What devilish detail might kill your grand design? An example of connecting breadth and depth

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Abstract

We briefly look at some devilish details and their consequences. We observe that there is a natural tendency to either zoom in on details, or to zoom out for a helicopter view. We pose that it is the systems engineer’s contribution to connect depth and breadth:

• to help experts to understand the broader context

• to help “helicopter pilots” to see details that must be taken into account

Later we discuss an example from the logistics world, a warehouse, to see how a systems engineer can make such connection.

Distribution

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status: draft
version: 0
Deepwater Horizon: What Went Wrong?

original problems
- instable concrete
- too few distance holders
- pressure test wrongly explained
- pressure verification inconsistency ignored
- Blow Out Preventer did not work:
  - connections were severed
  - backup battery was empty
  - BOP type fails in 50%
- Alarm in crew cabins was switched-off

conclusions in retrospect
- missing communication
- missing overview
- local crew did not understand system
Connecting Breadth and Depth

many engineers live here in a world full of details

Depth

system requirements

multidisciplinary design

static system definition

monodisciplinary

num of details

$10^0$

$10^1$

$10^2$

$10^3$

$10^4$

$10^5$

$10^6$

$10^7$
Breadth

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CBADbreadth

surrounding systems
- supply
- receive
- manage

stakeholders
- concerns
- needs
- interests

System of Interest

regulations
- processes
- procedures

supporting systems
- train
- plan
- maintain
<table>
<thead>
<tr>
<th><strong>Depth</strong> What &quot;detail&quot; might kill your business?</th>
<th><strong>Breadth</strong> What contextual information is missing or unknown to your engineers?</th>
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| Maarten Bonnema  
System Design’s Three Pillars: Process, Tools and Thinking Tracks |  |
| Haldor Husby  
Narrow but shallow, an unfortunate combination |  |
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Wave Energy Converters and system engineering in startup environments |  |
| Alf Dale  
Systems engineering in advanced missiles design |  |
| Rob Cloutier  
Graphical CONOPS – A Strategy to Improve Stakeholder/Designer Shared Understanding |  |
| Tom Eddy Johansen  
Toolbox to ensure control of the details to fulfill system requirements |  |
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Knowledge Capture, Cross Boundary Communication and Early Validation with Dynamic A3 Architectures |  |
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meta
remember this

breadth
intro
warehouse
case
goals
method

depth
grippers + breadth impact

T-model
conclusion

human
or
robot

method (2)

second iteration

first iteration

warehouse

questions
Time To Reflect

- meta
  - remember this
- breadth
  - we are here
  - intro
    - warehouse
    - case
- depth
- goals
- questions
  - method
- method (2)
- second iteration
  - grippers + breadth impact
- T-model
  - conclusion

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CBADlogo1

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Human labor, a.o. for pick and place is major part of cost

In Western world lack of staff

Can pick and place be automated?

Understand design choices and impact of pick and place automation
Method to Connect Depth and Breadth

physical partitioning

functional model

quantification

#items/hour, order size, order variation, delivery time, storage capacity, etc.
First Iteration

- meta
- remember this

breadth

- intro
- warehouse case

depth

- goals
- method
- questions

we are here

- method
- method (2)
- T-model
- conclusion

second iteration
- grippers + breadth impact

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Goods and Information Flow

**Financial, Administrative, and Logistics Control**

- Planning
- Purchase
- Sales
- Delivery

**Goods Flow**

- Factories
- Suppliers
- Warehouses
- Outlets, e.g., Retailers

- Trucks
- Trains
- Planes
- Ships
- Vans
Functional Model Warehouse

- Loading
- Unpacking
- Routing
- Storing and fetching
- Unpacking
- Routing
- Picking & packing
- Loading
- Operators
- Forklifts
- Robots
- Belts
- Switches
- Cranes
- Belts
- Operators
- Robots
- Belts
- Forklifts

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SOSCwarehouse
Some Warehouse Jargon
Pick and Place

Storage

Pick and Place workstation
What do We Want to Know?

intro
warehouse
case
goals
method
first iteration
questions
human
or
robot
grippers + breadth impact
second iteration
T-model
conclusion
meta
remember this
we are here
method (2)

breadth

depth
Pick and Place Design

One order at a time?

One item at a time?

Stock travels along many workstations?

What are the critical design choices?

What concepts are available?
From Human to Robot

- Intelligent
- Adaptive
- Many DOF
- Fine control
- Flexible
- Movable
- Flexible
- Arm design
- General purpose
- Tactile nerves
- Flexible
- Human
- Brains
- Arms
- Hands
- Legs
- Camera
- Gripper
- Computer
- Software
What Method can We Apply?

- **meta**
  - remember this

- **breadth**
  - intro warehouse case

- **depth**
  - goals method
  - warehouse first iteration
  - questions

- **we are here**
  - method (2)
  - grippers + breadth impact
  - second iteration

- **T-model**
  - conclusion

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Method Recommendations

**recommendations**

- Time-box
- Iterate
- Multi-view
- Multiple levels
- Visualize
- Quantify early
- Use examples

- 6 slides
- first explanation of warehouse space 2D, 3D time qualities logistics chain
- warehouse, workstation, robot gripper

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What Gripper and Robot Concepts are appropriate?

What are the desired properties?

What kind of items must be handled, and how?

Use examples to explore
Example 1: Large Volume Drugstore

Large quantities
box-like packages

w, l, h: 0.1..0.5m
weight: 1..40 Kg

simple gripper
1 DOF

simple robot
"H" for X, Y, and Z
movements
Example 2: High Dynamics

suppliers

warehouse

drugstore

highly dynamic product mix and suppliers

large quantities various packages

w, l, h: 0.1 .. 2.0m
weight: 0.1 .. 50 Kg

multiple grippers needed?

there is no time to teach (program) the robots how to handle package variety
And more variants...

- supplier
- warehouse
- shop
- small quantities
- fragile packages
- packaging constraints
- production
- critical delivery time (e.g. fresh food)
- delivery at shop

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Bringing Order into Chaos

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Recap: Levels and Partitioning

global goods distribution
warehouse
pick and place station
robot
gripper
arm
sensor
vision
camera
recognizer

super SoS
SoS
system
subsystem
component
Recommended Flow for Management Presentation

societal trends
opportunities
problems
needs

business/market trends
opportunities
problems
needs

competition

customers

stakeholders
key drivers
concerns
applications

product project
system
functions
key performance

design and concepts
functional, physical
quantified

specific aspects
functional, physical
quantified

technology
critical or new

summary how
solution answers
needs

summary and conclusions
why choices are appropriate

conclusions
and
recommendations

breadth

breadth

depth

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To see the relevance of details (depth) sufficient understanding of the context (breadth) is required.

For a sensible understanding of breadth, the right details must have been touched.

**recommendations**

- Time-box
- Iterate
- Multi-view
- Multiple levels
- Visualize
- Quantify early
- Use examples
My Questions:

Who wants to share an example of

a devilish detail (depth)

and/or

a lack of understanding of the context (breadth)?