Abstract

The fundamental concepts and approach system partitioning are explained. We look at physical decomposition and functional decomposition in relation to supply chain, lifecycle support, project management, and system specification and design.
Parts, Dynamics, Characteristics

- **characteristics**
  - prime interest of customer

- **dynamics**
  - functionality

- **interact**

- **parts**
  - prime interest of organization

- **results in**

- **prime system responsibility**
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Example Physical Decomposition

1. Fluidic subsystem
   2. Chamber
   3. Bottom chuck
   4. Process power supply
   5. Electronics infrastructure

6. Base frame + x, y, θ stage
   7. ZUBA
   8. Optics stage
   9. Vision
   10. Covers and hatches
    11. Cabling
    12. Ventilation air flow
    13. Contamination evacuation
    14. Machine control
    15. "Remote" electronics rack

back side view
front side view
integrating

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REPLI subsystemsAll
Partitioning is Applied Recursively

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SPFrecursion
the part is cohesive

functionality and technology belongs together

the coupling with other parts is minimal

minimize interfaces

the part is selfsustained for production and qualification

can be in conflict with cost or space requirements

clear ownership of part

e.g. one department or supplier
How much self-sustained?

How self sustained should a part be?
trade-off:

- cost/speed/space optimization
- logistics/lifecycle/production flexibility
- clarity
Decoupling via Interfaces

- part e.g. pipe
- part e.g. pressure and flow regulator
- part e.g. pipe
- control interface e.g. CAN
- mechanical mounting interface
- other part with same interfaces can replace original
- hydrocarbon interface
- power interface

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SPFInterfaceDecoupling
System is composed

by using standard interfaces

limited catalogue of variants (e.g. cost performance points)
System Creation

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SPFsystemCreation

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System Partitioning Fundamentals

- System Creation
  - Engineering
    - Design
      - Architecture
        - Guidelines
        - Top-level design rationale
      - Functions
      - Interfaces
      - Partitioning
    - Engineering
      - Documentation
        - System and parts data procedures
      - Quality assurance
      - Installation
      - Production
      - Support
    - Procurement
Simplistic Functional SubSea Example

- Prevent blow-outs
- Regulate flow and pressure
- Combine multiple streams
- Separate gas, oil, water, sand
- Increase well pressure
- Transport to top-side

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SPFfunctionalExample
How does the system work and operate?

Functions describe *what* rather than *how*.

Functions are *verbs*.

Input-Process-Output paradigm.

Multiple kinds of flows:

- physical (e.g. hydrocarbons)
- information (e.g. measurements)
- control

At lower level one part \(\sim\) one function

- pump pumps, compressor compresses, controller controls

At higher level functions are complex interplay of physical parts

- e.g. regulating constant flow, pressure and temperature
## Quantification

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>2.4m * 0.7m * 1.3m</td>
</tr>
<tr>
<td>Weight</td>
<td>1450 Kg</td>
</tr>
<tr>
<td>Cost</td>
<td>30000 NoK</td>
</tr>
<tr>
<td>Reliability</td>
<td>MTBF 4000 hr</td>
</tr>
<tr>
<td>Throughput</td>
<td>3000 l/hr</td>
</tr>
<tr>
<td>Response time</td>
<td>0.1 s</td>
</tr>
<tr>
<td>Accuracy</td>
<td>+/- 0.1%</td>
</tr>
</tbody>
</table>

Many characteristics of a system, function or part can be quantified. Note that quantities have unit.
How about the **<characteristic>** of the **<component>** when performing **<function>**?

What is the **accuracy** of the **fuse** when **printing**?

Example from a high volume printer.
Example Technical Budget

- **process overlay 80 nm**
  - matched machine 60 nm
  - single machine 30 nm
  - process dependency sensor 5 nm
  - matching accuracy 5 nm

- **lens matching 25 nm**
  - stage overlay 12 nm
  - stage grid accuracy 5 nm
  - metrology stability 5 nm

- **global alignment accuracy 6 nm**
  - stage Al. pos. meas. accuracy 4 nm
  - alignment repro 5 nm

- **off axis pos. meas. accuracy 4 nm**
  - off axis Sensor repro 3 nm

- **system adjustment accuracy 2 nm**
  - interferometer stability 1 nm

- **frame stability 2.5 nm**
  - tracking error WS 2 nm
  - tracking error X, Y 2.5 nm
  - tracking error phi 75 nrad

- **stage pos. meas. accuracy 7 nm**
  - tracking error RS 1 nm
Example of A3 overview

A3 architecture overview of the Metal Printer
(all numbers have been removed for competitive sensitivity)

back-end factory: systems and process model

metal printing cell: systems and performance model

metal printing time-line

metal printing cell: functional flow

metal printer back side
metal printer front side

metal printer subsystems, functions, and cycle time model

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LEANoverviewA3