Module 31, Architectural Reasoning Conceptual Design

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Abstract

This module conceptual design methods, such as budgeting and concept selection.

July 3, 2023
status: preliminary draft
version: 1.1

Modeling and Analysis: Budgeting

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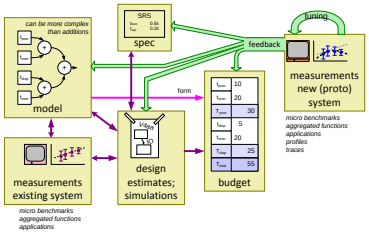
Abstract

This presentation addresses the fundamentals of budgeting: What is a budget, how to create and use a budget, what types of budgets are there. What is the relation with modeling and measuring.

July 3, 2023
status: preliminary draft
version: 1.0



Budgeting

content of this presentation

What and why of a budget

How to create a budget (decomposition, granularity, inputs)

How to use a budget

What is a Budget?

*A **budget** is*

*a **quantified instantation** of a **conceptual model***

*A **budget** can*

prescribe** or **describe** the **contributions

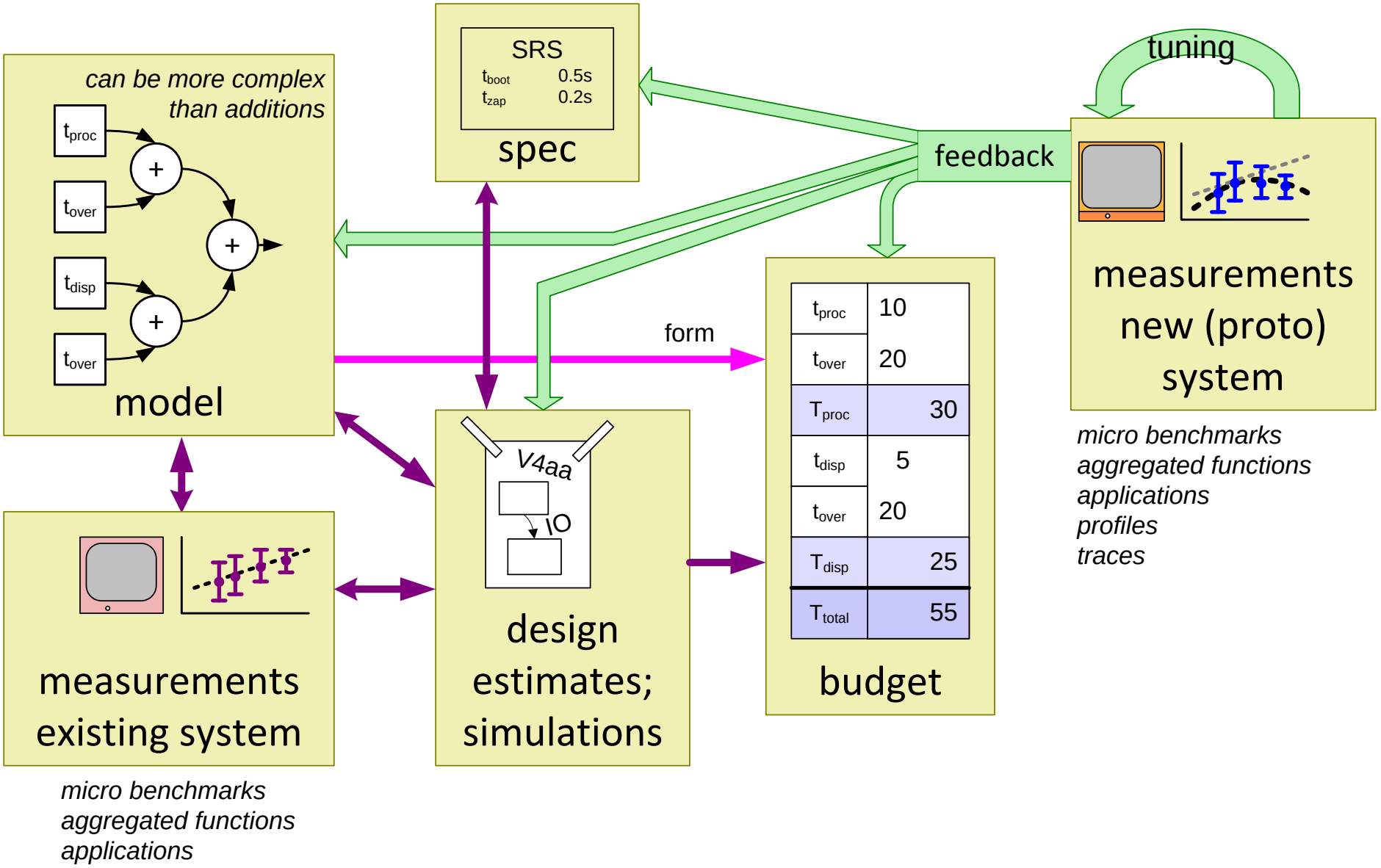
*by **parts** of the **solution***

*to the **system quality** under consideration*

Why Budgets?

- to make the design explicit
- to provide a baseline to take decisions
- to specify the requirements for the detailed designs
- to have guidance during integration
- to provide a baseline for verification
- to manage the design margins explicitly

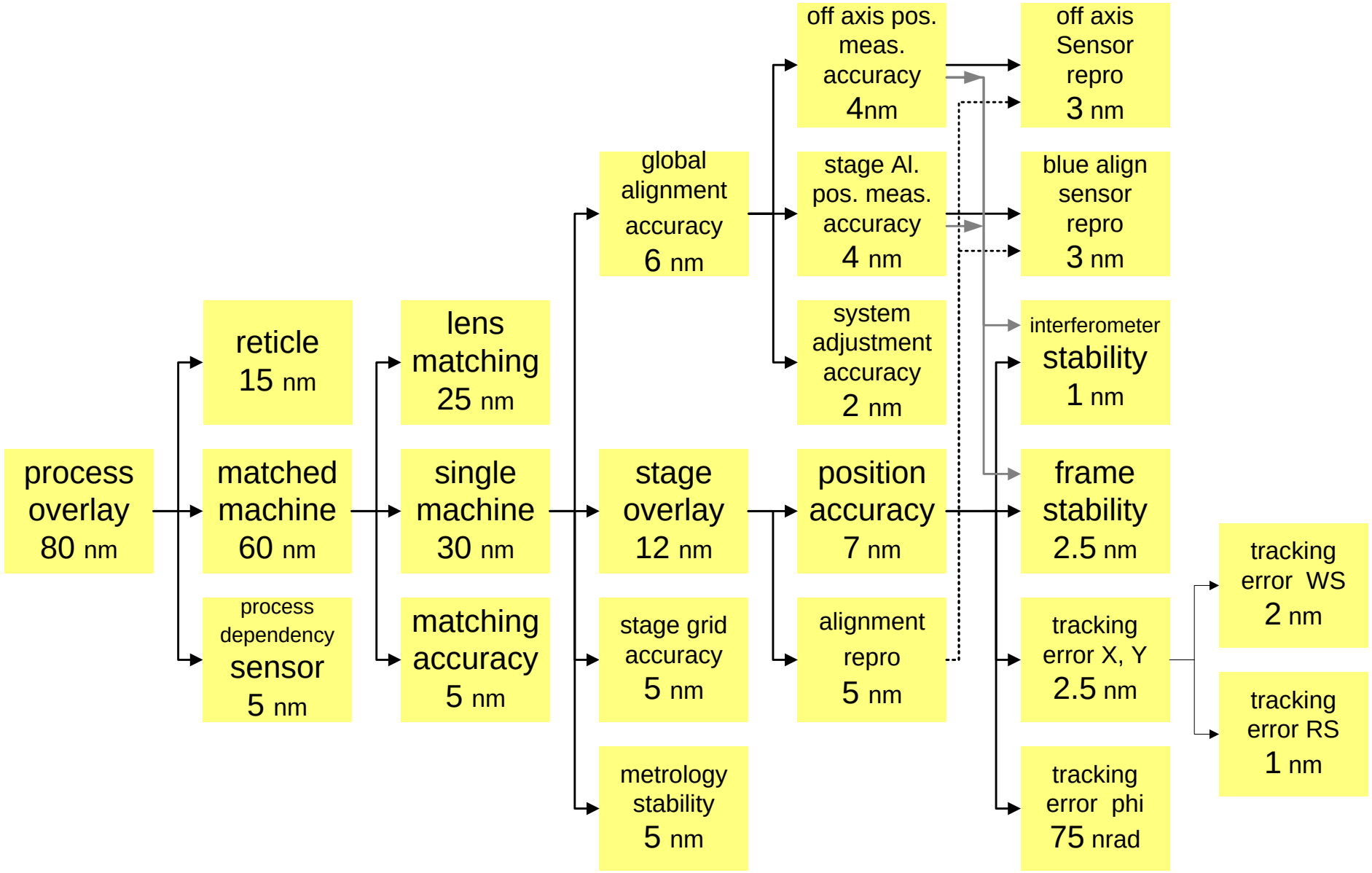
Visualization of Budget Based Design Flow



Stepwise Budget Based Design Flow

step	example
1A measure old systems	micro-benchmarks, aggregated functions, applications
1B model the performance starting with old systems	flow model and analytical model
1C determine requirements for new system	response time or throughput
2 make a design for the new system	explore design space, estimate and simulate
3 make a budget for the new system:	models provide the structure measurements and estimates provide initial numbers specification provides bottom line
4 measure prototypes and new system	micro-benchmarks, aggregated functions, applications profiles, traces
5 Iterate steps 1B to 4	

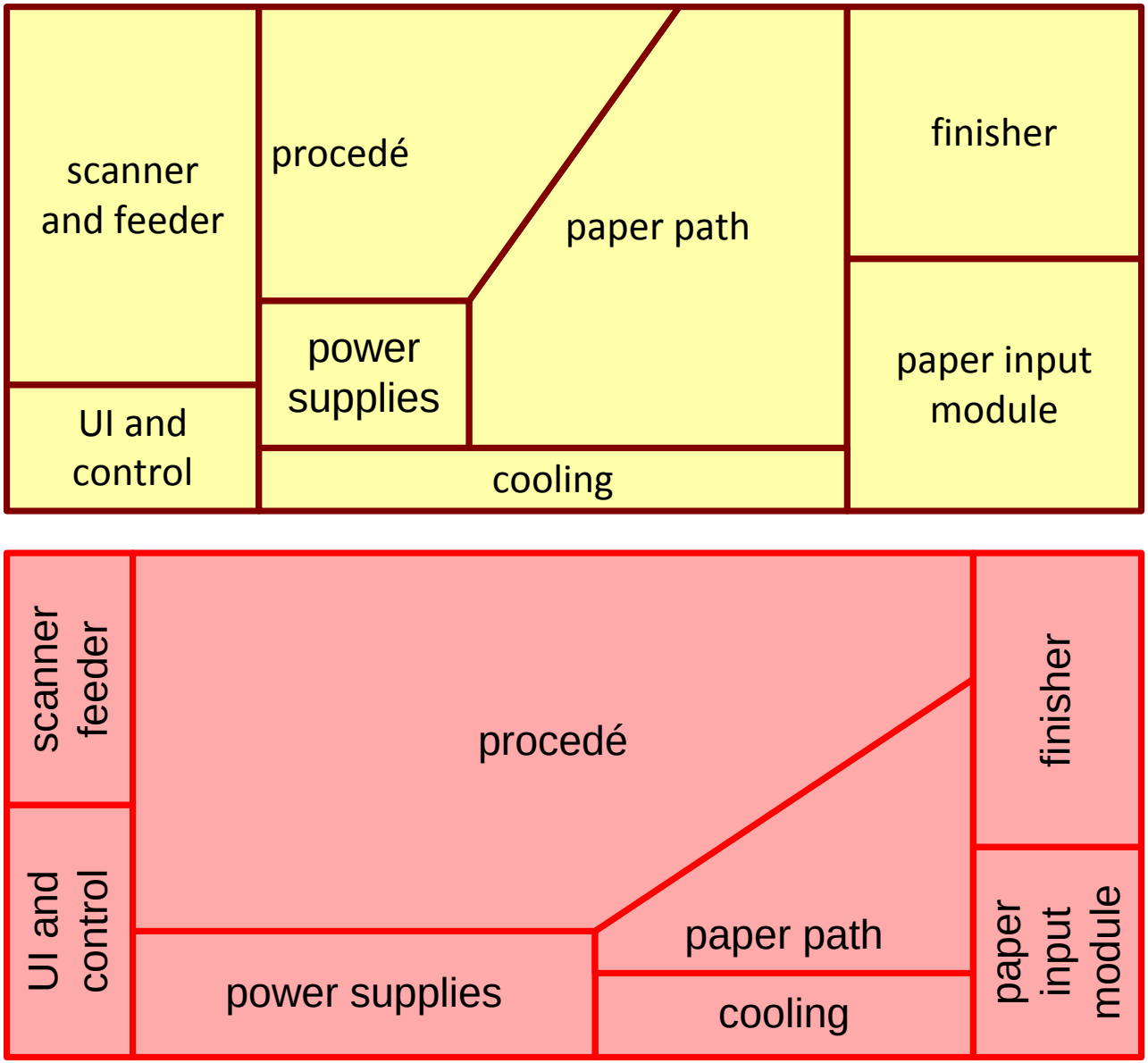
Budgets Applied on Waferstepper Overlay



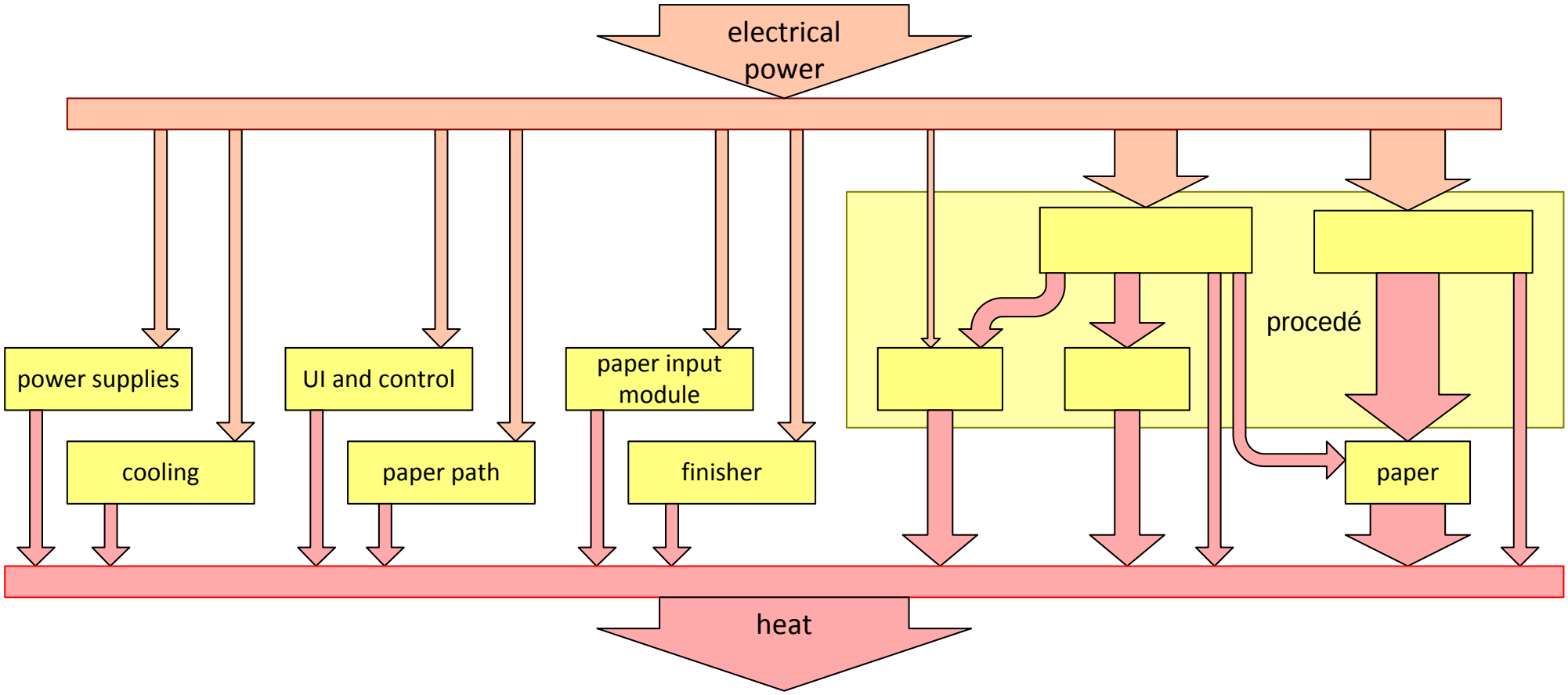
Budgets Applied on Medical Workstation Memory Use

memory budget in Mbytes	code	obj data	bulk data	total
shared code	11.0			11.0
User Interface process	0.3	3.0	12.0	15.3
database server	0.3	3.2	3.0	6.5
print server	0.3	1.2	9.0	10.5
optical storage server	0.3	2.0	1.0	3.3
communication server	0.3	2.0	4.0	6.3
UNIX commands	0.3	0.2	0	0.5
compute server	0.3	0.5	6.0	6.8
system monitor	0.3	0.5	0	0.8
application SW total	13.4	12.6	35.0	61.0
UNIX Solaris 2.x				10.0
file cache				3.0
total				74.0

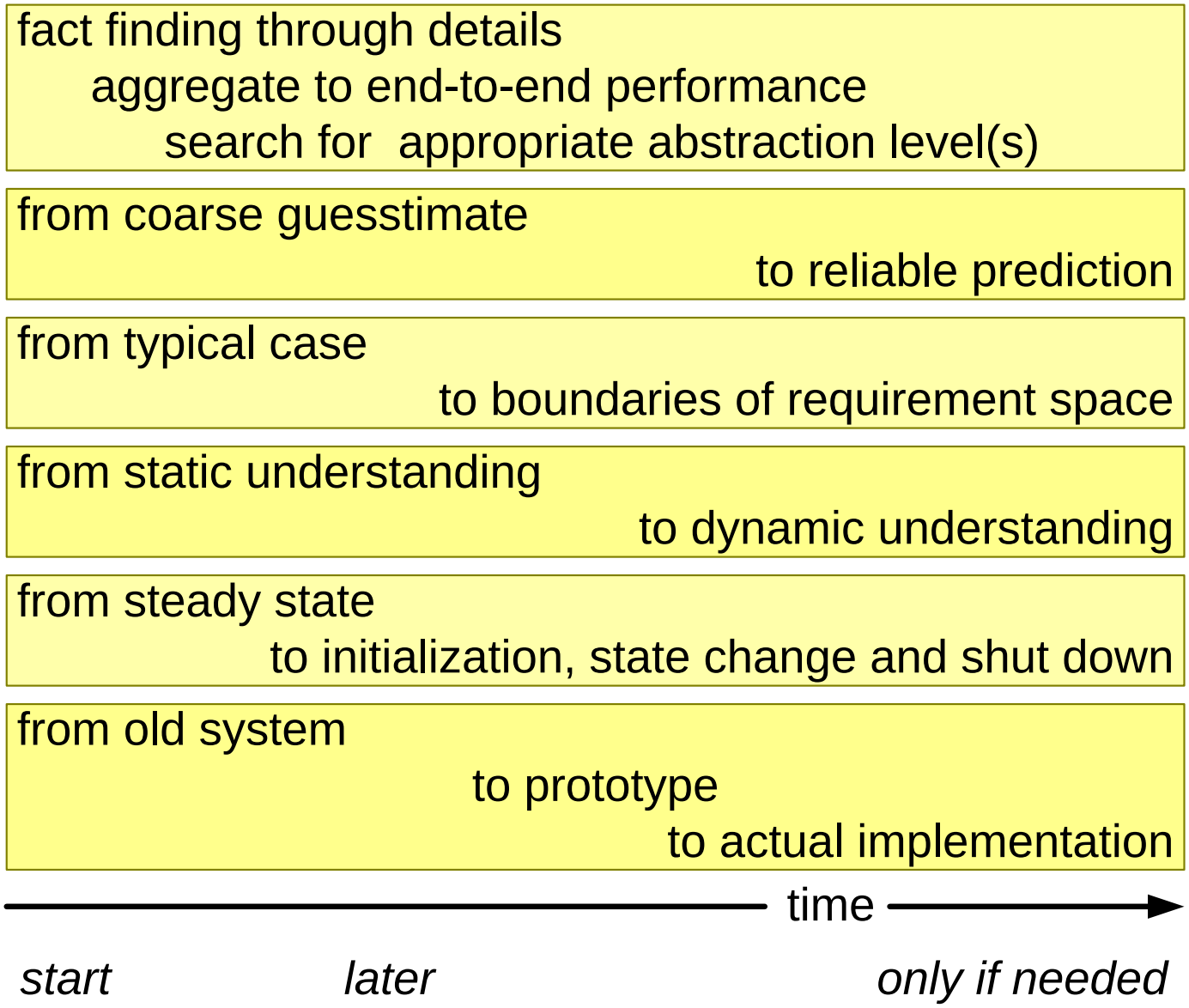
Power Budget Visualization for Document Handler



Alternative Power Visualization



Evolution of Budget over Time



Potential Applications of Budget based design

- resource use (CPU, memory, disk, bus, network)
- timing (response, latency, start up, shutdown)
- productivity (throughput, reliability)
- Image Quality parameters (contrast, SNR, deformation, overlay, DOF)
- cost, space, time

What kind of budget is required?

static	dynamic
typical case	worst case
global	detailed
approximate	accurate

is the budget based on
wish, empirical data, extrapolation,
educated guess, or expectation?

Summary of Budgeting

A budget is a quantified instantiation of a model

A budget can prescribe or describe the contributions by parts of the solution to the system quality under consideration

A budget uses a decomposition in tens of elements

The numbers are based on historic data, user needs, first principles and measurements

Budgets are based on models and estimations

Budget visualization is critical for communication

Budgeting requires an incremental process

Many types of budgets can be made; start simple!

Colophon

The Boderc project contributed to Budget Based Design. Especially the work of

Hennie Freriks, Peter van den Bosch (Océ),

Heico Sandee and *Maurice Heemels* (TU/e, ESI)

has been valuable.

Exercise Budget

Make a **technical budget** for one of the **key performance parameters**.

- a good budget has 20 to 30 contributing elements
- elements should be balanced (remove or combine insignificant contributions)
- use the previously defined parts and dynamic behavior

Concept Selection, Set Based Design and Late Decision Making

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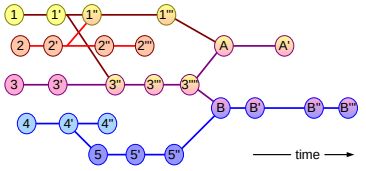
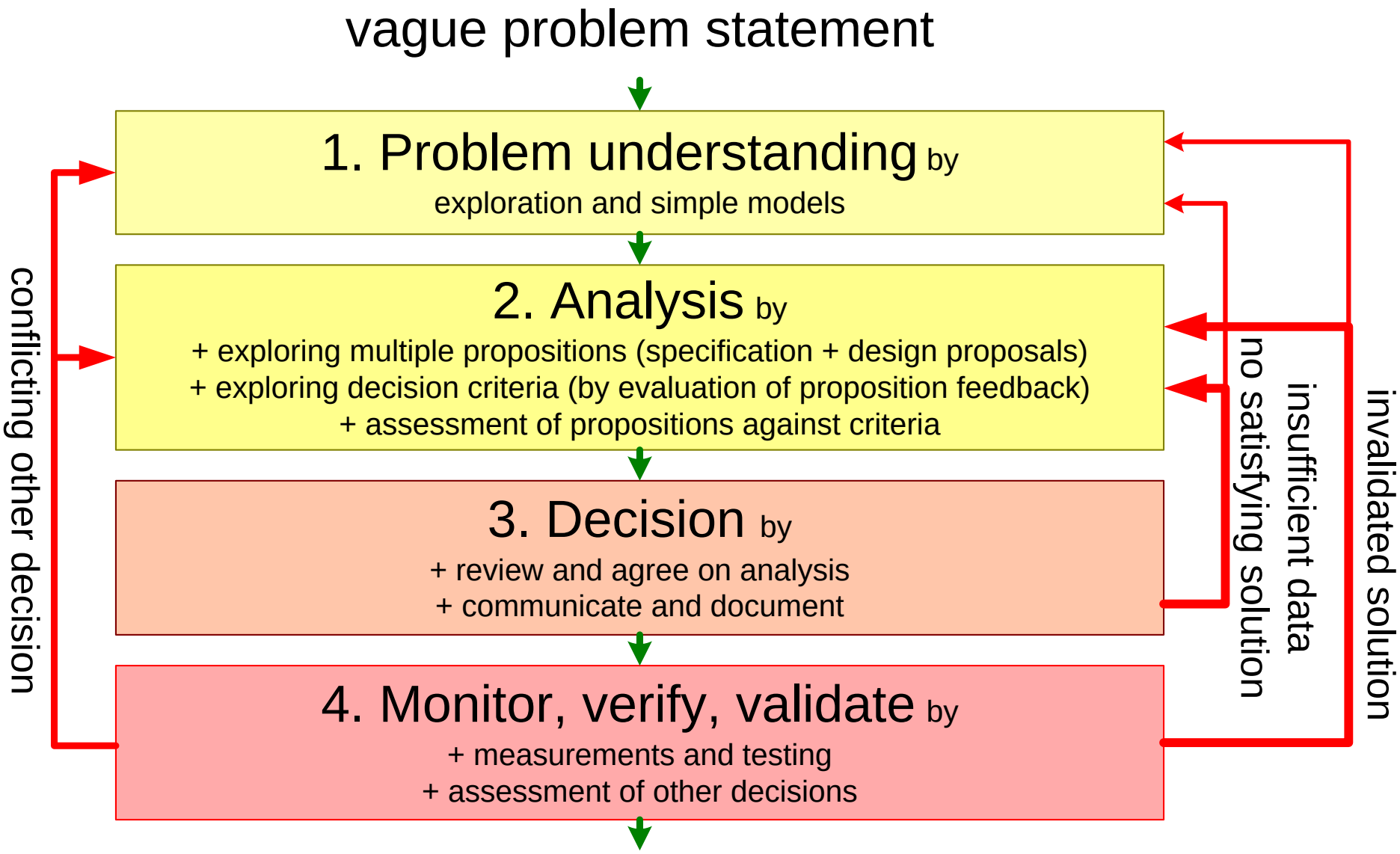
Abstract

We discuss a systems design approach where several design options are maintained concurrently. In LEAN Product Development this is called set-based design. Concentioanl systems engineering also promotes the concurrent evaluation of multiple concepts, the so-called concept selection. Finally, LEAN product development advocates to keep options open as long as feasible; the so-called late decision making.

July 3, 2023
status: planned
version: 0

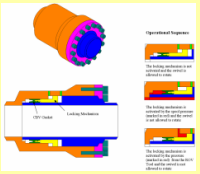
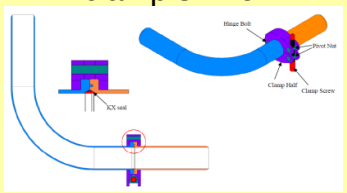
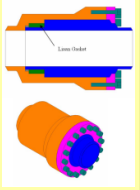


Problem Solving Approach



Examples of Pugh Matrix Application

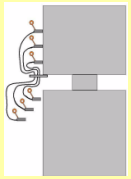
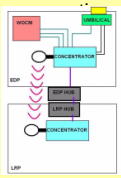
Swivel concept selection

CBV swivel	clamp swivel	dynamic
		

evaluation criteria	weight	CBV		clamp		dynamic	
Maturity	10						
Development level		5	50	2	20	2	50
Cost	20						
Hardware cost		4	80	2	40	5	100
Development cost		5	100	2	40	2	40
Design robustness	25						
Design life							
swivel cycles		5	125	3	75	3	75
pressure cycles		5	125	4	100	5	125
Pressure range		4	100	4	100	4	100
internal		2	50	5	125	2	50
external		4	100	4	100	4	100
Temperature range							
Installation	20						
Initial installatio/retrieval		2	40	3	60	4	80
Connection/disconnection		2	40	4	80	5	100
Operation	25						
Swivel resistance		1	25	4	100	5	125
Spool Length Short		1	25	4	100	5	125
Spool Length Long		3	75	5	125	5	125
Hub loads		2	50	4	100	5	125
Σ points			985		1165		1290

from master paper Halvard Bjørnsen, 2009

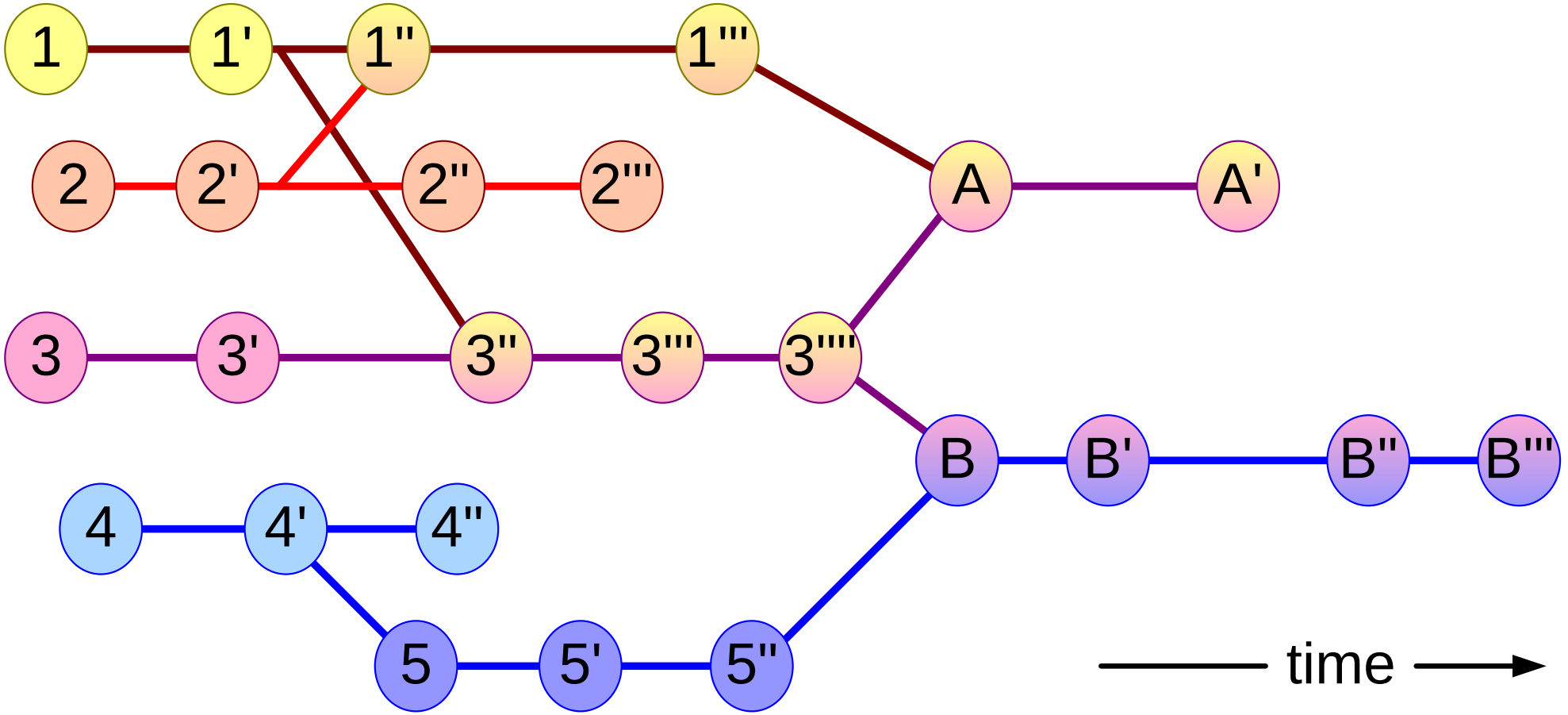
EDP-LRP connection

two sided	connectors in hub	connectors in hub	wireless
			

		Concepts			
Evaluation Criteria	Score	1	2	3	4
Time to connect					
Need for ROV		-	+	+	+
Design		-	+	+	+
Robustness					
Connector design		-	S	S	+
Number of parts		-	-	+	+
Handle roll-off		+	-	S	+
Influence other		+	S	-	S
Redundancy					
Design		+	-	-	S
Interchangeability		+	-	-	-
Cost					
HW cost		-	-	-	-
Manufacturing cost		S	S	-	S
Engineering cost		+	-	S	-
Service cost		-	+	+	+
Maturity		-	-	S	+
	Σ-	7	7	5	3
	ΣS	1	3	4	3
	Σ+	5	3	4	7
	Pos.	3	4	2	1

from master paper Dag Jostein Klever, 2009

Evolution of Design Options



Conclusions

Evolving multiple concepts increases insight and understanding (LEAN product development: set-based design, SE: Pugh matrix)

Articulation of criteria sharpens evaluation

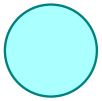
The discussion about the Pugh matrix is more valuable than final bottomline summation

Delaying decisions may help to keep options (Lean Product Development: late decision making, finance: real options)

Exercise Concept Selection

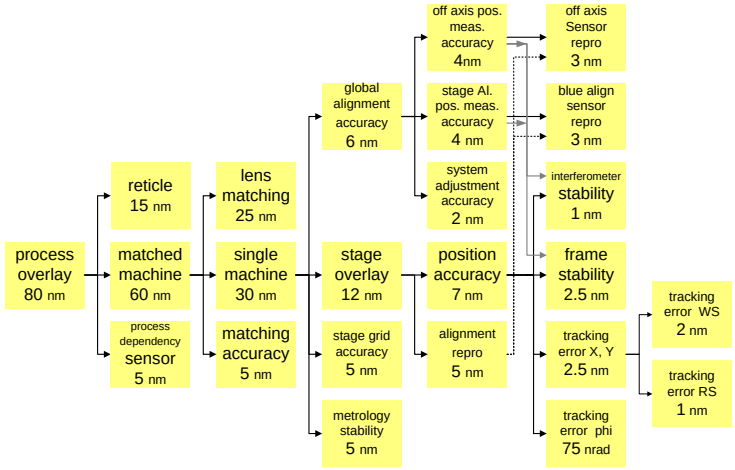
Make a **decision matrix** for one of the **concept selections**.

- define at least 3 concepts
- define 7 to 10 criteria for selection
- score the concepts against the criteria, for example using a scale from 1 to 5: 1 = very poor, 5 = very good
- recommend a concept with a rationale

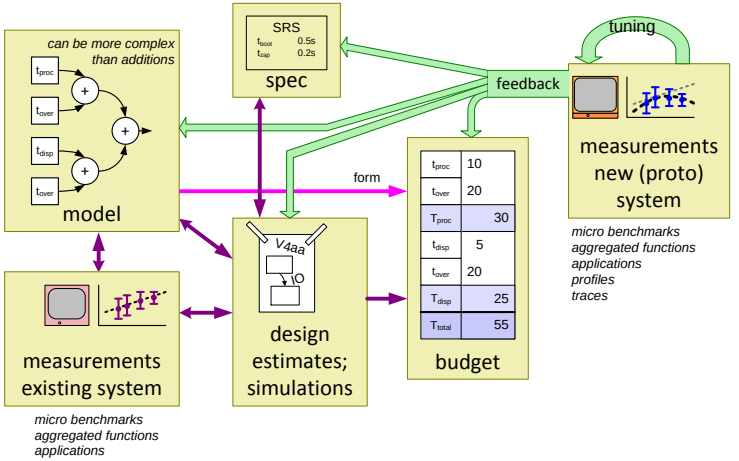
	concept 1 	concept 2 	concept 3 
criterion 1	1	3	5
criterion n	4	4	2
			best, because ...

Budgeting

Budget: Decomposition of Contributions



plus Models, Measurements, Estimates



Tens of (Measurable) Numbers

memory budget in Mbytes	code	obj data	bulk data	total
shared code	11.0			11.0
User Interface process	0.3	3.0	12.0	15.3
database server	0.3	3.2	3.0	6.5
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application SW total	13.4	12.6	35.0	61.0
UNIX Solaris 2.x				10.0
file cache				3.0
total				74.0

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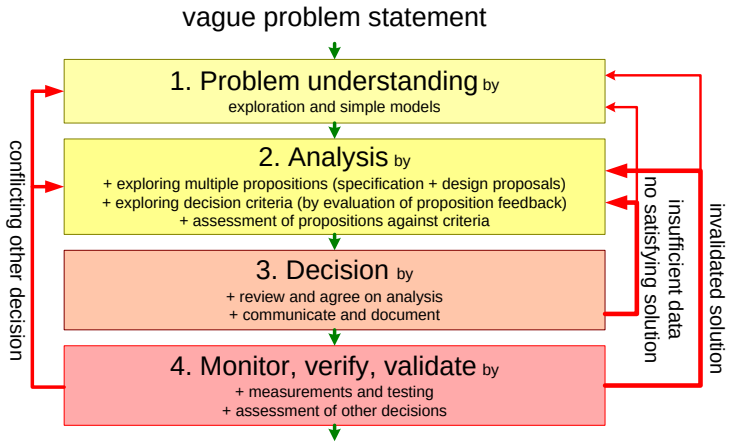
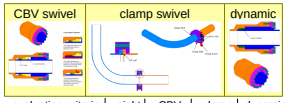
Concept Selection and Evolution

Understand Problem, Analyze, Decide, Monitor



Concept Selection: Pugh Matrix

Swivel concept selection



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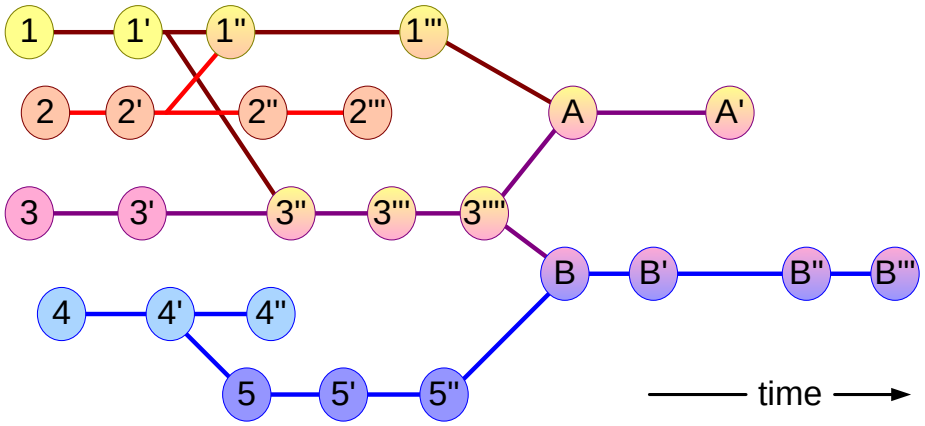
Design		-	+	+	+
Robustness					
Connector design		-	S	S	+
Number of parts		-	-	+	+
Handle roll-off		+	-	S	+
Influence other		+	S	-	S
Redundancy					
Design		+	-	-	S
Interchangeability		+	-	-	-
Cost					
HW cost		-	-	-	-
Manufacturing cost		S	S	-	S
Engineering cost		+	-	S	-
Service cost		-	+	+	+
Maturity		-	-	S	+
Σ-		7	7	5	3
Σ0		1	3	4	3
Σ+		5	3	4	7
Pos.		3	4	2	1

from master paper Dag Jostein Klever, 2009

Evolution of design Options



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