Do Useful Multi-Domain Methods Exist?

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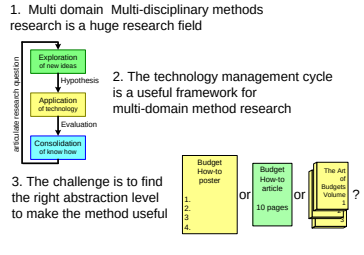
Abstract

The creation of embedded systems requires multi-disciplinary methods. The class of embedded systems is a quite heterogeneous class of systems, ranging from small high volume integrated circuits to expensive one-of-a-kind systems, such as electron microscopes or air-traffic controllers. The Embedded Systems Institute has been founded on the assumption that multi-disciplinary methods to create embedded systems can be applied in multiple doamins, despite the wide variation in embedded systems over the domains. In this article we discuss this assumption and we give a budget method as an example of a multi-disciplinary multi-domain method. Multi-disciplinary methods are used widely in the industry, but these methods are poorly consolidated and founded. We discuss the required research steps to advance from *implicit* methods to *explicit* and *founded* methods.



This work has been carried out as part of the Boderc project under the responsibility of the Embedded Systems Institute. This project is partially supported by the Netherlands Ministry of Economic Affairs under the Senter TS program. This work is also part of the Gaudí project.

June 5, 2018
status: concept
version: 0.8

Assumptions of the ESI Research Agenda

1. *Methods* that fulfil *multiple objectives* exist to *create embedded systems*

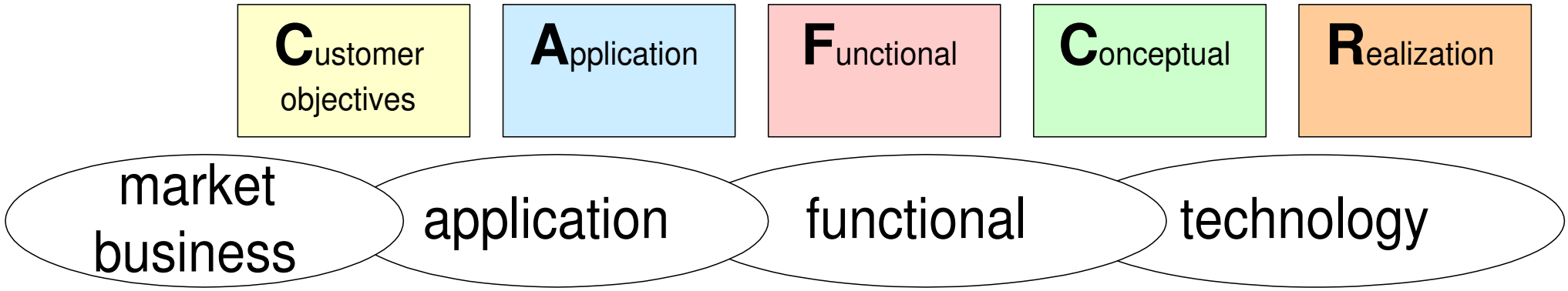
2. These methods help to *speed up* the *creation* process, *reduce* the *risks*, and *increase* the *product quality*

3. These *methods* are *generic* for multiple *market/business domains* , *application domains* and *functional domains*

4. These *methods build upon* the *software* and *electronics technologies* , and to a lesser degree these methods build upon the more *conventional technologies* , such as *mechatronics* and *physics* .

5. These *methods* need an *intelligent adaptation* to the *specific domain*

Domains Mapped on CAFCR



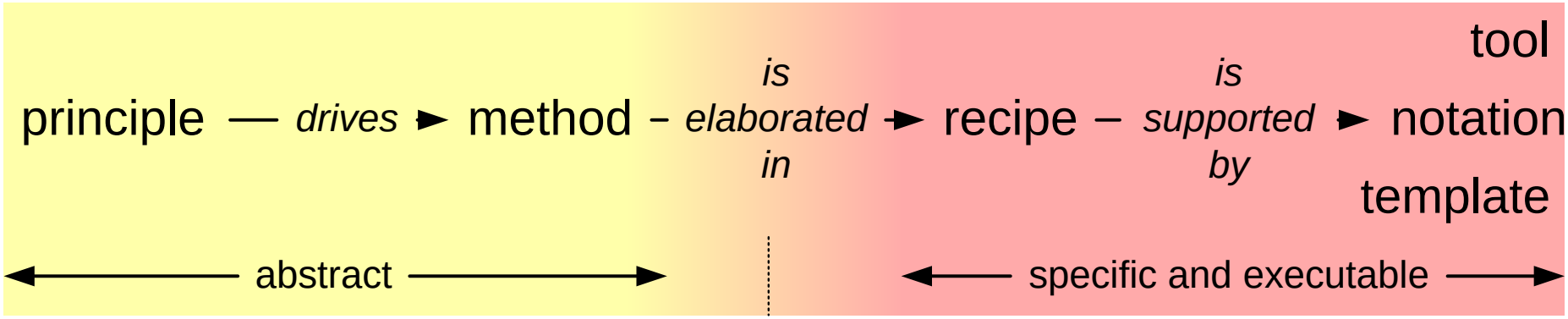
health care
consumer electronics
office
semiconductor equipment
automotive

cardio/vascular
video entertainment
professional document
lithography
car navigation

persistent storage
search/query
wireless communication
image processing
motion control
print, display
workflow

DVD+RW, FLASH
DBMS
bluetooth, WLAN, UWB
MPEG 4
PID control
LCD, plasma, OLED
scheduling
VxWorks, RT-Linux,
Embedded Windows

Method abstraction hierarchy



Attributes of a method

- a goal
- a decomposition in smaller steps
- possible orders of taking these steps
- visualization(s) or representation(s)
- guidelines

Examples of Methods Applied in Multiple Domains

methods successfully applied in multiple domains:

- key driver model;
- context modeling;
- cost of ownership modeling;
- use cases, worst cases
- graph representation for logistics purposes (commercial, goods flow, service)
- mapping functions to products and others (QFD)
- interface specification
- construction decomposition
- functional decomposition
- designing with multiple decompositions
- execution architecture
- performance modeling
- micro benchmarking
- **budget-based design**
- safety, reliability and security analysis, for example FMEA
- work break down structure
- integration plan
- quality checklist
- story telling

domains where these models have been applied:

wafersteppers
health care
electronics infrastructure projects
document handling
consumer electronics
semiconductors

the budget-based design method will be discussed as applied in wafersteppers, health care, and document handling

this list of methods based on:
CAFCR: A Multi-view Method for Embedded Systems Architecting; Balancing Genericity and Specificity
(Muller 2004)

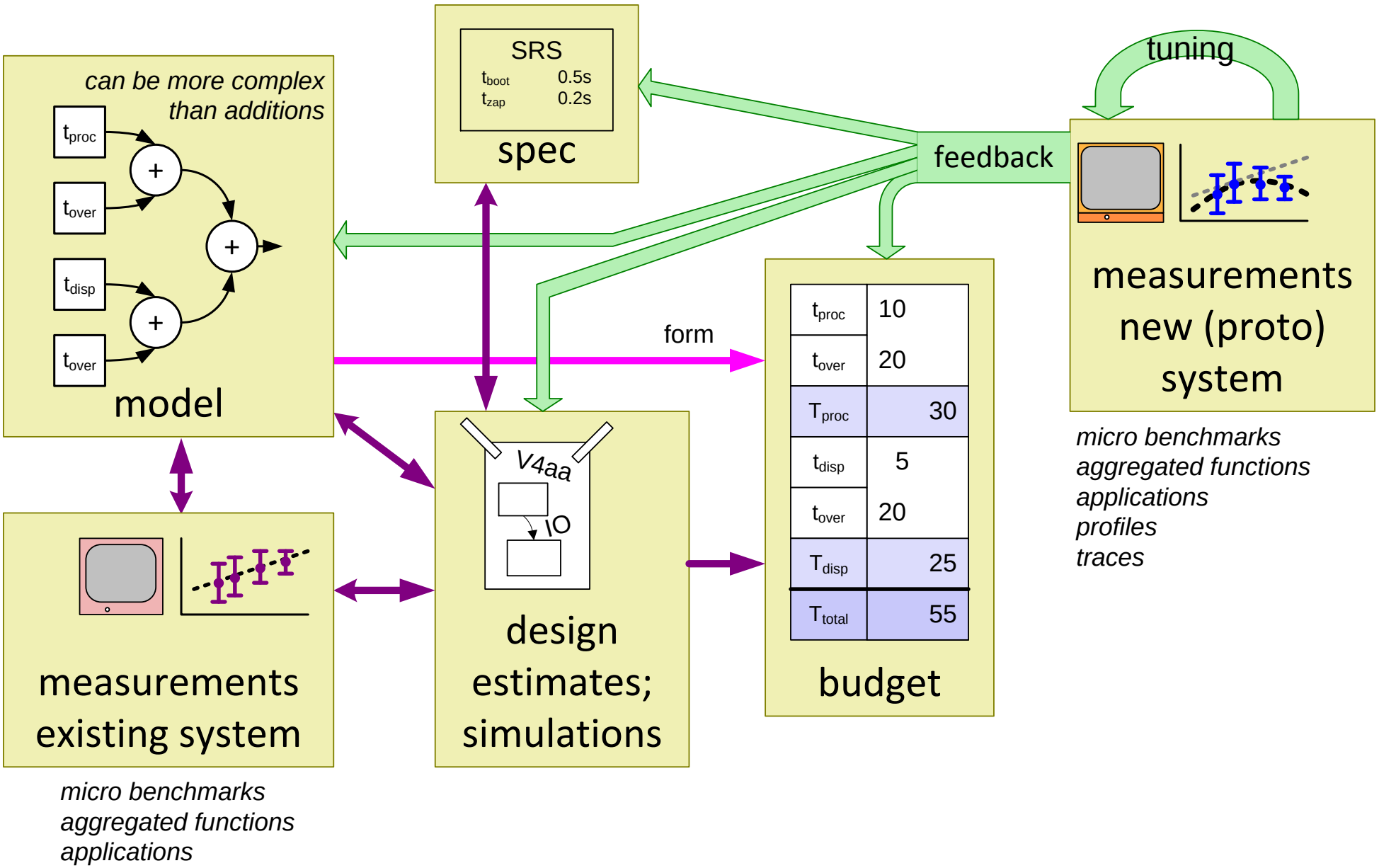
So, What are the Problems?

- generic nature of methods
  need for customization
  need for highly skilled designers
- lack of description
  concepts
  how tos
- lack of education in this type of methods
  where to learn (graduate, postgraduate, postdoc)?
  which discipline?
- lack of research (exploration and consolidation)
  when to apply?
  what are the limits?
  what are alternative methods?
  what are the options for (partial) solutions?
- lack of relation with mono-disciplinary methods
  how to use the results, f.i. how to transform a construction decomposition into a class decomposition?
- lack of tools?

Goals of Budget Based Design

- 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

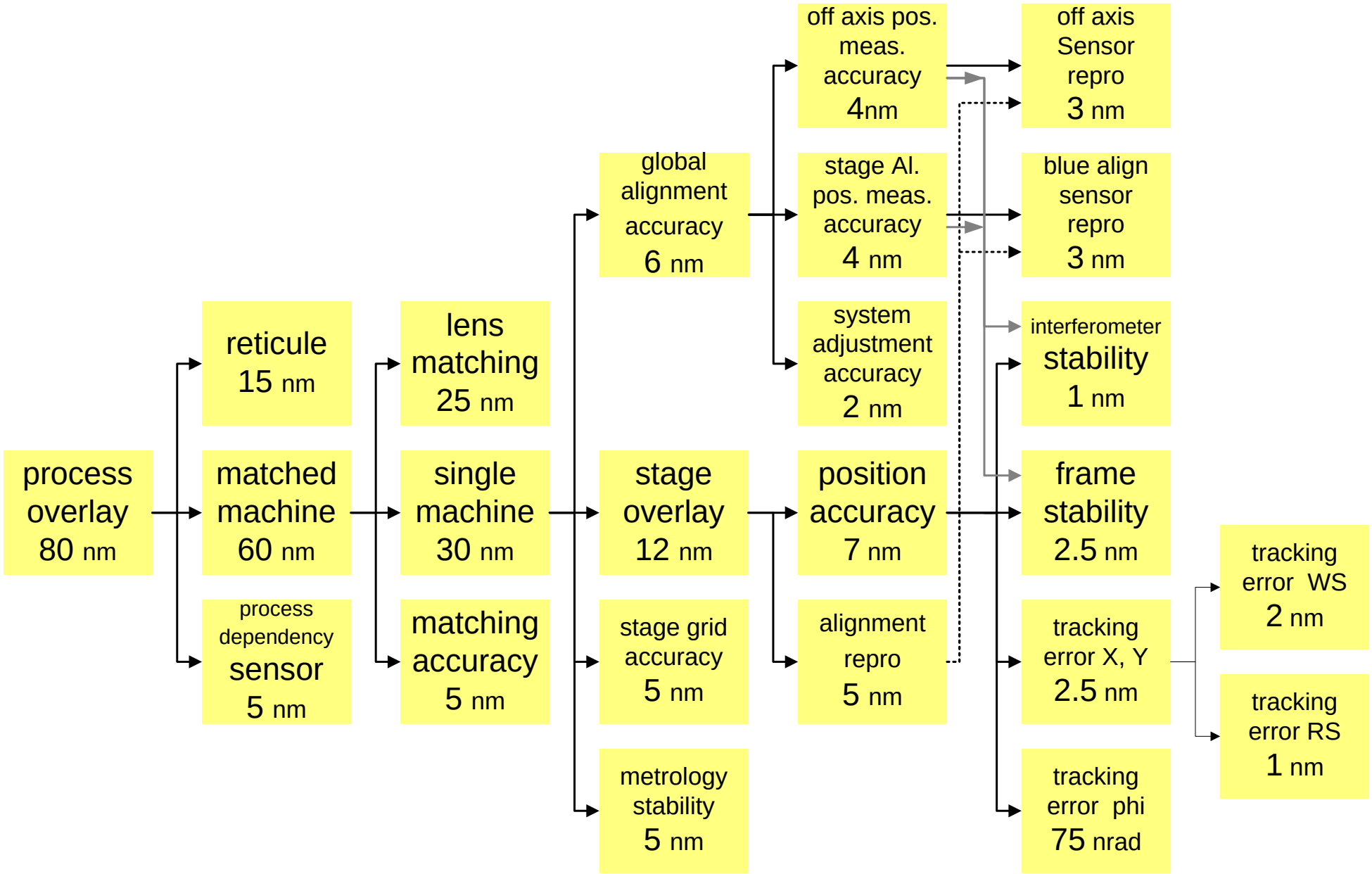
Visualization of Budget Based Design Flow



Example: 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	

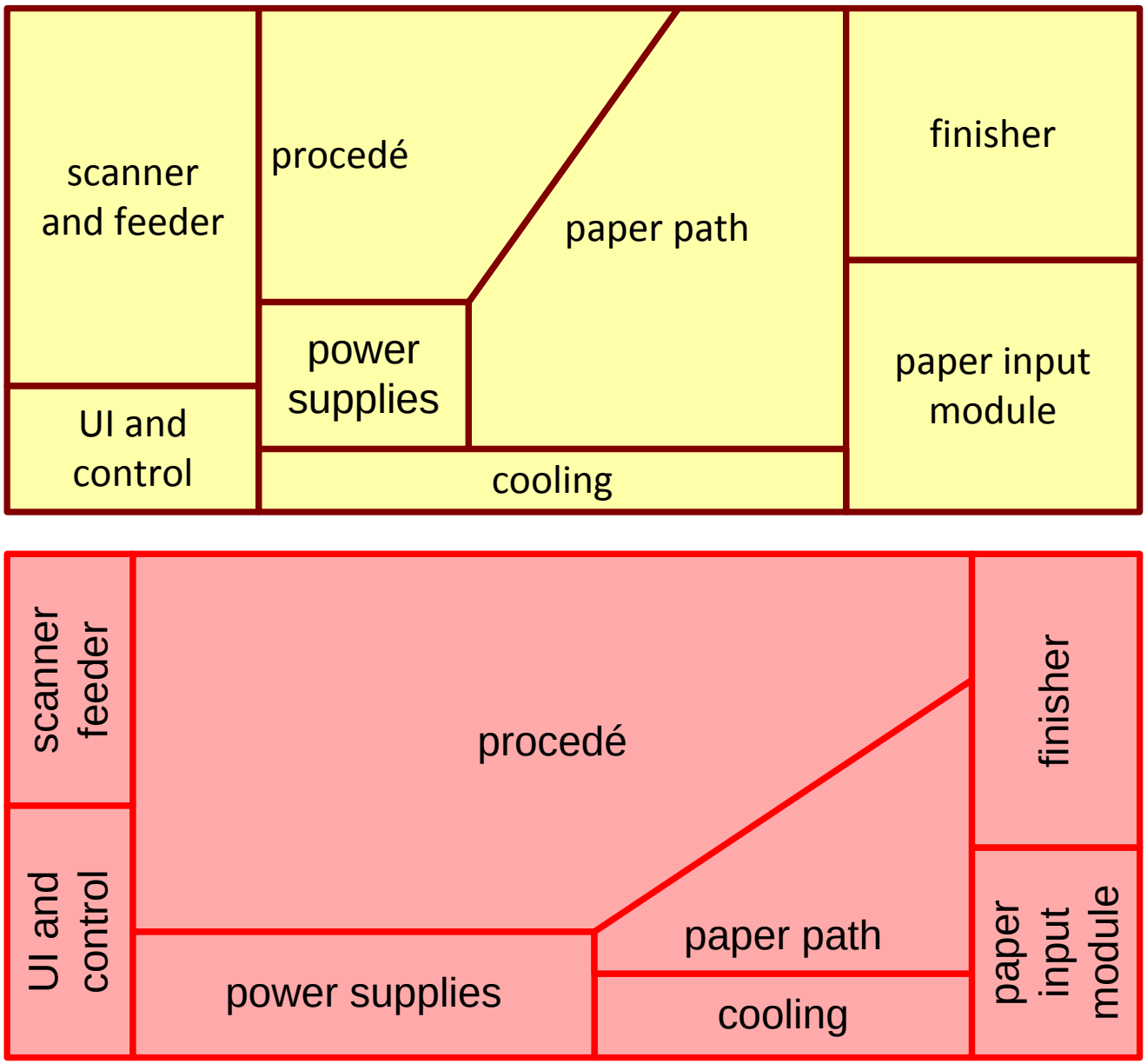
Budgets Applied on Waferstepper Overlay



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

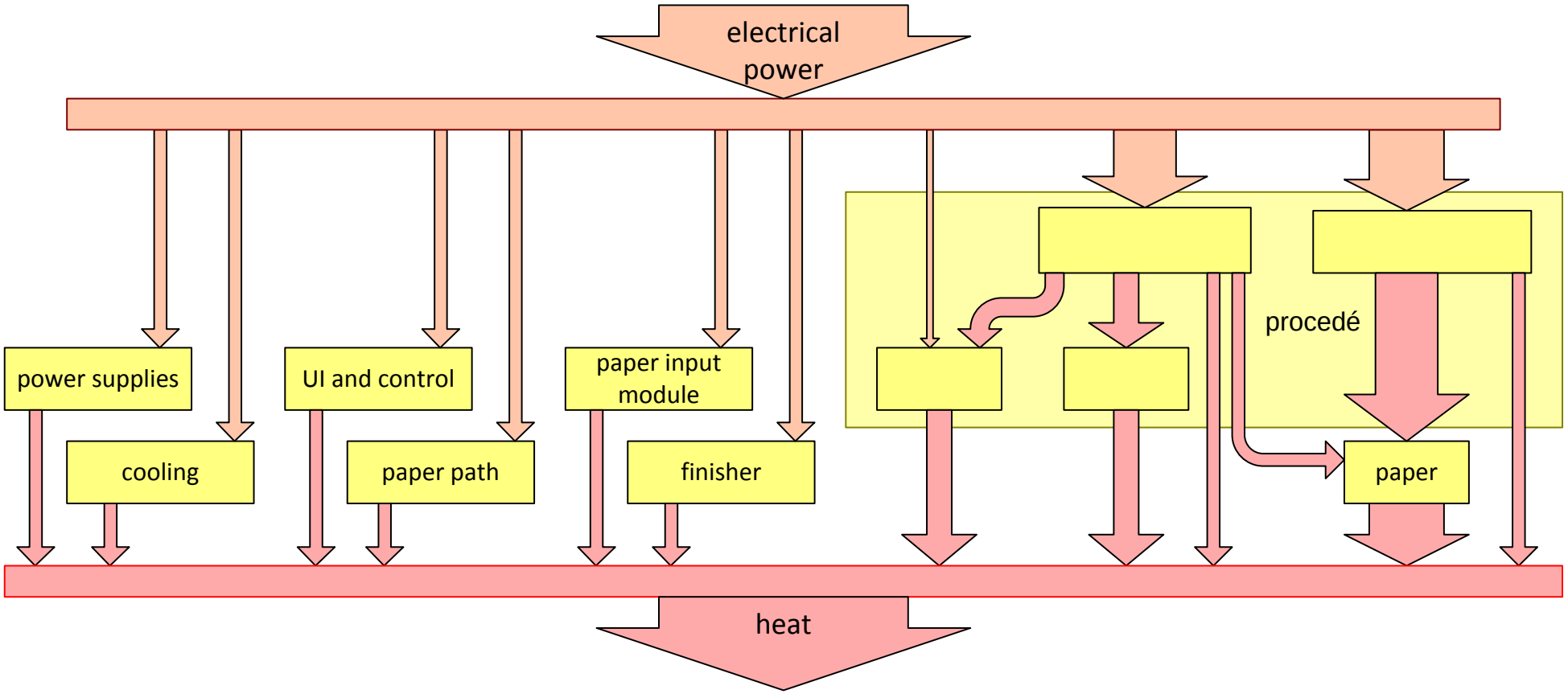


legend

physical layout

size proportional to power

Alternative Power Visualization



Research questions

- What are potential applications for budgets?
- What kind of budget is required?
- What is the decomposition to be used?
- How to manage margins?
- How to verify a budget?
- How to use and maintain a budget?
- Does it provide value when a budget is coupled to other design information?
- and many more...

Potential Applications of Budget based design

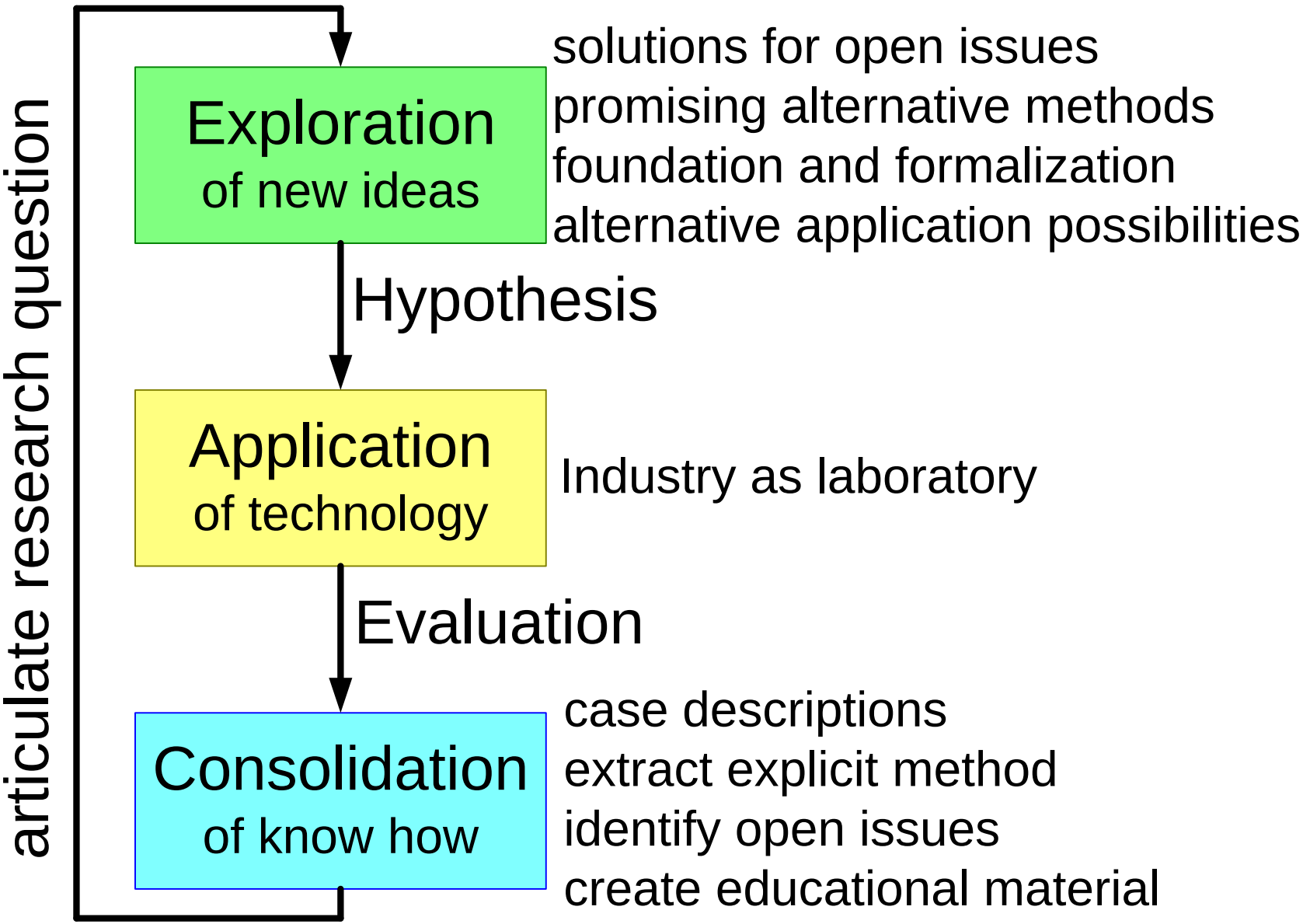
- resource use (CPU, memory, disk, bus, network)
- timing (response, latency, start up, shutdown)
- productivity (throughput, reliability)
- Image Quality parameters (contrast, SNR, deformation, overlay, DOF)
- cost, space, time

What kind of budget is required?

static	dynamic
typical case	worst case
global	detailed
approximate	accurate

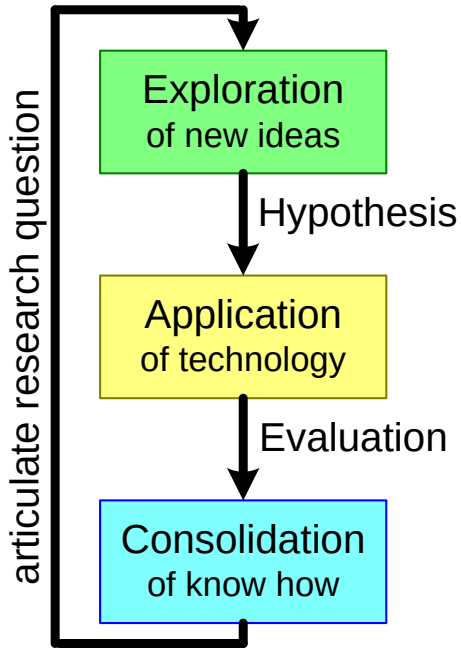
is the budget based on
wish, empirical data, extrapolation,
educated guess, or expectation?

Start Research by Consolidation of Implicit Methods



Conclusions

1. Multi domain Multi-disciplinary methods research is a huge research field



2. The technology management cycle is a useful framework for multi-domain method research

3. The challenge is to find the right abstraction level to make the method useful