ME Module 11: Production Systems Engineering
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Systems Engineering

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Problem Statement

Etone Enterprises is an Original Equipment Manufacturer, and wants to enter the market of construction elements to broaden their product portfolio. They have found a new customer, Port of Ashdod, that requires the design and production of construction parts for STS cranes. A larger redesigned production facility is required to fully accommodate its current and new production lines.

The principles of Systems Engineering are used in order to develop, integrate & test the different operations involved in the production system. This is done so that the Production System can be efficiently redesigned and functioned to meet the production requirements without compromising the quality of the products and production.

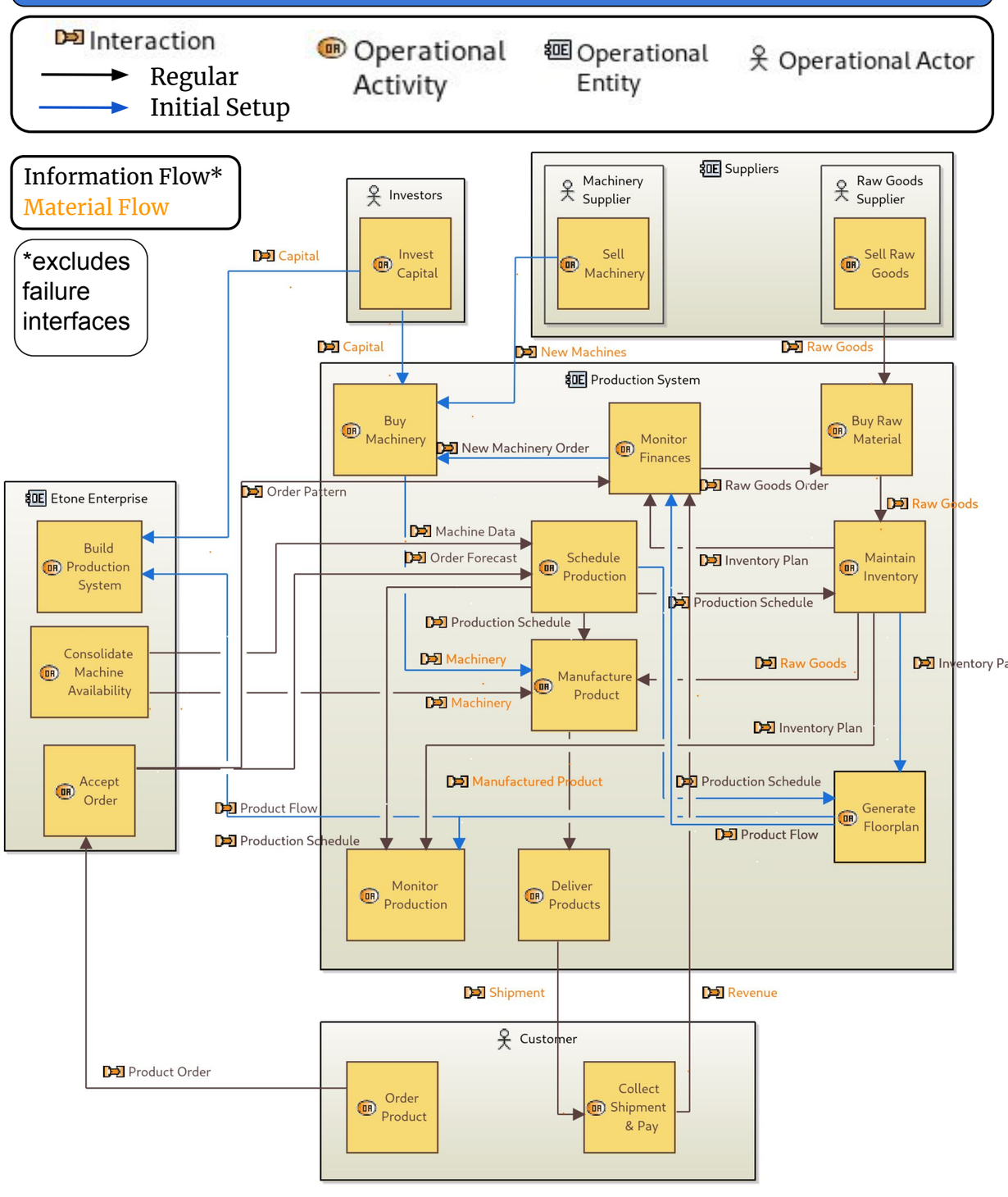
System Requirements

After Performing a stakeholder analysis and defining key drivers to each stakeholder, the system requirements were split into functional and non functional KPIs.

Non-Functional KPI: Efficiency, Reliability, Flexibility, Maintainability, Cost Effectiveness

Key Driver	Functional KPI
1. Law Compliance	1.1 Standard Working hours 2 shifts/day, 48 weeks/year 1.2 Minimum Working wage 1.3 Safety exits at least 0.7 m wide
2. Sustainability	2.1 Less than 5% wasted product and material
3. Financial Forecast	3.1 Cost of new machines < €40, 000 3.2 Breakeven point reached in 5 years
4. Product Flow	4.1 Walking distance < 2 m 4.2 Product Transit Time/Production Time < 0.13 4.3 Total idle time < 10% of the total production time
5. Raw Material Order Pattern	5.1 Regular and reliable raw material order patterns with a < 10% variation 5.2 Safety Stock < 5%, ordered raw materials left unused < 5%
6. Production Quality	6.1 OEE >= 90% overall 6.2 Cpk > 1.5 6.3 Machine startup defects < 1% per machine 6.4 Average scrap < 5% per machine 6.5 Downtime < 8 hours
7. Product Quality	7.1 No. of defective products per batch / total products per batch < 0.02 7.2 For the STS cranes horizontal displacement of boom tip <= 4mm
8. Order Delivery	8.1 Orders should be ready at least 1 day before the required delivery date

Operational Flow



N² Architecture

Etone		2			3			
	P.S.				14			12
		PP&C	4	4	4			
7			PF&D	6	7			
8			5	F&IM	5	8		5
9		15			QC&RM	9		
10						Investor		
1				13			Customer	
	11				14		12	S & D

Abbreviations :
PS : Production System
S&D : Suppliers & Distributors
PP&C : Production Planning & Control
PF&D : Production Flow & Design
F&IM : Finance & Inventory Management
QC&RM : Quality Control & Risk Mitigation

1. Product Order
2. Order Forecast, Existing Machine Data.
3. Performance Requirements
4. Production Sequence & Schedule
5. Inventory Pattern & Order Plan
6. Land Requirements
7. Product Flow & Factory Layout
8. Financial Projections
9. System & Product Performance
10. Investment Capital
11. Raw Material
12. Manufactured Product
13. Revenue
14. Failure
15. Risk & Maintenance Protocol

The orange interfaces are **Materials**.
- Raw Material
- Manufactured Product

The other interfaces are **Information**.
- Inventory Plans, Order Plan
- Performance Reports, Financial Plans

The green interfaces are **information** interfaces **activated when a failure occurs**.
- Lack of workforce on certain days
- Lack of inventory
- Unexpected Machine Failure

The blue interfaces are **information** interfaces **exist during the initial setup**.
- Existing Machine Data
- Factory Layout

Verification

	Functional KPI																			
kd	1			2	3		4			5		6						7		8
kpi	1	2	3	1	1	2	1	2	3	1	2	1	2	3	4	5		1	2	1
T1	X	X			X	X				X										
T2			X				X				X									X
T3								X	X			X	X							
T4														X	X	X	X	X		
T5				X																

Test Protocol 1 : Unit Testing
- [T1] Test 1 : Documentation Check
- [T2] Test 2 : Floor Inspection
- [T3] Test 3 : Efficiency Check
- [T4] Test 4 : Quality Check
- [T5] Test 5 : Waste Check

Test Protocol 1 is meant for the testing of the Functional KPIs and Test Protocol 2 is for testing the Non-Functional KPIs.

Test Protocol 2 : Integration Testing
- Test 1 : Virtual Environment Testing
- Test 2 : Real Life Monitoring

Non-Functional KPIs :
- Efficiency
- Reliability
- Flexibility
- Cost Effectiveness

Conclusion

The Systems Engineering approach proved beneficial in the design of a new Production System. Along with successful integration, our efforts were to distribute the workload equally among subsystems. Many performance indicators have been excluded, which can be included and worked on further.

From our System Verification and Integration Analysis, we conclude that the designed Production System was not able to meet the required OEE and Cpk values however, the system is flexible, robust, failure modes are limited and there is room for expansion. The OEE and Cpk values can be improved by further iteration of the production layout and product flow.

References [1] Systems Design and Engineering - G. Maarten Bonnema, Karel Th. Veenvliet, Jan F. Broenink
[2] A3 Architecture overviews: A tool for effective communication in product evolution - P. Daniel Borches
[3] System Architecture Modeling with the Arcadia Method - Pascal Roques

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