = 20 min
loading time = 480-20= 460 min
downtime = 60 min

$$= \frac{460\ \text{min} - 60\ \text{min}}{460\ \text{min}} = 87\%$$

Measuring availability

Data Collection Sheet



Measuring availability

Data Collection Sheet - Codes

- Example codes for shut down losses = those items excluded from OEE

Shut-down time	
Type	Code
Planned Maintenance	PM
Meals & Rest	MR
Meetings	MT
Training	TR
No Materials	NM

- Example codes for down time losses = those items included in OEE-availability

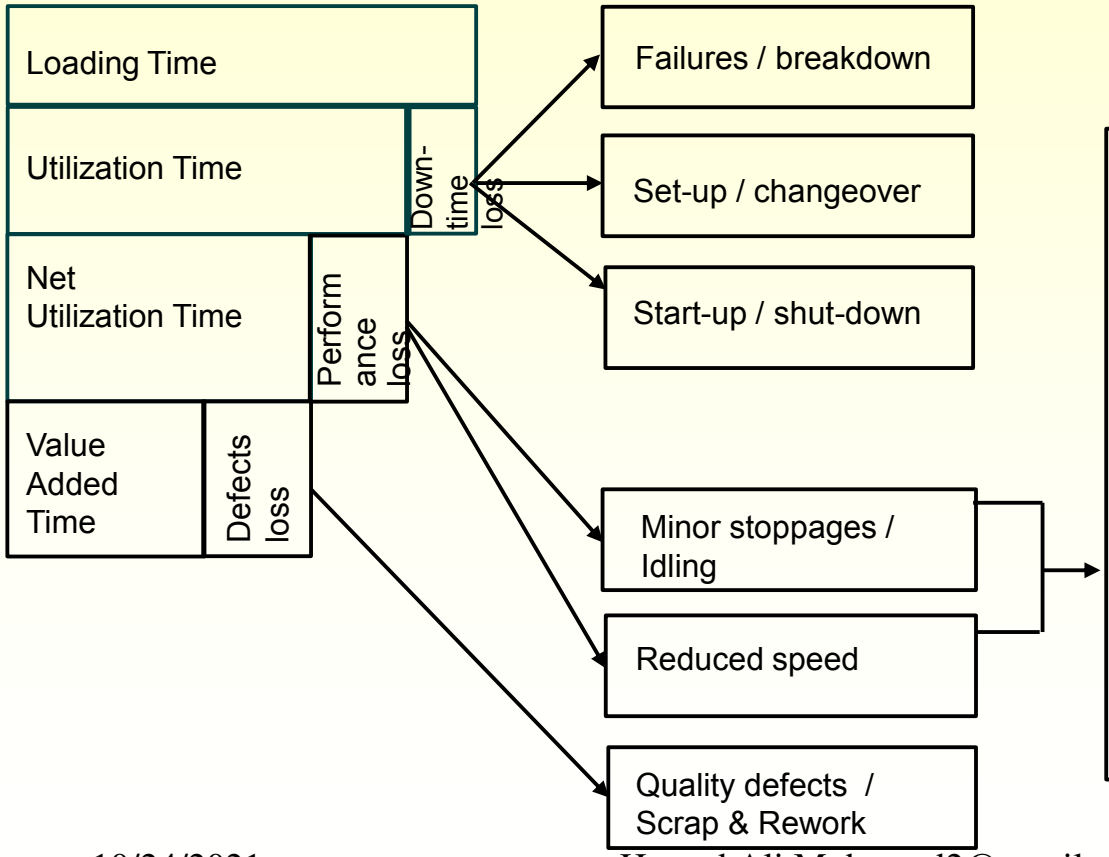
Failure = Type code + Machine code			
Type	Code	Machine	Code
Electrical	E	Bottle Infeed	I
Pneumatic	P	Filler	F
Motor	M	Capper	C
Control system	C	Labeller	L

Start up-shut down	
Type	Code
Warming up time	WU
1/2 Ramp up time	RU
1/2 Ramp down time	RD
Cool down time	CD

Set-up C/O Adj.	
Type	Code
CO Product A->B	AB
CO Product A->C	AC
CO Product A->D	AD
color/size change etc.	
- - - - -	
Adjustments	AX
Cleaning (not scheduled)	CL

Performance rate

Equipment



6 Big losses

- Failures / breakdown
- Set-up / changeover
- Start-up / shut-down
- Minor stoppages / Idling
- Reduced speed
- Quality defects / Scrap & Rework

Calculation

Performance rate:

$$= \frac{\text{actual production}}{\text{utilization time * standard speed}} \times 100\ \%$$

example:
standard speed = 2 products / min
actual production = 400 products
utilization time = 400 min

$$\frac{400 \text{ products}}{400 \text{ min} * 2 \text{ products /min}} = 50\ \%$$

Measuring performance rate

- Speed loss rate = $\frac{\text{Set speed}}{\text{Standard speed}}$

•The "set speed" is the speed as set on the machine
•The standard speed is max speed of the "bottleneck" machine making the particular product based on:
• spec: "designed speed"/"Name Plate Capacity"
•or highest speeds obtained in other factories
•or run machine at top speed and measure it

- Minor stoppage loss rate = $\frac{\text{Actual production}}{\text{Utilization time} * \text{Set speed}}$

Note: The minor stoppage loss rate accounts for all non recorded downtime which consists mainly of the minor stops = failures < 5 min, non-recorded speed variations and idling (line is running without product being produced on the line)
If possible try to count the number of small stops on each machine and identify the causes

- Performance rate = minor stoppage loss rate * speed loss rate

$$= \frac{\text{Actual production} * \text{Set speed}}{\text{Utilization time} * \text{Set speed} * \text{Standard speed}} = \frac{\text{Actual production}}{\text{Utilization time} * \text{Standard speed}}$$

Measuring performance rate
Data collection sheet

Performance Data Registration

Product Code	Running Time	Standard Speed	Set Speed	Standard Prod.	Set Production	Actual Prod.
A	195	50	45	9750	8775	8450
B	140	60	50	8400	7000	6950
				0	0	0
				0	0	0
				0	0	0
Total	**335**	**54.2**	**47.1**	**18150**	**15775**	**15400**
	G	H = weighted	I = weighted	J = G * H	K = G * I	L

Speed loss rate = I / H = 47.1 / 54.2 =	**86.9%**
Minor Stoppage Loss rate = L / K = 15400 / 15775 =	**97.6%**
Performance rate = L / J = 15400 / 18150 =	**84.8%**

Minor Stops (<5 min) Count			
Code	#		4
	5		5
	4		6
	7		7
	8		12
Total		**58**	

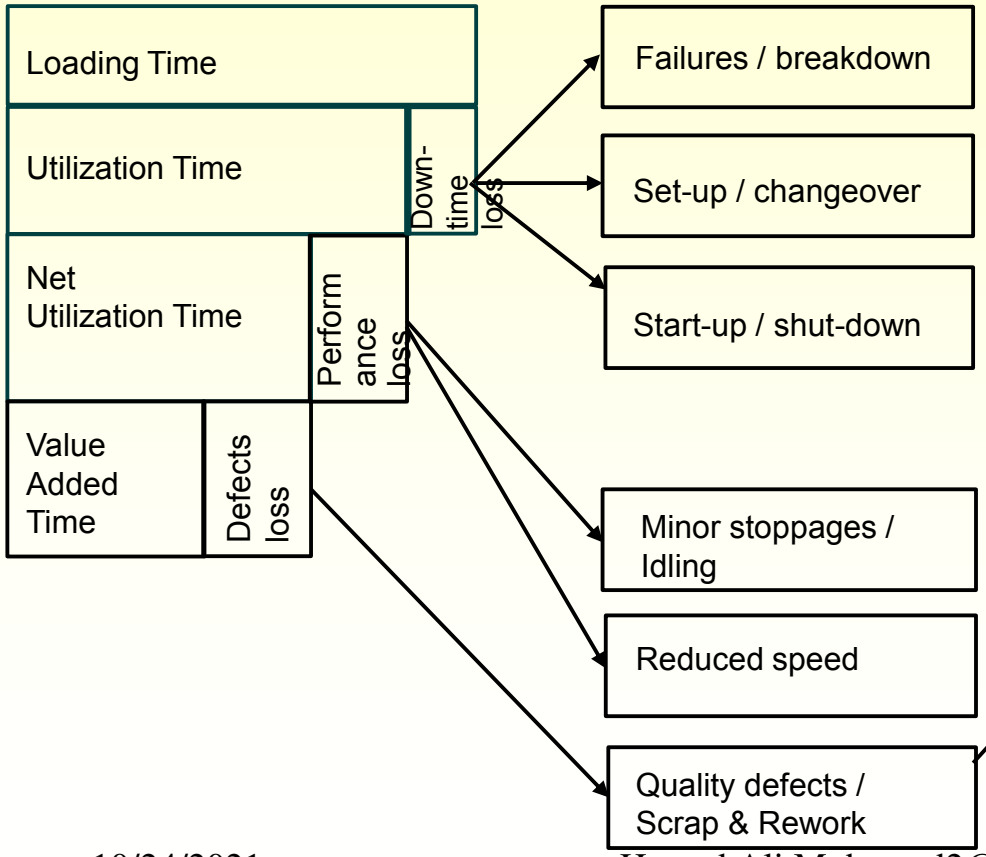
Minor stops and idling are major reasons for losses!

- Example codes for minor stops

Minor Stops = Type Code + Machine Code			
Type	Code	Machine	Code
Bottle Jam	J	Bottle Infeed	I
Bottle Broken	B	Filler	F
No Cap	C	Capper	C
No Fill	F	Labeller	L
No Label	L	Palletizer	P

Quality rate

Equipment



6 Big losses

- Failures / breakdown
- Set-up / changeover
- Start-up / shut-down
- Minor stoppages / Idling
- Reduced speed
- Quality defects / Scrap & Rework

Calculation

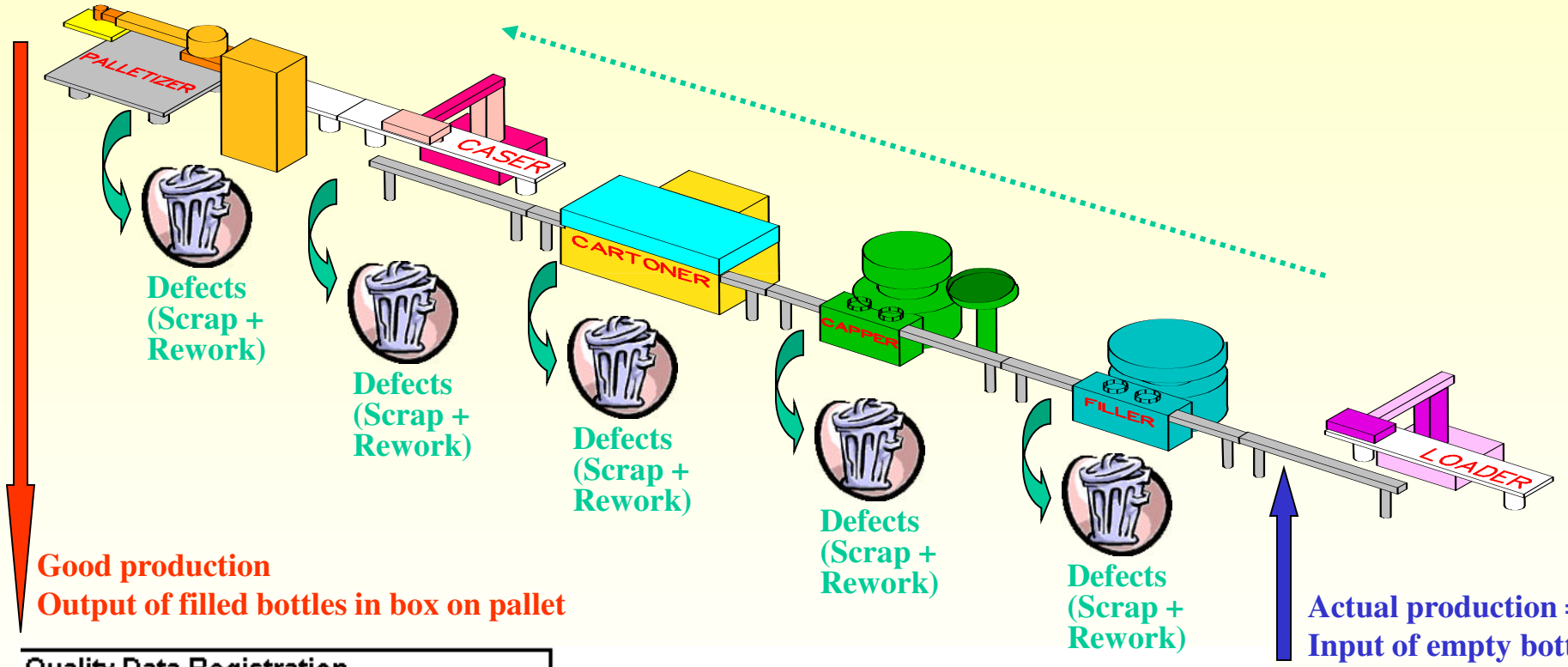
Quality rate:

$$= \frac{\text{actual production} - \text{defective production}}{\text{actual production}} \times 100\ \%$$

example:
actual production = 400 products
defective production = 8 products (scrap+rework)

$$= \frac{400 \text{ products} - 8 \text{ defects}}{400 \text{ products}} = 98\%$$

Measuring & Calculating Quality products rate



Quality Data Registration

Actual Prod.	Scrap	Rework	Other	Good Prod.
15400	100	350	50	14900
L	M	N	O	P = L-M-N-O

$$\text{Quality Rate} = \frac{\text{Actual production} - \text{Defects}}{\text{Actual production}} = \frac{\text{Good production}}{\text{Actual production}} = \frac{14900}{15400} = 96.7\%$$

Overall Equipment Efficiency

Availability:

$$= \frac{\text{loading time - downtime}}{\text{loading time}} \times 100\ \%$$

example:
loading time = 460 minutes
downtime = 60 minutes

$$\frac{460 \text{ min} - 60 \text{ min}}{460 \text{ min}} = 87\%$$

Performance rate:

$$= \frac{\text{actual production}}{\text{utilization time} * \text{standard speed}} \times 100\ \%$$

example:
standard speed = 2 products / min
actual production = 400 products
utilization time = 400 min

$$\frac{400 \text{ products}}{400 \text{ min} * 2 \text{ products/min}} = 50\ \%$$

Quality rate:

$$= \frac{\text{actual production} - \text{defective production}}{\text{actual production}} \times 100\ \%$$

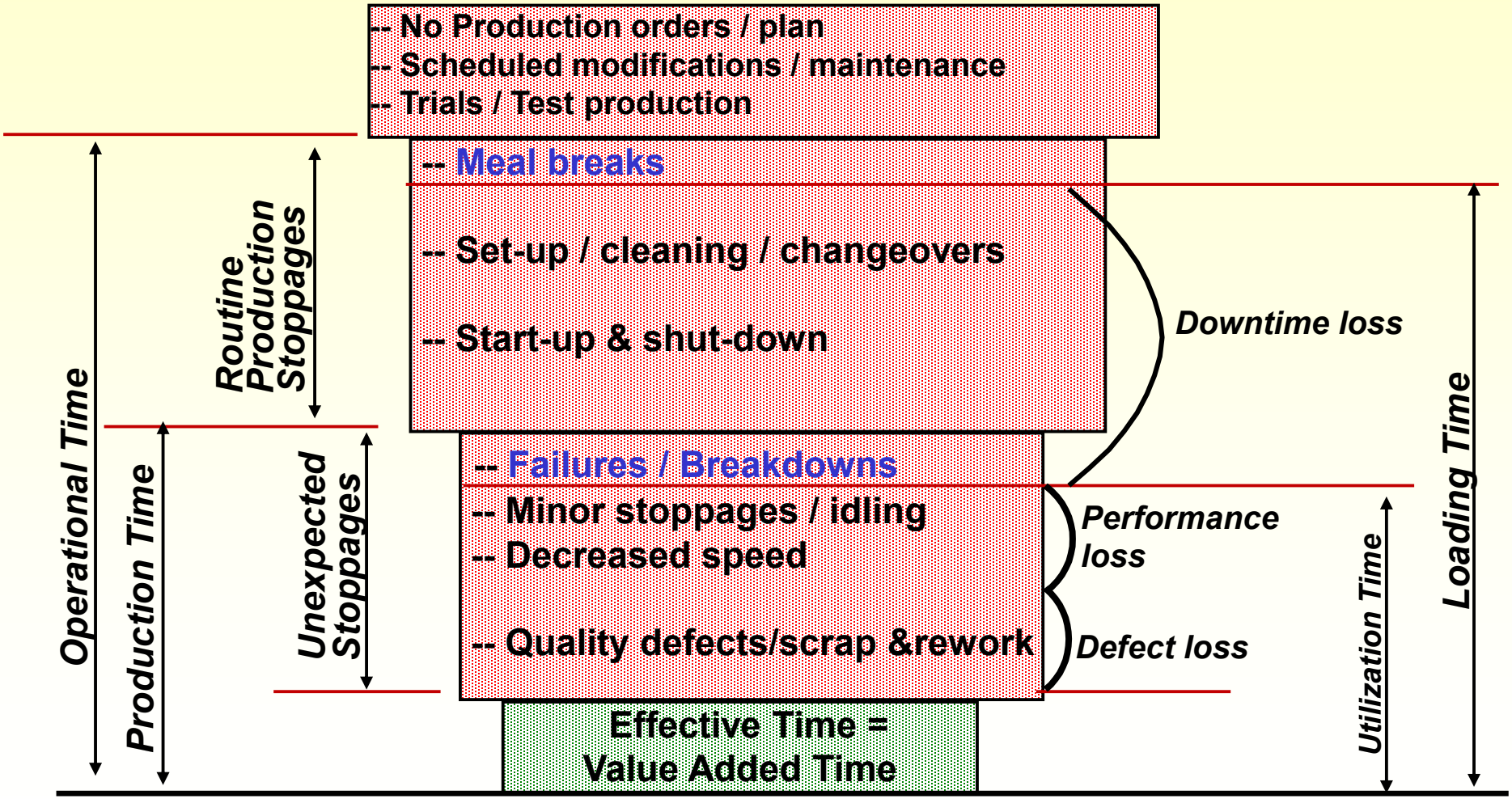
example:
actual production = 400 products
defective production = 8 products (scrap+rework)

$$= \frac{400 \text{ products} - 8 \text{ defects}}{400 \text{ products}} = 98\%$$

OEE = Availability x Performance rate x Quality rate
= 0.87 x 0.50 x 0.98 x 100% = 42.6 %

$$= \frac{\text{Good Quality Production}}{\text{Loading Time} * \text{Standard Speed}} = \frac{392}{460 * 2} = 42.6\%$$

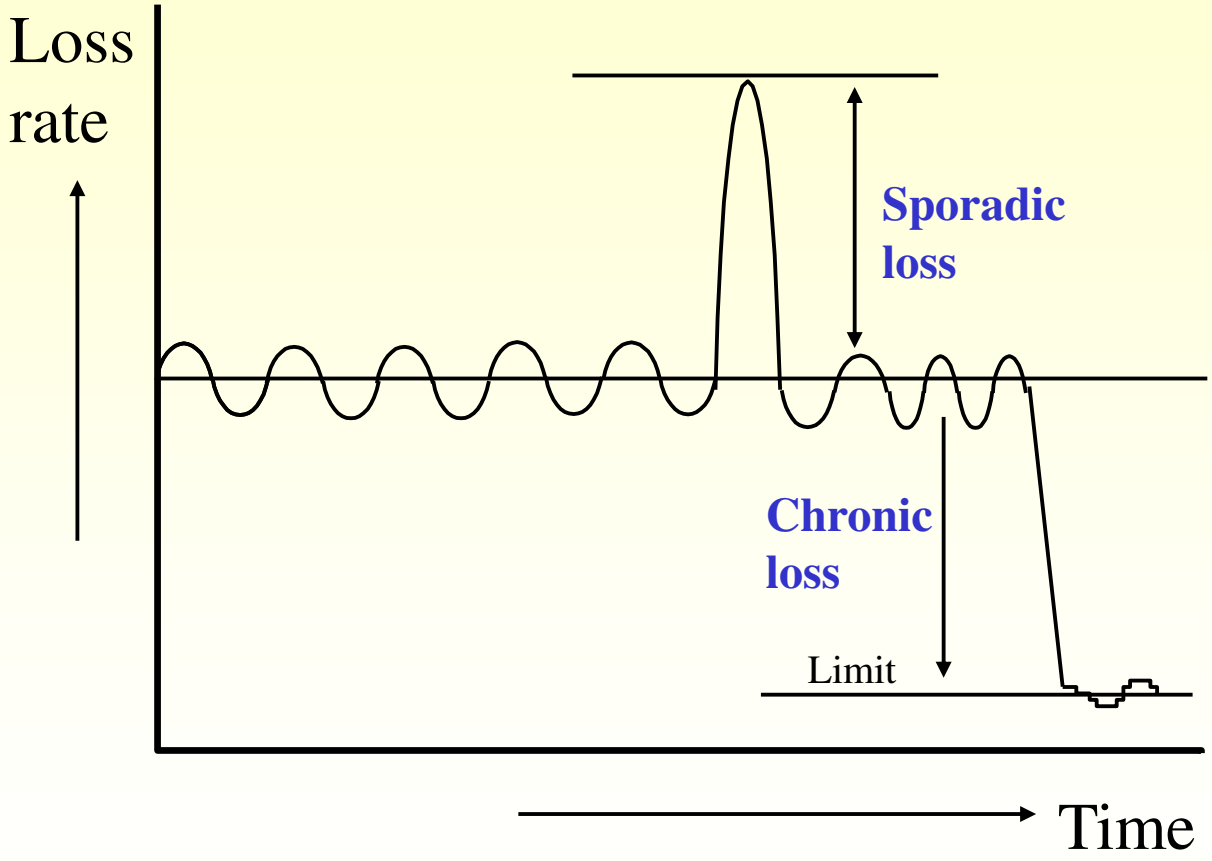
Pamco versus TPM loss analysis



Pamco versus TPM loss analysis

- Pamco's OE includes lunch break as routine stoppage. TPM's OEE does not include meal breaks as down time loss. Therefore OEE >= OE
- To confirm to Unilever Pamco include the meal breaks into TPM's down time loss so that OE = OEE.
- Monitoring each of the six losses individually enables calculation of Pamco OE/PE and TPM availability, performance rate and quality product rate as well as generation of a loss tree showing all 6 big losses
- Knowing each of your 6 big losses is more important for improvement than knowing your OE or OEE!!!

Sporadic versus chronic loss

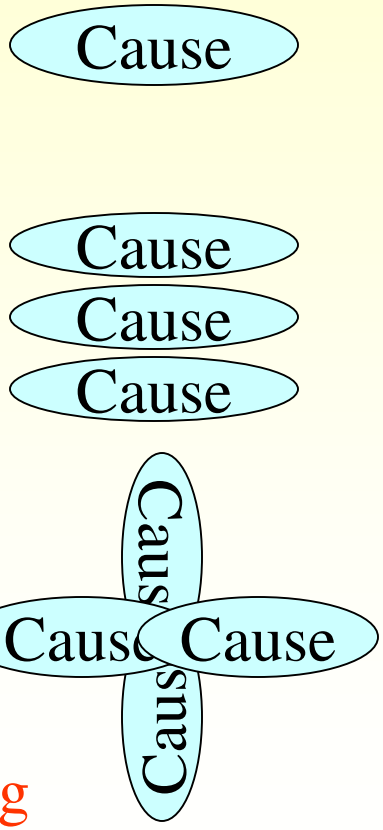


* Restoration type countermeasures are needed to reduce the loss rate to its earlier level

* Improvement type countermeasures are needed to reduce the loss rate to its limit

Loss cause structure

- Sporadic Loss
  - Single Cause
    - One cause is responsible for loss
- Chronic Loss
  - Multiple cause
    - There is one triggering cause, but there are many different causes which change each time
  - Compounding Cause
    - One cause alone does not trigger the loss, but a loss is created when various causes are compounded. The combination of causes changes each time



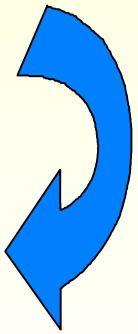
Chronic losses can only be eliminated by identifying and taking countermeasures against all causes !

All losses are caused by ourselves

- **The production floor is** a source of losses
  - 6 big losses (failures, minor stoppages, defects, start-up, set-up, speed)
- **We cause the losses ourselves**
  - Circumstances and logical situations exist that cause losses, but these losses can not be discovered directly
  - Symptoms of failures are not clear
  - Wear and tear is not evident
  - Defects are not evident
- **Our way of thinking must change**

Philosophy of prevention

- **Prevention is essential**
- **Target is "0"**
- **It is important to eliminate the sources of failures**
- **Implication of prevention:**
  - Maintain normal conditions
  - Find defects as early as possible
  - Prevent wear and tear
  - Improve inspection methods



- **Control and understand logical relations**
  - It is important to develop systems for early detection of potential problems
- **It is not sufficient to notice the losses/problems!**

How to attack losses ?

1. **Decide definition of Losses which occur on-site**
2. **Establish a mechanism to measure the above losses**
3. **Identify Loss structure**
4. **Emphasis on losses and the tasks to reduce them**
5. **Study approaches for reducing each loss**
6. **Make trends of each loss clear**

1. Define losses

- **Define the losses by name, characteristic, examples...**
  - **More than 1 name is being used for same loss:**
    - **Failure=Break down loss**
    - **Minor stoppages=Idling loss**
    - **Quality defects=Rework loss**
    - **Set-up and adjustment=Changeover loss**
    - **Reduced speed=Speed loss**
    - **Start-up&Shut-down=Yield loss**

2. Measure losses

- **Establish a mechanism to measure the losses**
  - **Who ?**
  - **What ?**
  - **When ?**
  - **Where ?**
  - **How ?**

3. Identify loss structure

- **Identify Bottleneck equipment / lines**

	Failure	Set-up	Start-up	Minor Stoppage	Reduced Speed	Scrap Rework	Total OEE%
Line A							
Line B							
Line C							
.							
.							
Total							

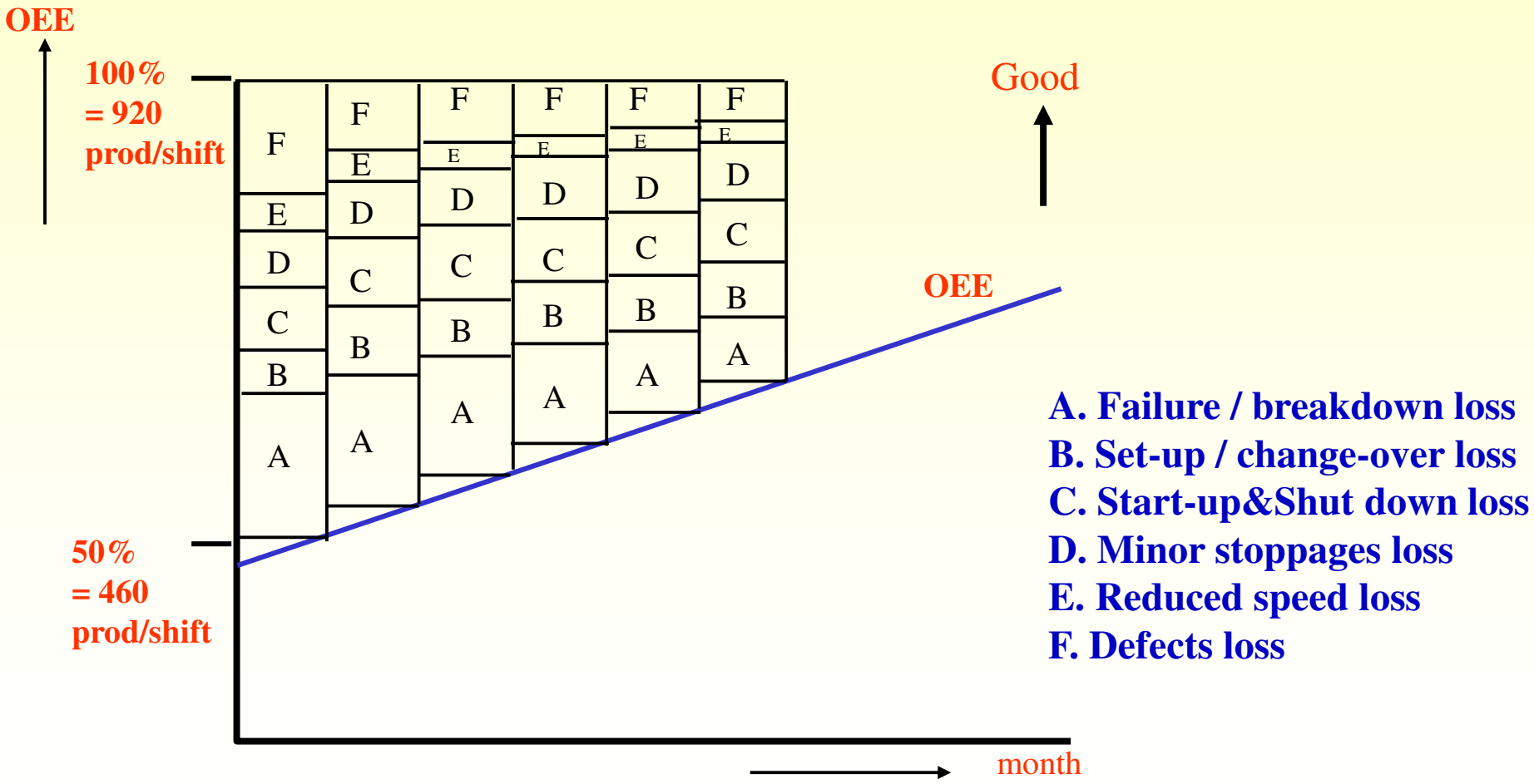
4. Emphasis on losses and the tasks to reduce them

- **Focus on the large losses**
- **Consolidate losses into "Kaizen" themes**

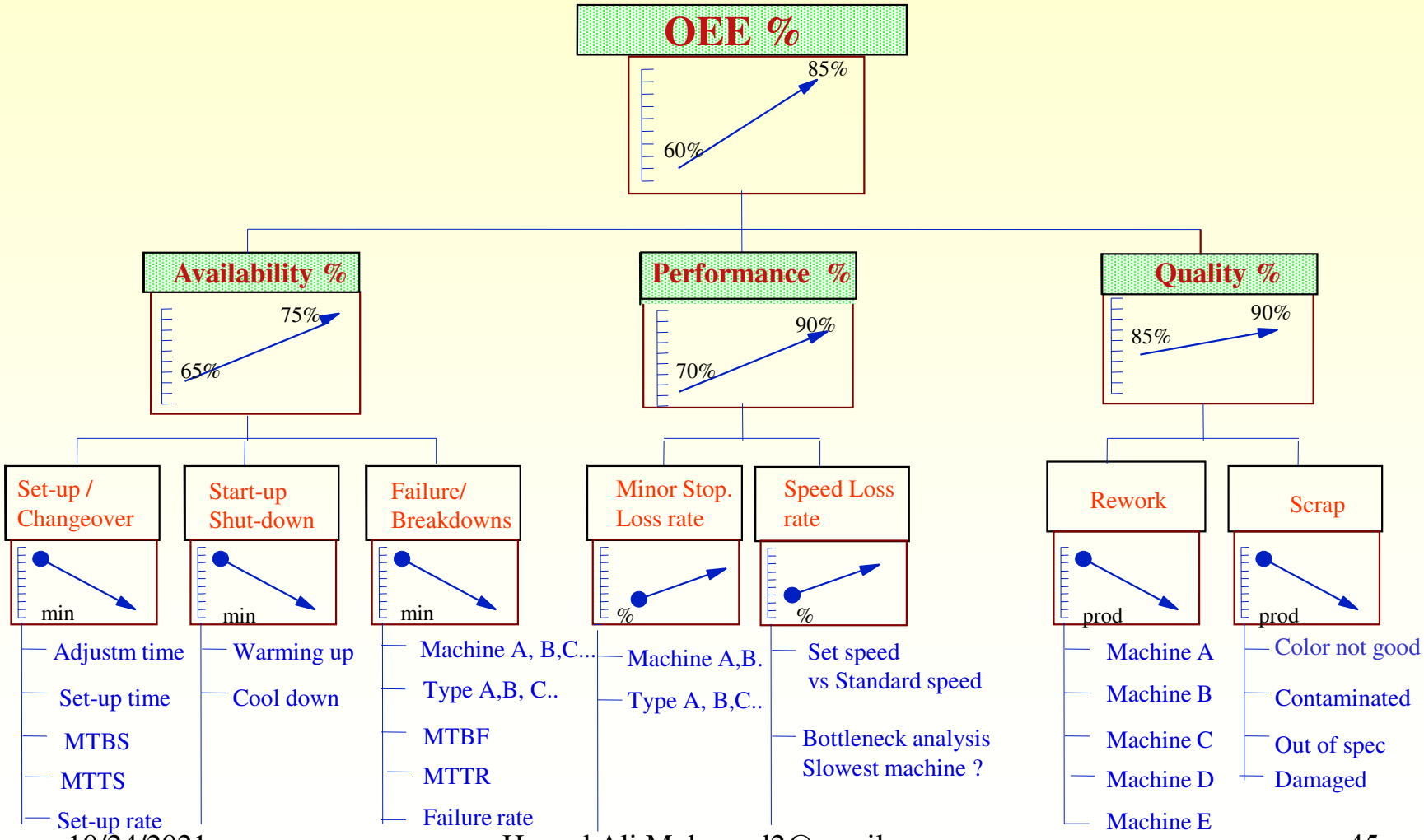
5. Study approaches for reducing each loss

- Focused Improvement
  - Why Why Why Analysis to reduce loss by 95%
  - PM- Analysis to reduce loss to zero
  - Line Performance Improvement
  - Set-up/ change over time Analysis etc.
- Autonomous Maintenance
- Planned Maintenance
- Training & Education
- Early Equipment Management
  - (new equipment with TPM features)

6-1. Make trends of each loss clear
OEE graph shows 100% - 6 losses



6-2. Make trends of each loss clear
Show losses in “Loss Tree”



Labor productivity and OEE

- Labor Productivity = $\frac{\text{Overall Equipment Efficiency}}{\text{Cycle Time} * \text{Manning}}$
- $\frac{\text{Kg}}{\text{ManHour}} = \frac{[1]}{\text{Hour/Kg} * \text{Man}}$.
- To improve labor productivity you can:
  - Reduce cycle time by upgrading/replacing the equipment
  - Reduce number of operators by automating the equipment
  - Improve OEE by reducing the 6 big losses
- Improving OEE is the easiest way to improve labor productivity and does not need capital investment !

Thanks For Your attaention