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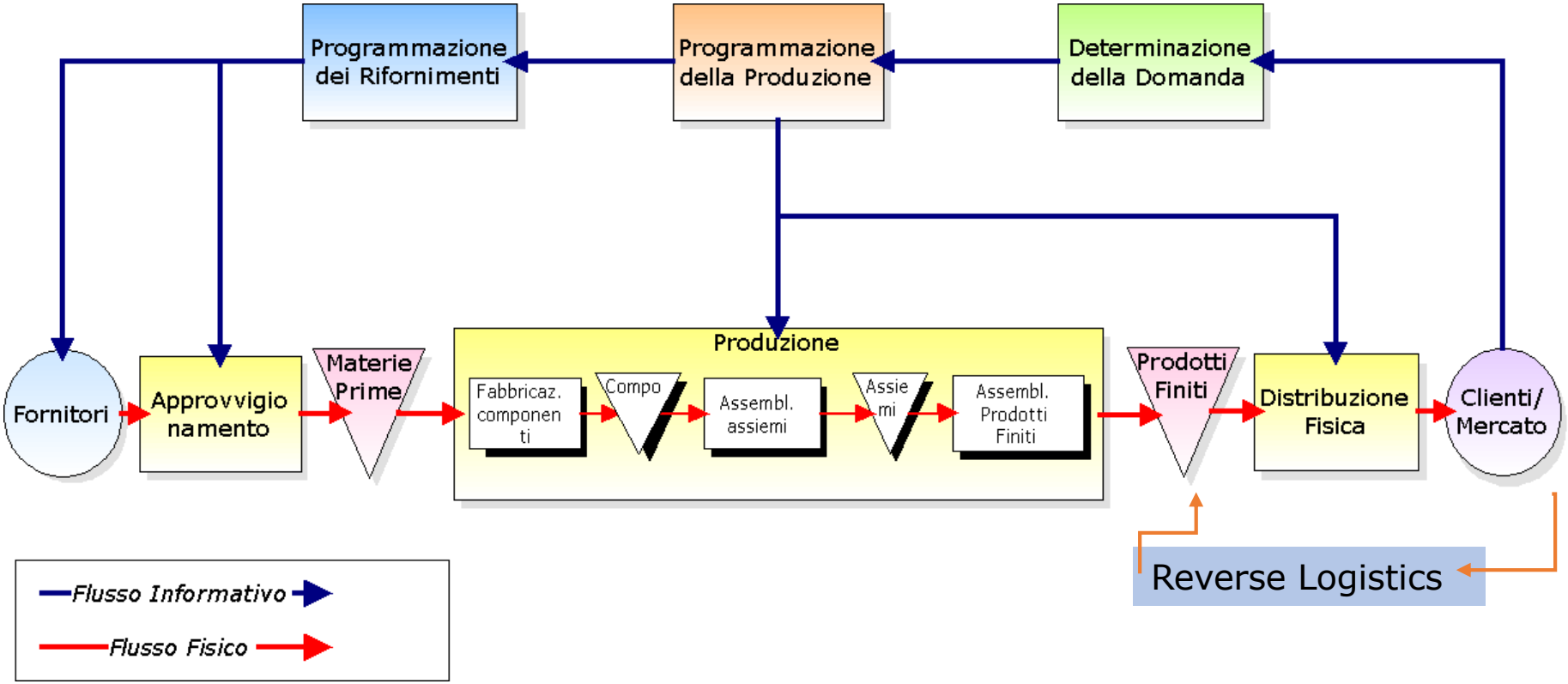
# Operations and Performance measures

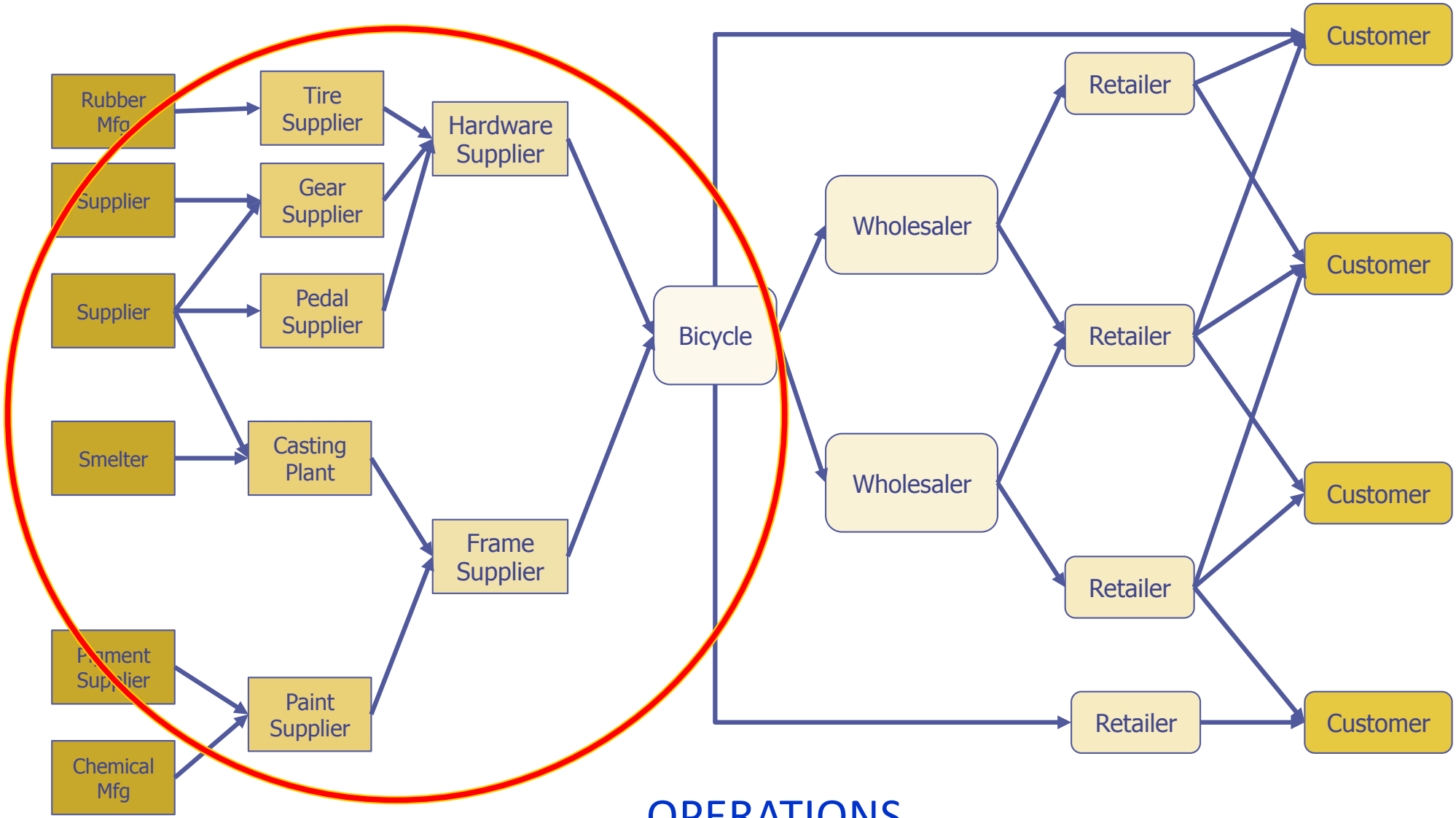
## *Trade-offs and Losses in production*

v2. Spring 2022

# Production, Operations And Flows



# Supply Chain – What does it mean?




OPERATIONS

# Macro Process Perspective (Software)

**Supplier Relationship Management**

- Sourcing
- Negotiation
- Buying
- Design and Supply Collaboration

**Internal Supply Chain Management**

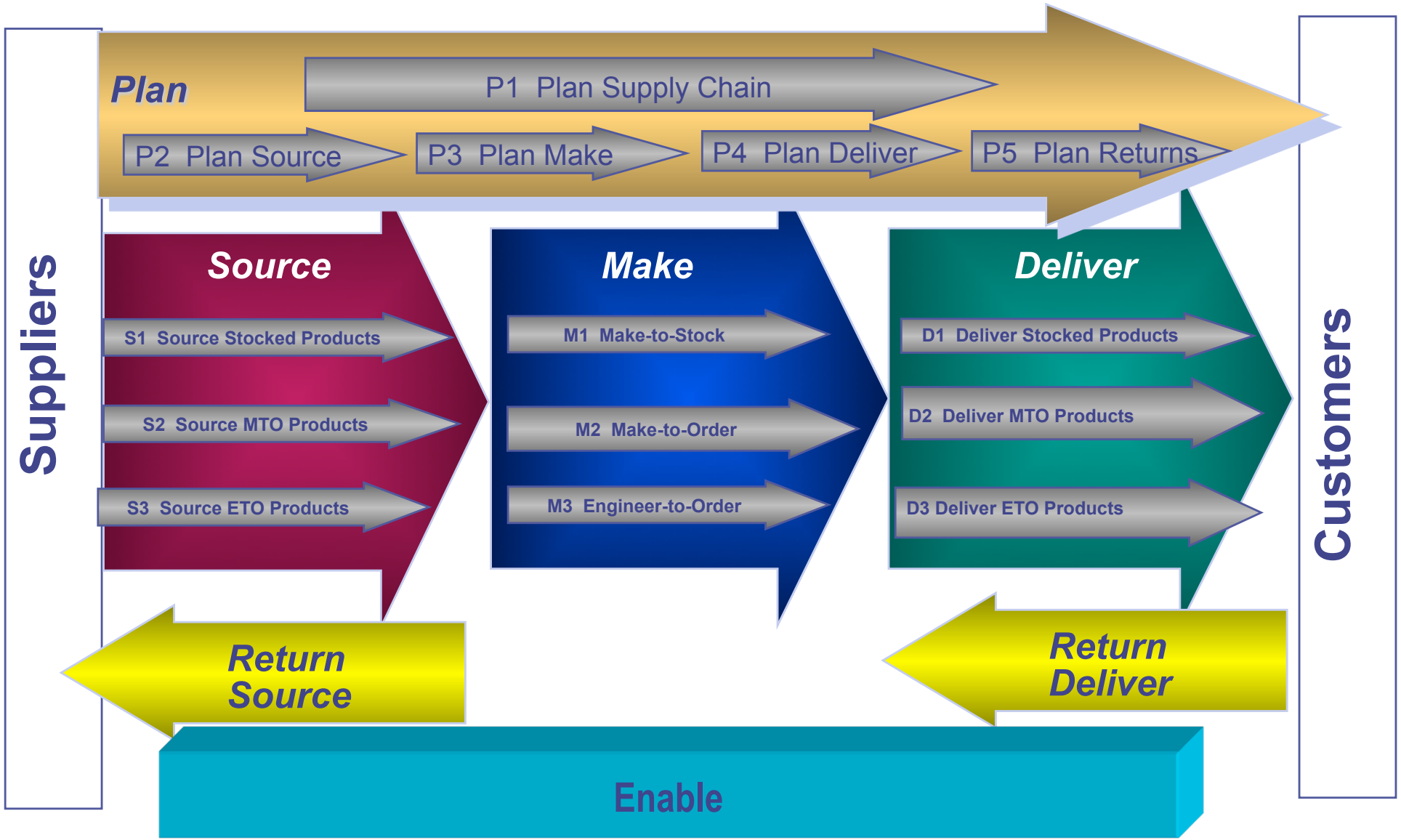
- Strategic Planning
- Demand Planning
- Supply Planning
- Fulfillment

**Customer Relationship Management**

- Marketing
- Selling
- Call Centers
- Order Management
- Return management

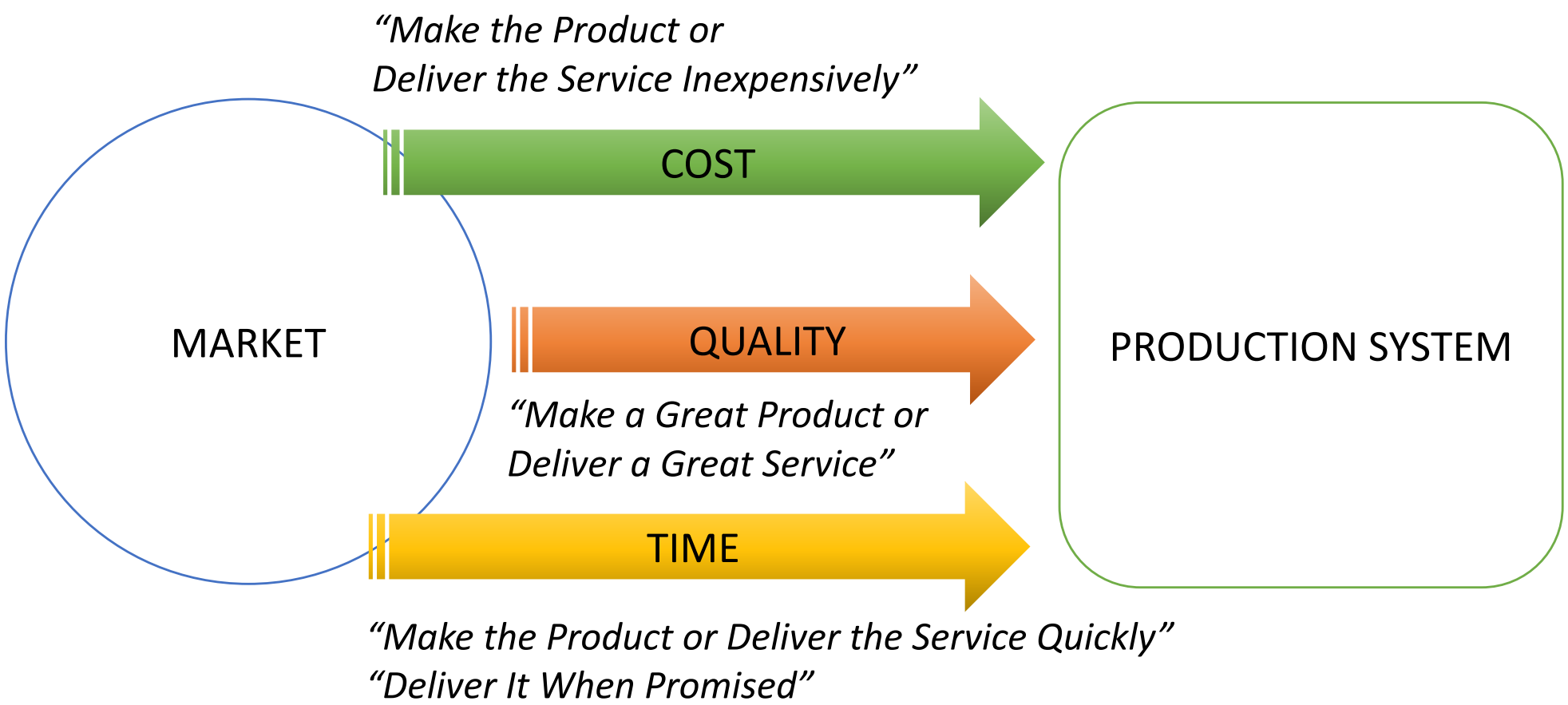
*Source: CTL.SC1x - Supply Chain and Logistics Fundamentals*

# Supply-Chain Operations Reference (SCOR) Model




*Source: Supply Chain Council*

# Competitive dimensions




*The competitive challenge is played on the ability to manage **complex systems** and to solve **trade-offs***

# Trade-offs

- Central to the concept of operations and supply chain strategy is the notion of operations focus and trade-offs
- An operation cannot excel simultaneously on all competitive dimensions
- Management has to decide which parameters of performance are critical to the firm's success and then concentrate the resources on these

# Efficiency, Effectiveness, and Value

**Efficiency**

A ratio of the actual output of a process relative to some standard. Ability of doing something at the lowest possible cost

**Effectiveness**

Doing the things that will create the most value for the customer

**Value**

The attractiveness of a product relative to its price

# Test

https://climeg2.poliba.it/course/view.php?id=45

- COMPETITIVE DIMENSIONQuiz

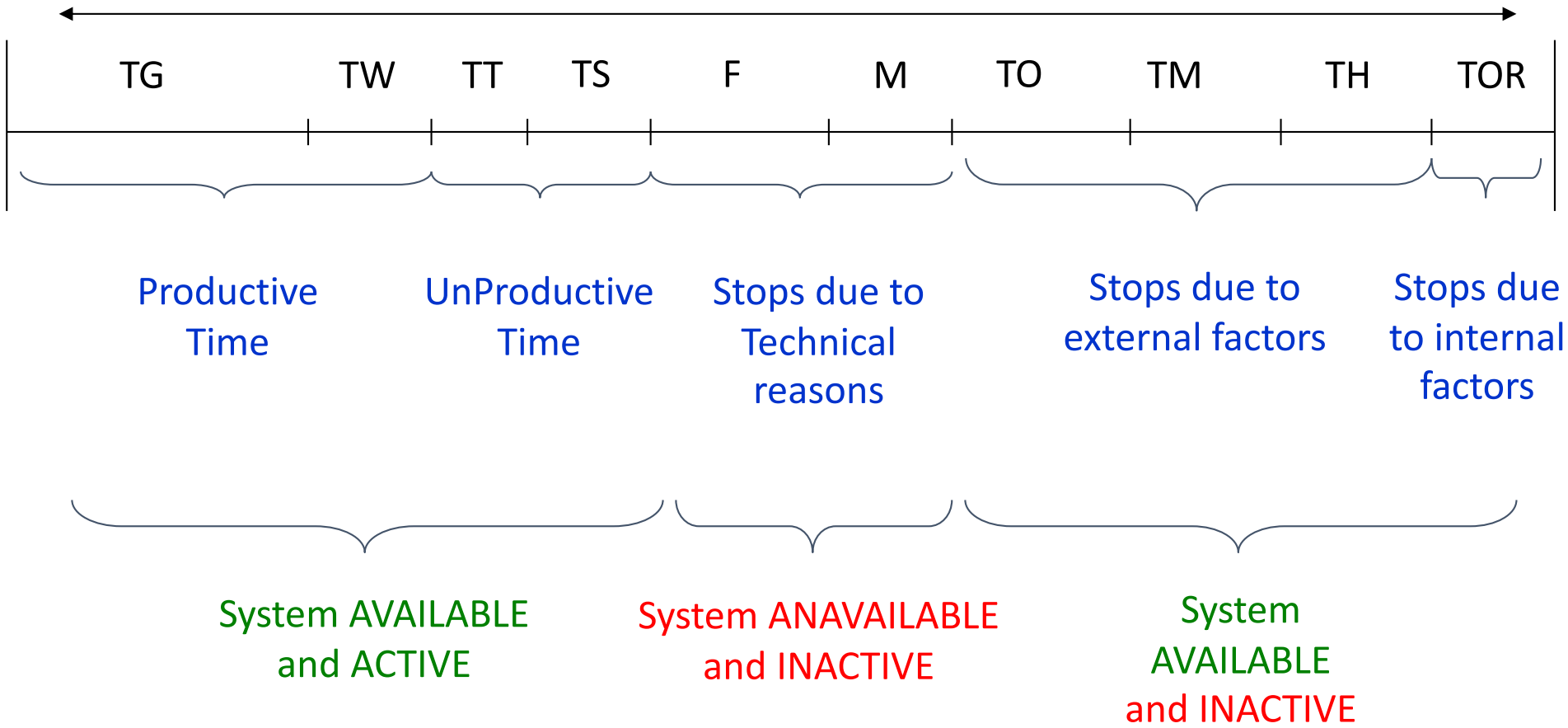
# PERFORMANCE MEASURES
## Potentiality of a production system

The concept of the potentiality of a production system is assimilable to the «**maximum expected value of the output**» of the system or «**maximum obtainable throughput**»

The goal is to identify and to define in a univocal way the conditions or ***states of a system*** and the relations that connect every state to the ***throughput of the system***

# States of a production System

**T = OPENING TIME**



# States of a production System

| | |
|---|---|
| TG | time the machine (line, system) produces good units |
| TW | time the machine produces waste units |
| TT | time the machine is used for sampling (or testing) |
| TS | time the machine is in reconversion phase (set up); the duration depends on the «previous-following» product couple |
| F | time the machine is out of service due to failure |
| M | time the machine is out of service due to scheduled shutdowns (periodic replacement, preventive maintenance, improvement interventions) |

| | |
|---|---|
| TO | time the machine is stopped due to lack of production orders |
| TM | time the machine is out of order due to an actual lack of raw materials despite the presence of production orders |
| TH | time the machine is stopped for trade union reasons (manpower) |
| TOR | time the machine is stopped due to departmental organizational causes (micro stops, micro-absenteeism of the workforce, lack of materials at the end of the line despite their presence in the warehouse) |

# Theoretical Potentiality ($P_t$)

$$P_t = PT \cdot A \quad \text{[unit/hour]}$$

Where

*PT* nameplate (or *nominal*) capacity [unit/hour]

*A* technical availability (dimensionless)

# Technical Availability (*A*)

$$A = \frac{T - (F+M) - (TO + TM + TH + TOR)}{T - (TO + TM + TH + TOR)}$$

In the availability calculation, generally, we do not consider the "non-activity" times (*TO, TM, TH, TOR*) since the incidence of failures and shutdowns must be related to the time in which the plant is operating

# Technical Availability

DEFINITION?

AVAILABILITYQuiz

CALCULATION?

# Number of producible units (*NP*)

$$NP = \sum_i RS_i \, (TG_i + TW_i) \quad [\text{unit}]$$

$RS_i$ Standard production Rate in the time interval *i*

$TG_i + TW_i$ total number of units produced in the time interval *i*

# Mix Potentiality ($P_m$)

Considering the production of a set of products in a given mix:

$$P_m = \frac{NP}{\sum_i (TG_i + TW_i) + TS} \cdot A \quad \text{[unit/hour]}$$

Represents the maximum production target achievable in the medium term.

*It is lower than the theoretical potential!*

# Expected production output (*NA*)

$$NA = P_m \cdot (T - TT - TM - TO - TH) \qquad \text{[unit]}$$

It represents the expected number of units in a given period T under the assumption that testing, lack of materials, lack of orders and strikes are beyond the control of the system manager.

*Obviously NA > NP !*

# Efficiency ($\eta$)

The yield $\eta$ can be defined as:

$$\eta = \frac{Effective\ Production}{Standard\ production\ in\ T}$$

$$\eta = \frac{\sum_i (QG_i + QW_i)}{[\sum_i (TG_i + TW_i) + TS] \cdot P_m}$$

# Coefficient of utilization ($U$)

$$U = \frac{Effective\ Production\ Time}{Opening\ Time}$$

$$U = \frac{T - TT - F - M - TO - TM - TH - TOR}{T}$$

$$U = \frac{\sum_i (TG_i + TW_i) + TS}{T}$$

*The coefficients of use should not be confused with those of efficiency!*

# Saturation

It express how long the system has been used compared to the time it could have been used.

It can be used for a first approximation analysis: *is there still room for further production or is it already saturated*?

GROSS SATURATION

$$SG = \frac{TG + TW + TT + TS}{T - F - M - TO - TM - TH}$$

NET SATURATION

$$SN = \frac{TG}{T - F - M - TO - TM - TH}$$

# Exercise

## Perfomance measures

**Data**

| | |
|---|---|
| NOMINAL CAPACITY (u/h) | 800 |
| T (h) | 400 |
| TG1 (h) | 100 |
| TG2 (h) | 200 |
| TW2 (h) | 5 |
| TT (h) | 6 |
| F (h) | 15 |
| M (h) | 12 |
| TS (h) | 10 |
| TO (h) | 8 |
| TM (h) | 4 |
| TH (h) | 0 |
| TOR (h) | 7 |
| QG (u) | 215000 |
| NT (u) | 225000 |
| RS1 (u/h) | 750 |
| RS2 (u/h) | 700 |

**Indexes**

| | |
|---|---|
| A (Disponibilità) | |
| Pt (Potenzialità teorica) (u/h) | |
| Pm (u/h) | |
| NP (u) | |
| NA (u) | |
| | |
| | |
| U | |
| | |
| SG | |
| SN | |

*A = (T-TO-TM-TH-TOR-F-M)/(T-TO-TM-TH-TOR)*

*Pt = (A)(PT)*

*NP = (RS1)(TG1+TW1)+(RS2)(TG2+TW2)*

*Pm = (NP)(A)/[(TG1+TW1)+(TG2+TW2)+S]*

*NA = Pm · (T – TT – TM – TO – TH)*

# The “6 big losses”

**Loading Time** or **Planned Operating Time**
(calendar time that is actually scheduled for operation)

**OPerating Time**

Losses due to Stops

**Net Operating Time**

Efficiency Loss

**Valuable Operating T**

Quality Loss

1. Failures and Breakdowns
2. Planned downtimes
3. Minor stops
4. Speed Loss
5. Production Rejects
6. Rework (reduction in production)

**ISO 22400-2:2014** Key performance indicators (KPIs) for manufacturing operations management — Part 2: Definitions and descriptions

# Overall Equipment Effectiveness (OEE)

## (TPM展開プログラム, Nakajima, 1982)

| Overall Equipment Effectiveness | = | Availability (A) | . | Performance Efficiency (P) | . | Quality rate (Q) |
|---|---|---|---|---|---|---|

OEE $\leq 1$

$$Availability = \frac{Operating\ Time}{Planned\ Operating\ Time}$$

$$Performance\ Efficiency = \frac{Net\ Operating\ Time}{Operating\ Time}$$

$$Quality\ Rate = \frac{Valuable\ Operating\ Time}{Net\ Operating\ Time}$$

# OEE estimation

$$Availability = \frac{Operating\ Time}{Operating\ Time + Stoppage\ Time}$$

$$Perf.Efficiency = \frac{Total\ Production \cdot Ideal\ Cycle\ Time}{Operating\ Time}$$

$$Quality\ Rate = \frac{Total\ Production - Defective\ Production}{Total\ Production}$$

# Test

https://climeg2.poliba.it/course/view.php?id=45

- PERFORMANCEQuiz

# Summary

- Operations and performance
- Understand trade-offs
- Evaluate productivity in operations
- Potentiality, efficiency and utilization of resources
- Overall Equipment Effectiveness – OEE

- References:

  *Ch.1 and Ch.3 Jacobs, Chase*