

# Do Useful Multi-Domain Methods Exist?

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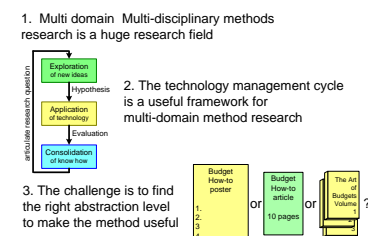
## Abstract

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 domains, 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.

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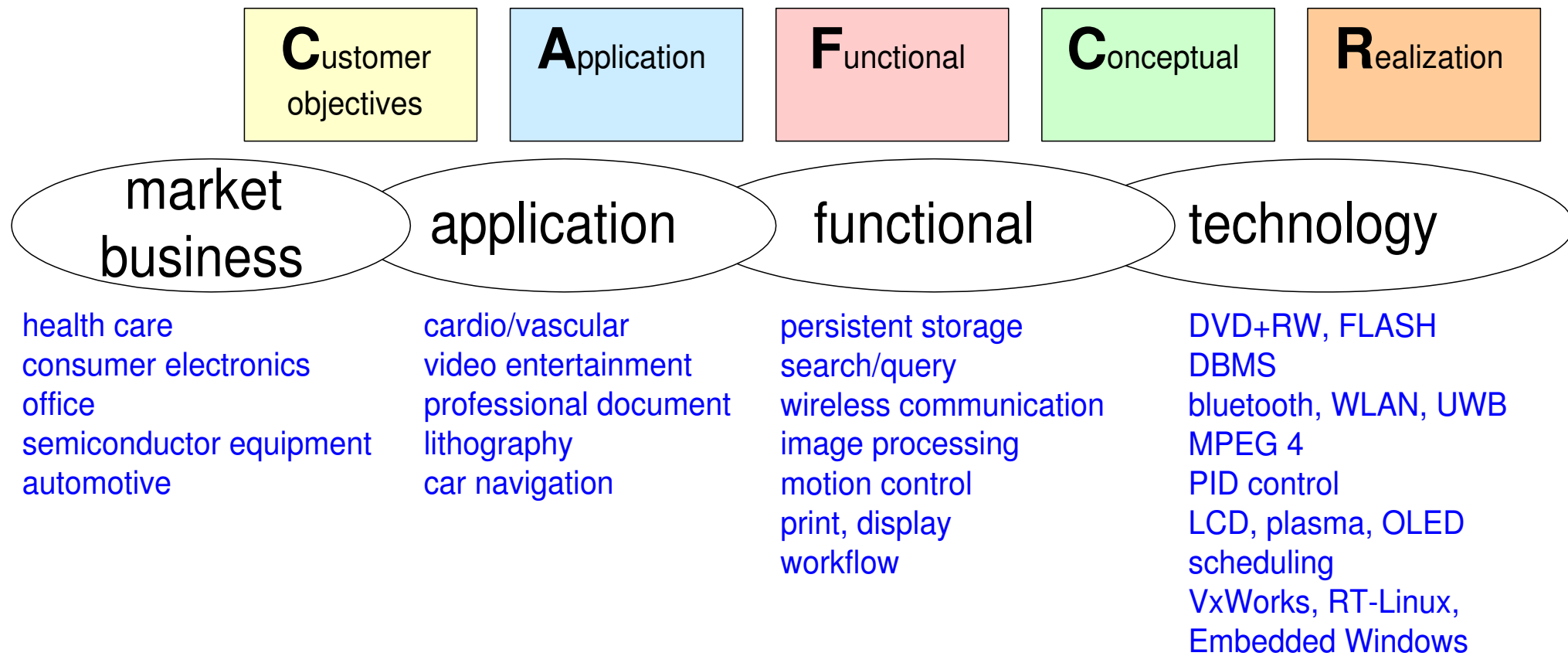


# Assumptions of the ESI Research Agenda

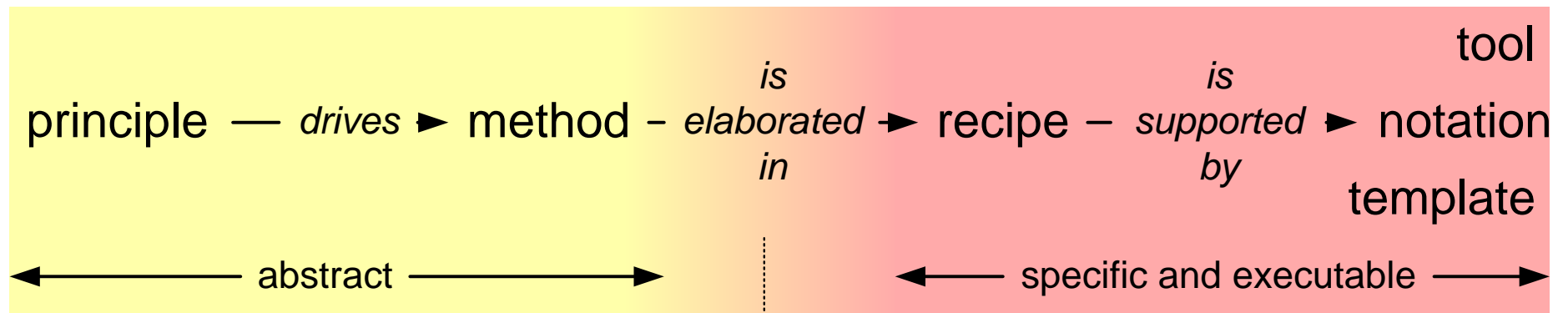
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1. *Methods* that fulfil *multiple objectives* exist to *create embedded systems*
2. These methods help to *speed up* the *creation* process, *reduce* the *risks*, and *increase* the *product quality*
3. These *methods* are *generic* for multiple *market/business 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



# Method abstraction hierarchy



# Attributes of a method

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- 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?

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- 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?

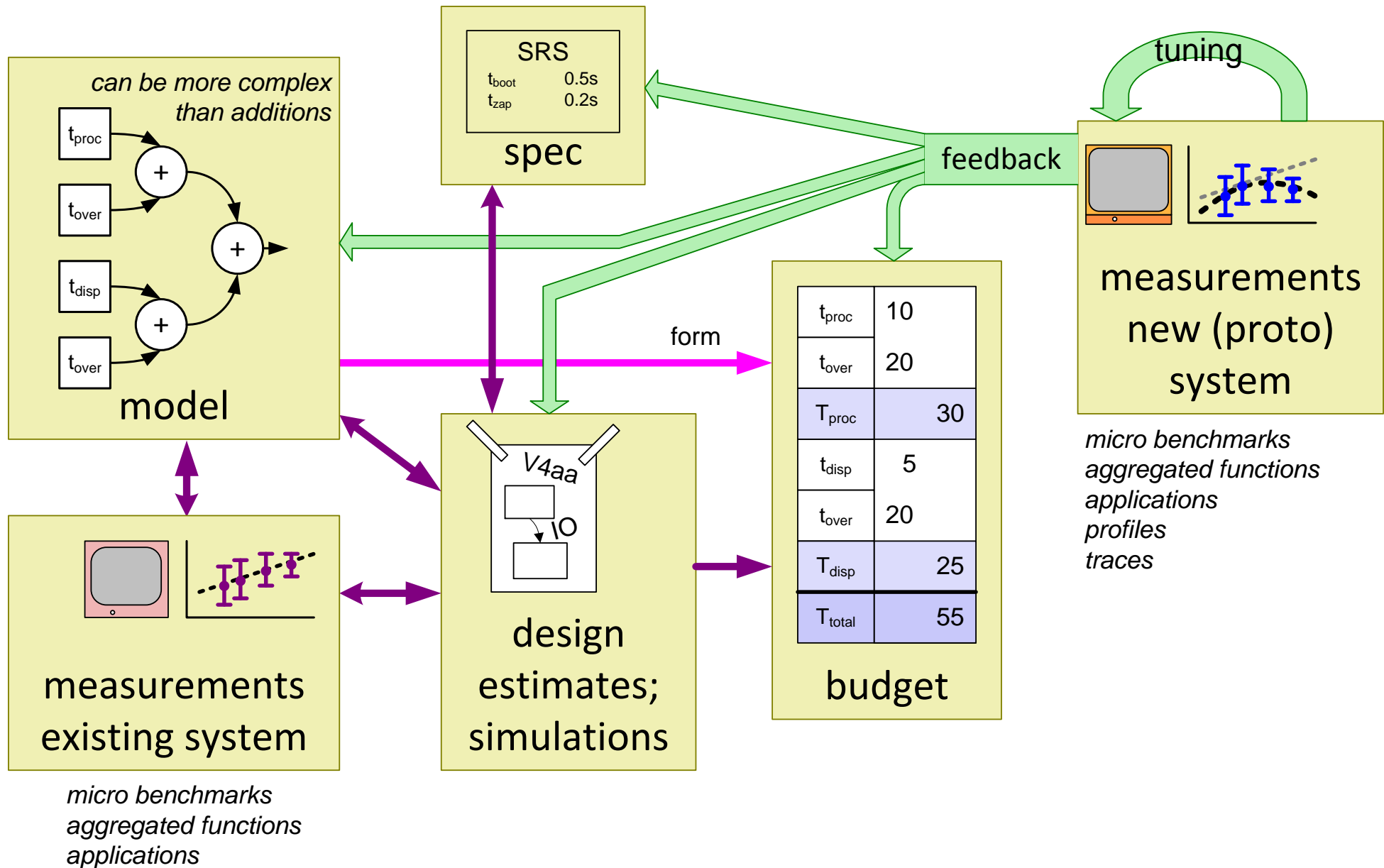
# Goals of Budget Based Design

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- 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



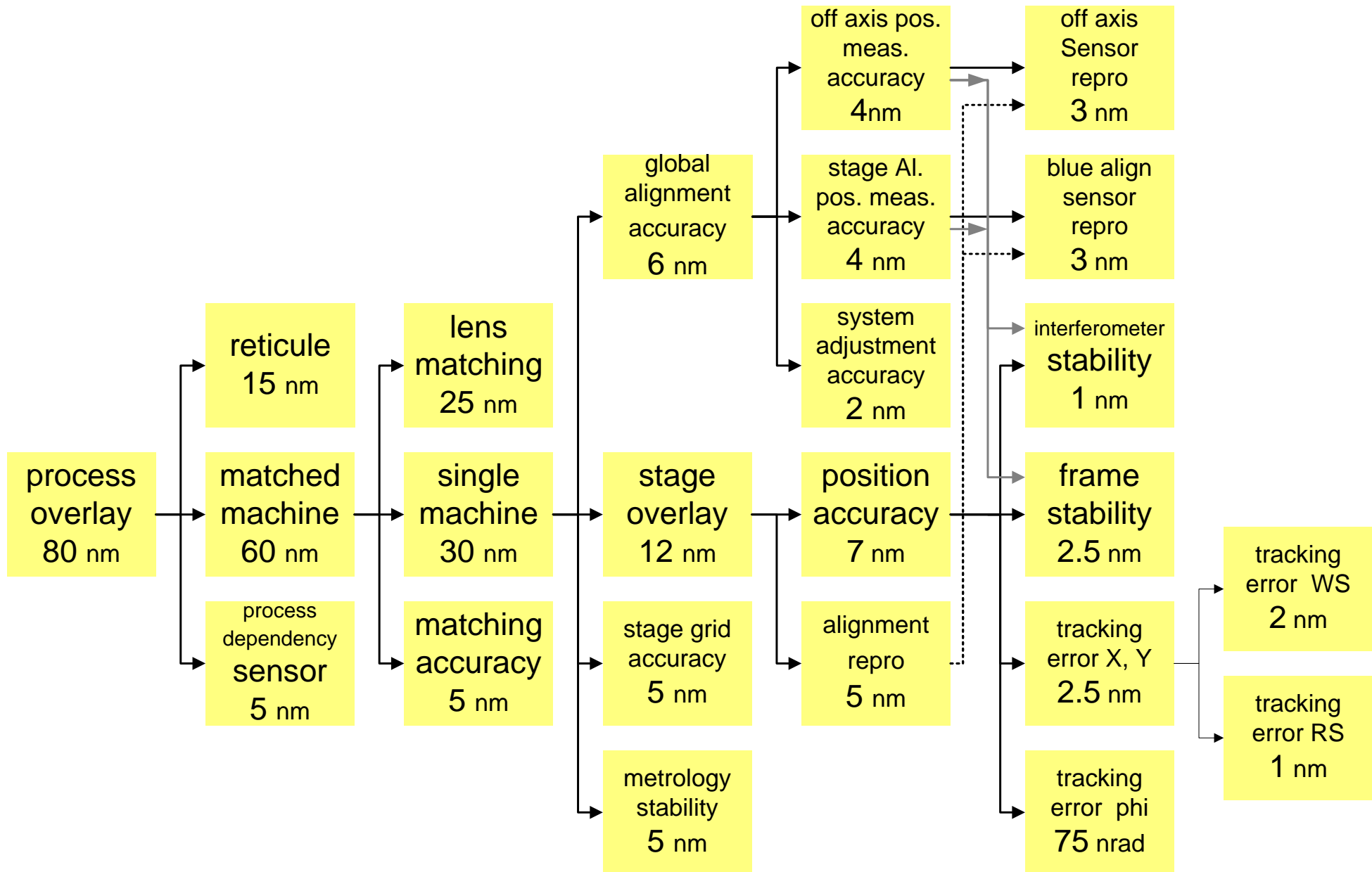
# Visualization of Budget Based Design Flow



# 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	

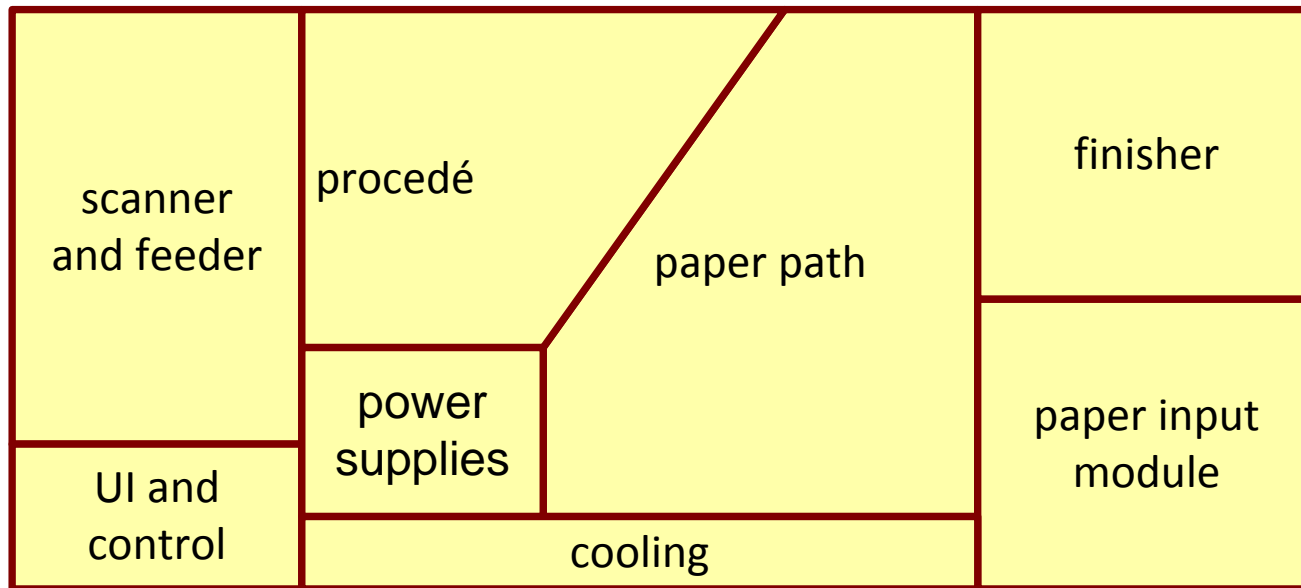
# Budgets Applied on Waferstepper Overlay



# Budgets Applied on Medical Workstation Memory Use

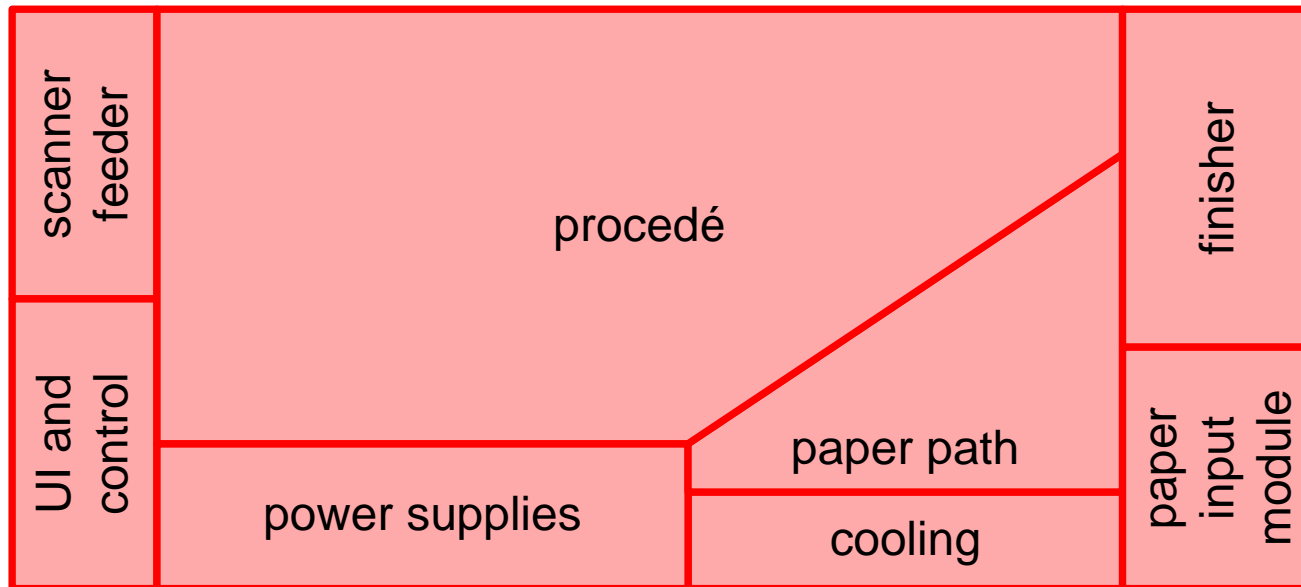
<i>memory budget in Mbytes</i>	code	obj data	bulk data	total
shared code	11.0			11.0
User Interface process	0.3	3.0	12.0	15.3
database server	0.3	3.2	3.0	6.5
print server	0.3	1.2	9.0	10.5
optical storage server	0.3	2.0	1.0	3.3
communication server	0.3	2.0	4.0	6.3
UNIX commands	0.3	0.2	0	0.5
compute server	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



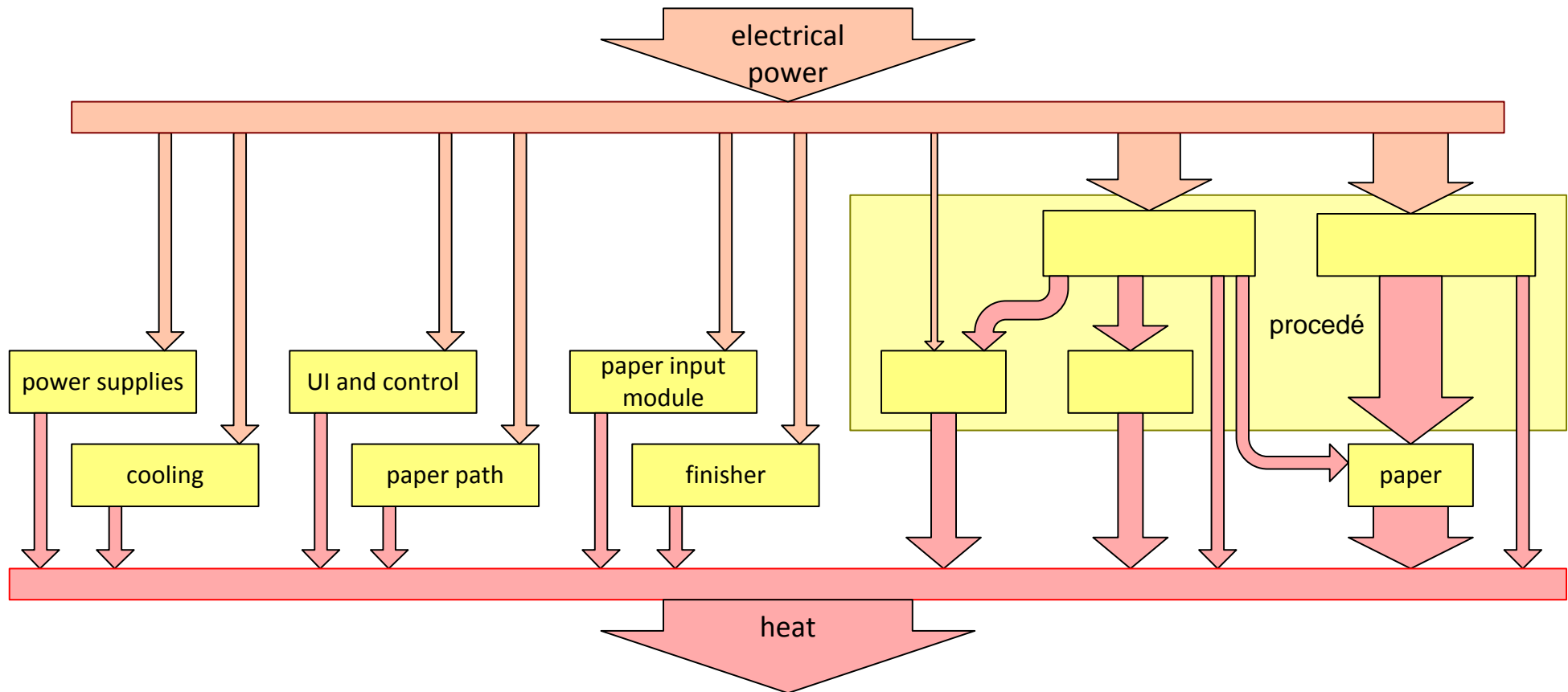
legend

physical layout



size proportional to power

# Alternative Power Visualization



# Research questions

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- 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

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- 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

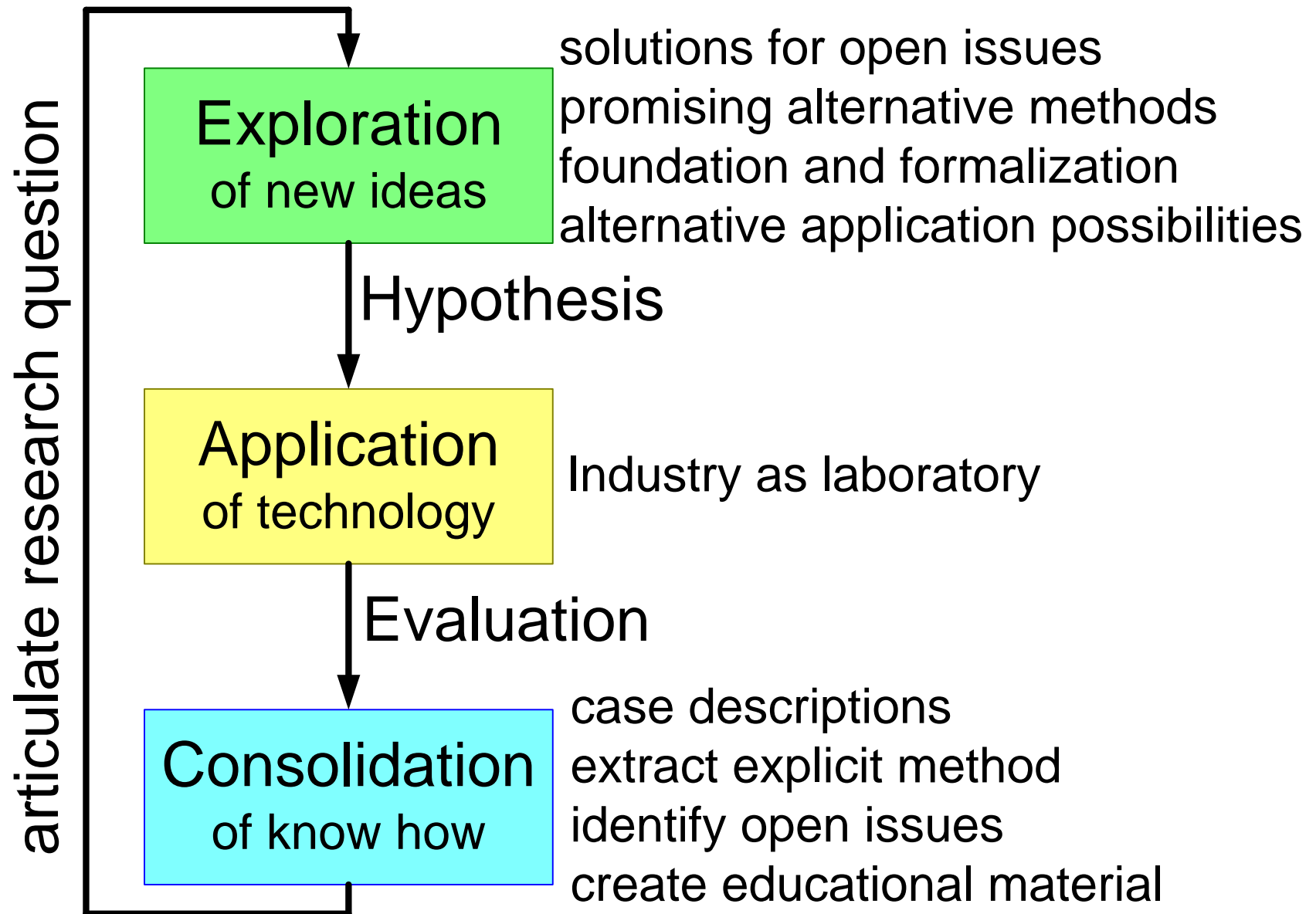
detailed

approximate

accurate

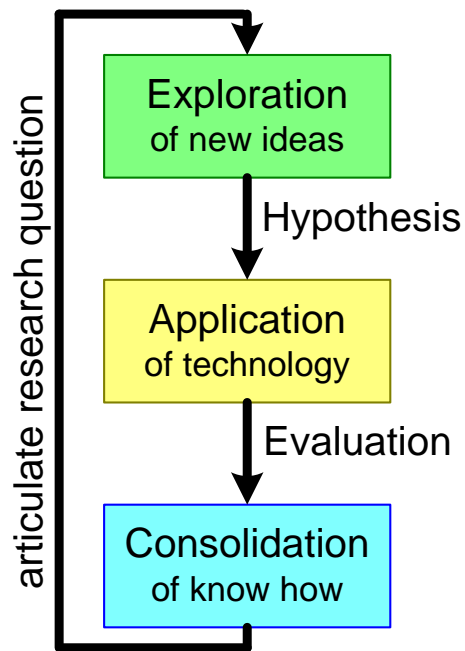
is the budget based on  
wish, empirical data, extrapolation,  
educated guess, or expectation?

# 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

