

# Model Based Open Innovation for Systems Engineering

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**RESEARCH  
PERSPECTIVES  
ON CREATIVE  
INTERSECTIONS**



# Title: Model Based Open Innovation for Systems Engineering

- Overall topics of interest
- Clarifying current understanding / Current state of the world
- A more ideal state
- Main questions and hypotheses
- Selecting type of research
- Determining areas of relevance and contribution
- Research plan (bad plan is better than no plan)

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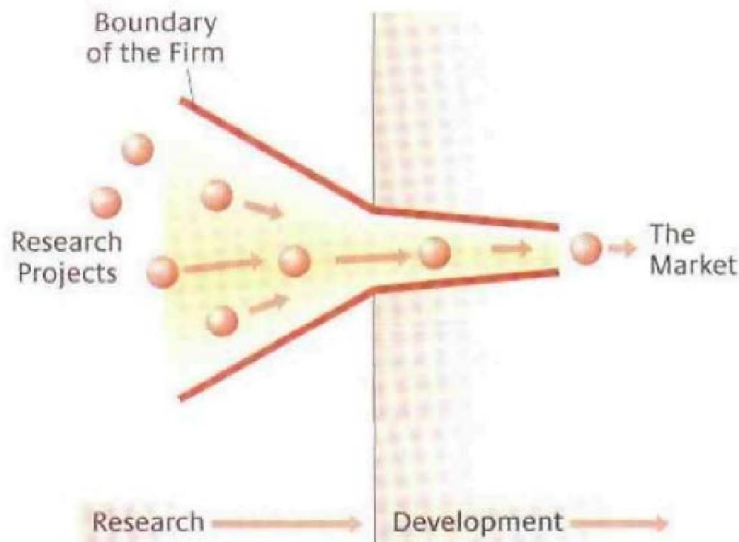
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  - Know this is important for economic growth (kind of the point of Engineering...)
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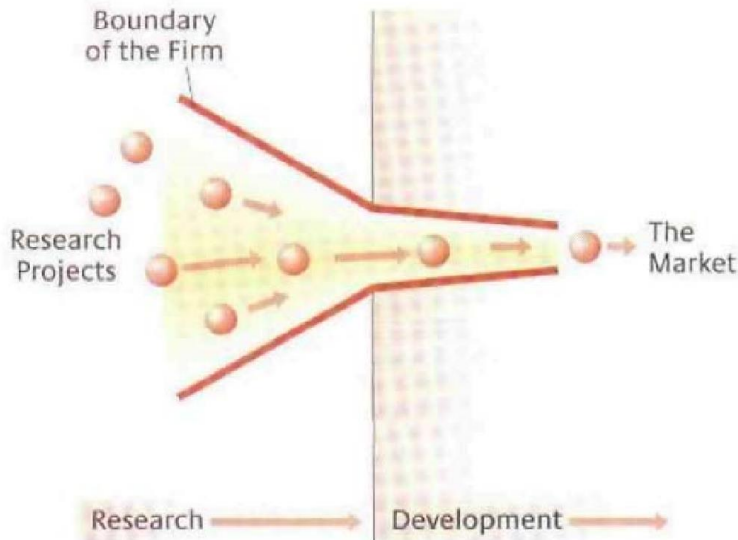
Closed innovation



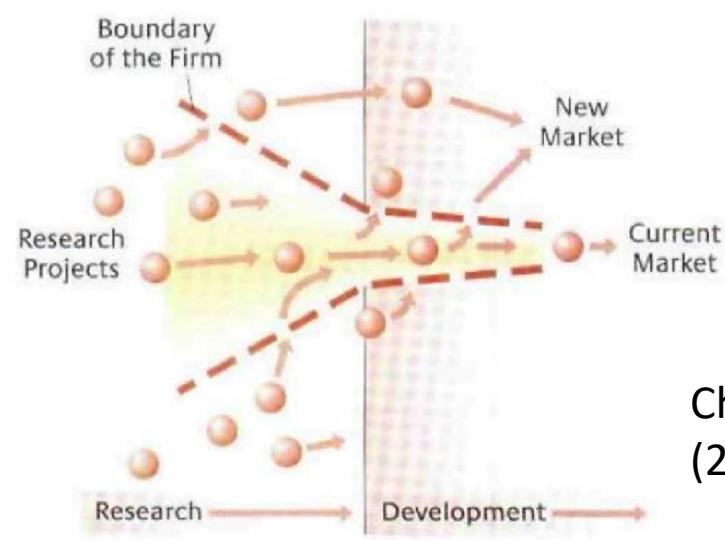
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Open innovation



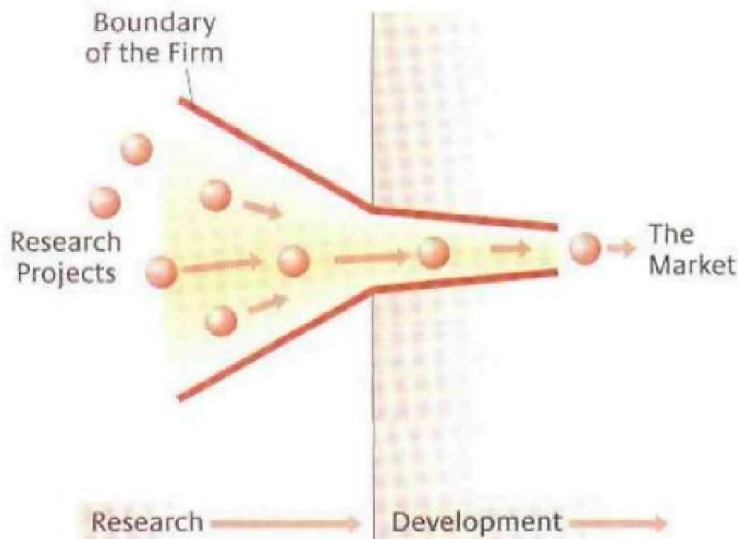
Chesbrough  
(2003)

Basic assumptions: There is stuff outside your company that you should use. There is stuff inside your company that others want to use. If contracts are adequately .

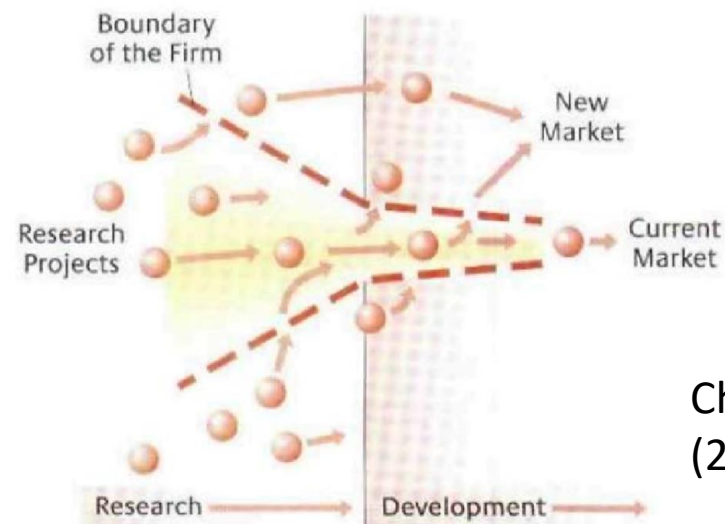
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- Allows us to form new designs by making use of existing part libraries. Just compose.
- Enabled by modularity

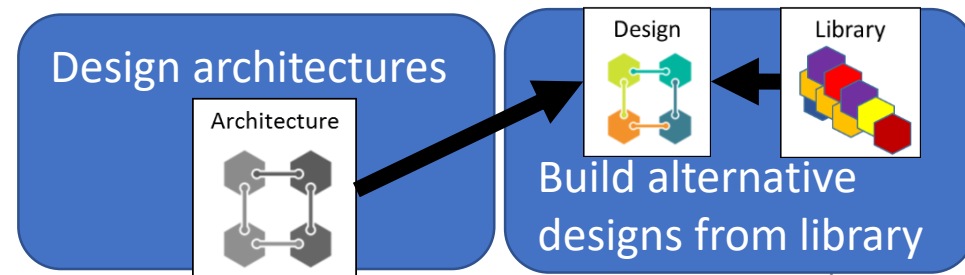
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- **Model Based X**

$X = \{\text{Systems Engineering, Design, Manufacturing, ...}\}$

- Lower cost than physical prototypes
- Opens up computers to do stuff:
  - Simulation
  - V&V
  - Complexity management
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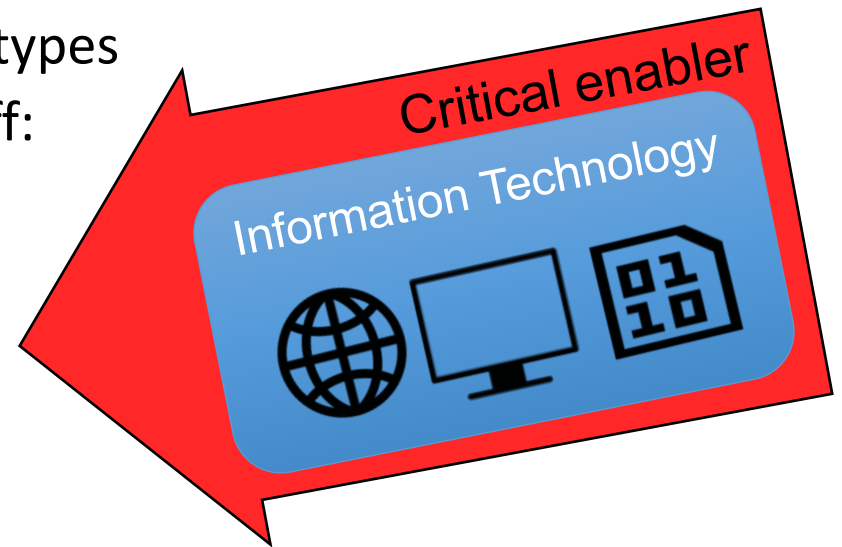
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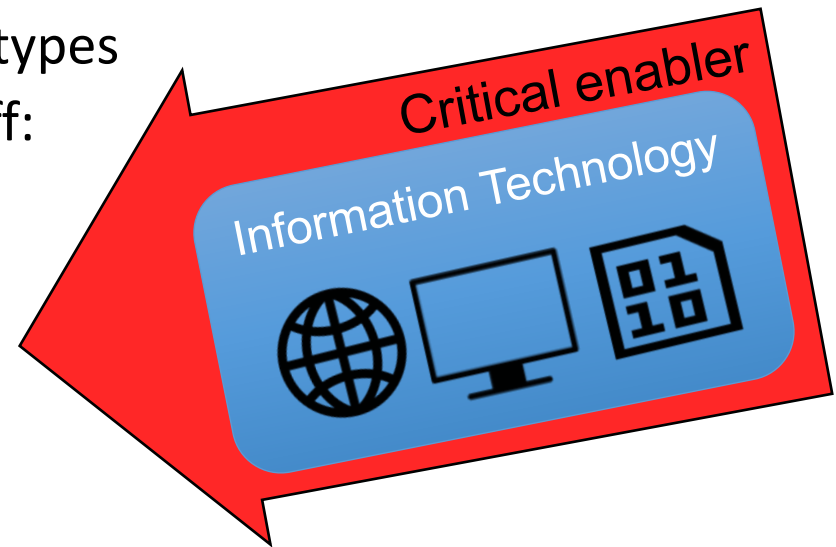


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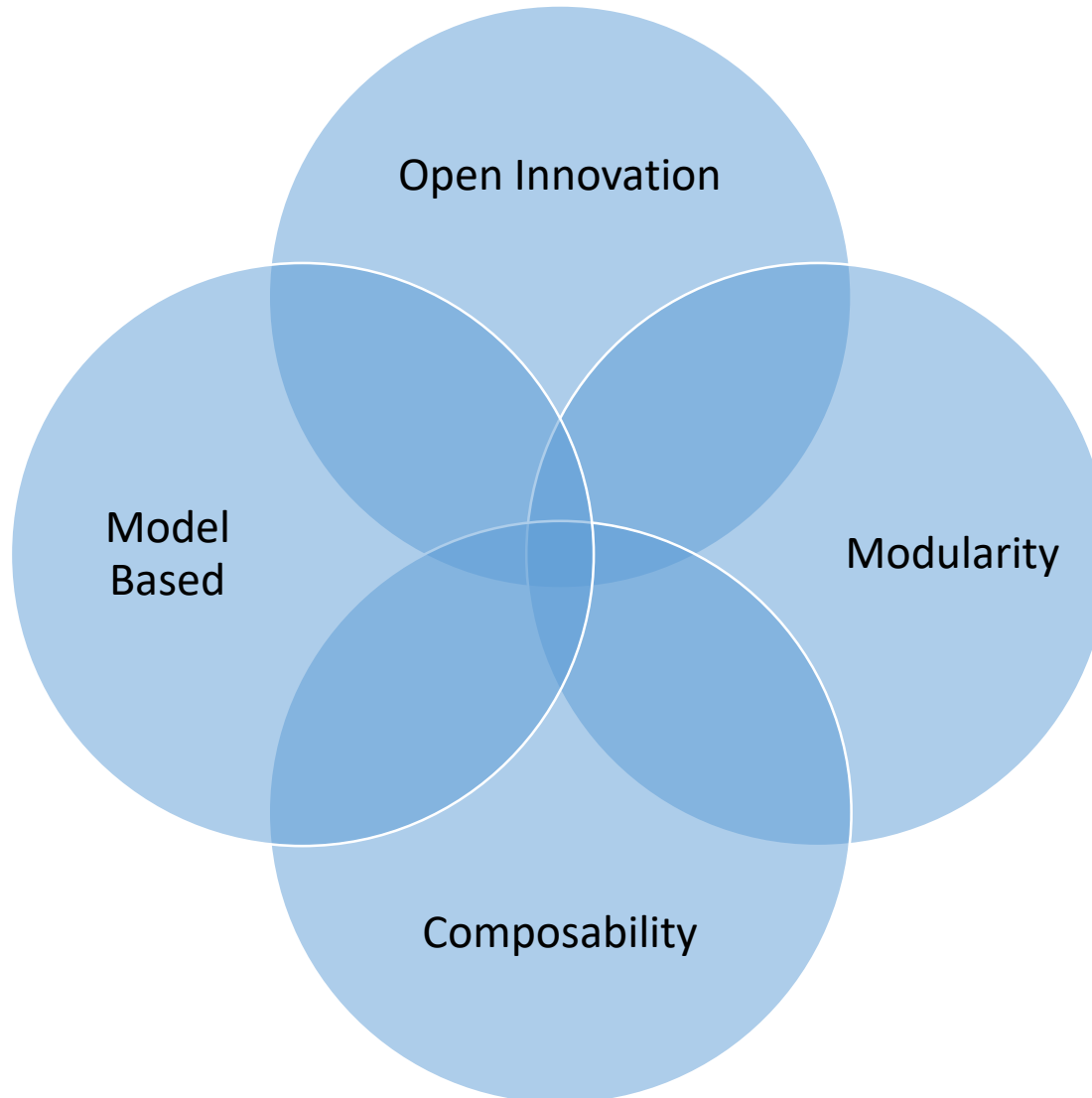
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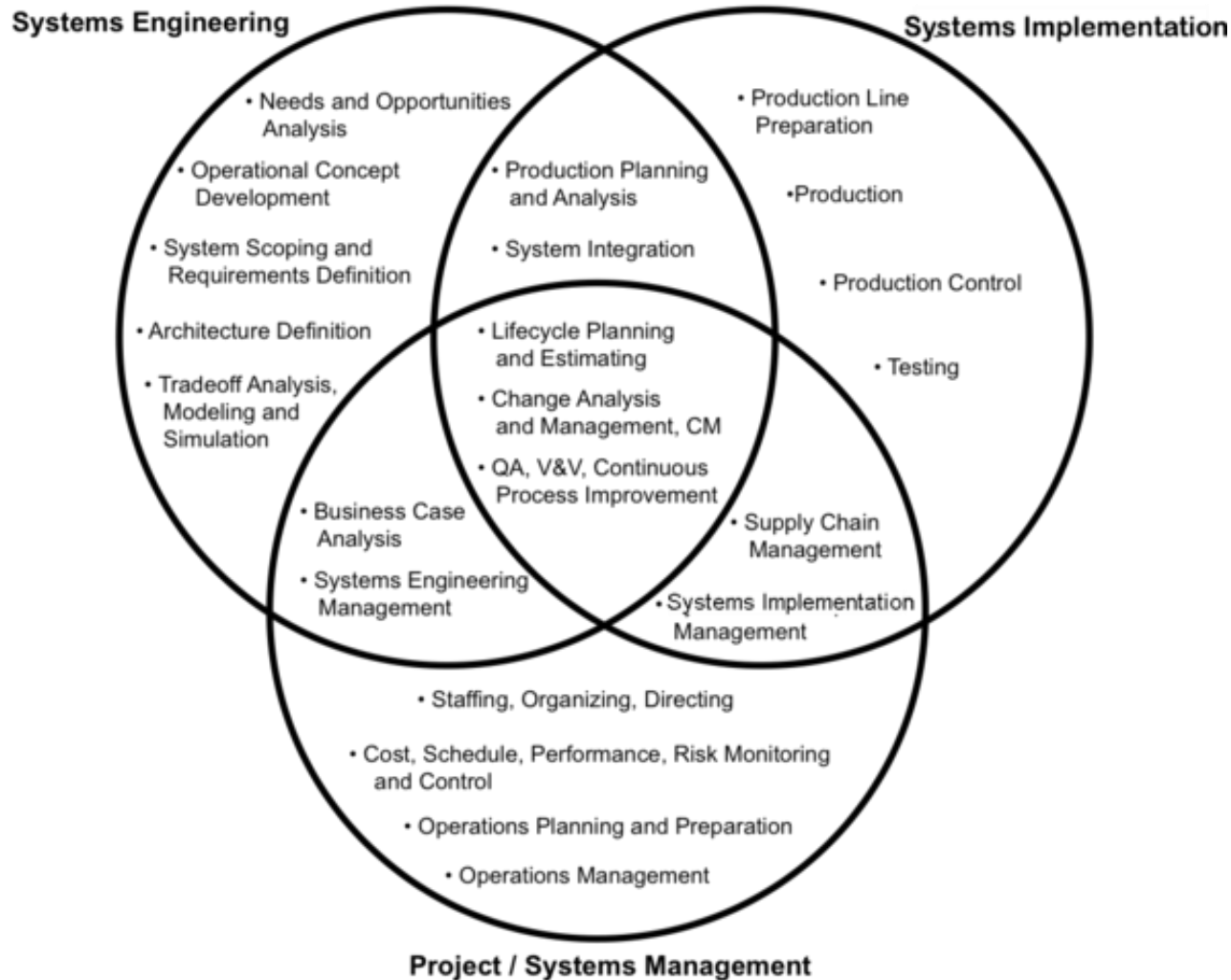
- Biggest driver in the changes in how we work (including in design)



# Overall topics of interest...



# But there are a lot of topics in Systems Engineering...



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# Clarifying current understanding / Current state of the world

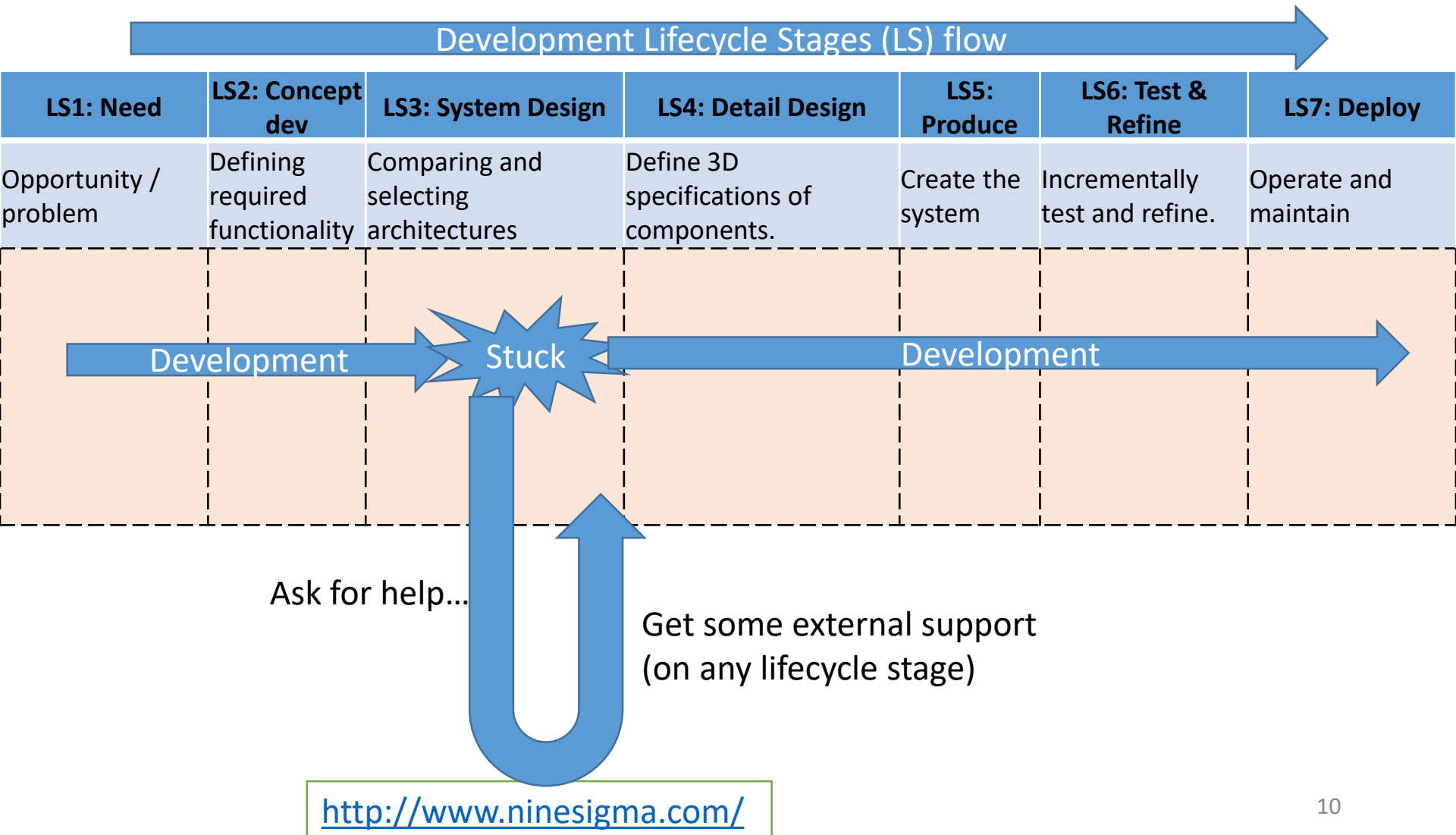
Development Lifecycle Stages (LS) flow

LS1: Need	LS2: Concept dev	LS3: System Design	LS4: Detail Design	LS5: Produce	LS6: Test & Refine	LS7: Deploy
Opportunity / problem	Defining required functionality	Comparing and selecting architectures	Define 3D specifications of components.	Create the system	Incrementally test and refine.	Operate and maintain

I will assume that this line in the boundary of the firm leading this lifecycle stage

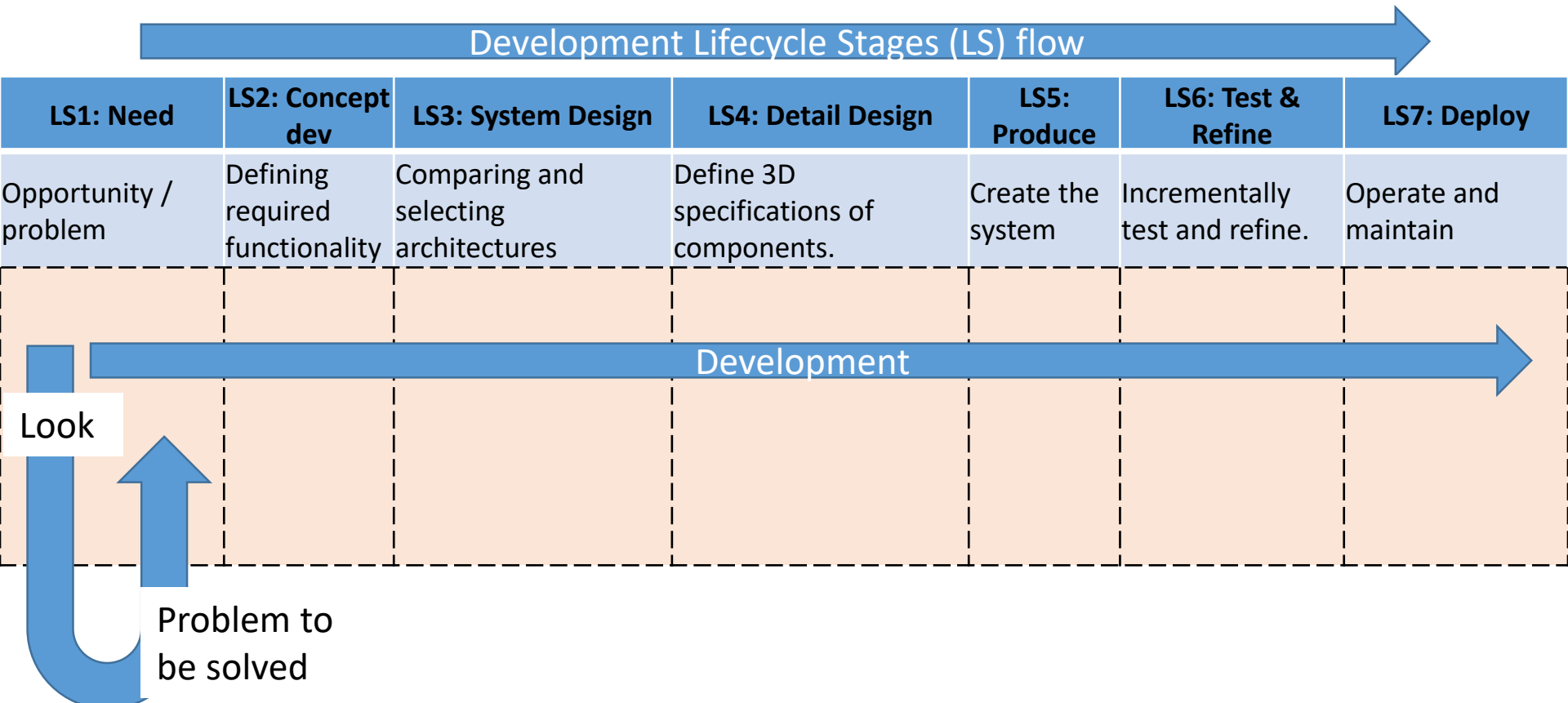
# Simple Open Innovation Approaches:

Call some consultants: e.g. <http://www.ninesigma.com/>



# Simple Open Innovation Approaches:

## Crowd sourced problem solving: e.g. X Prize



<https://www.innocentive.com/>

X Prize

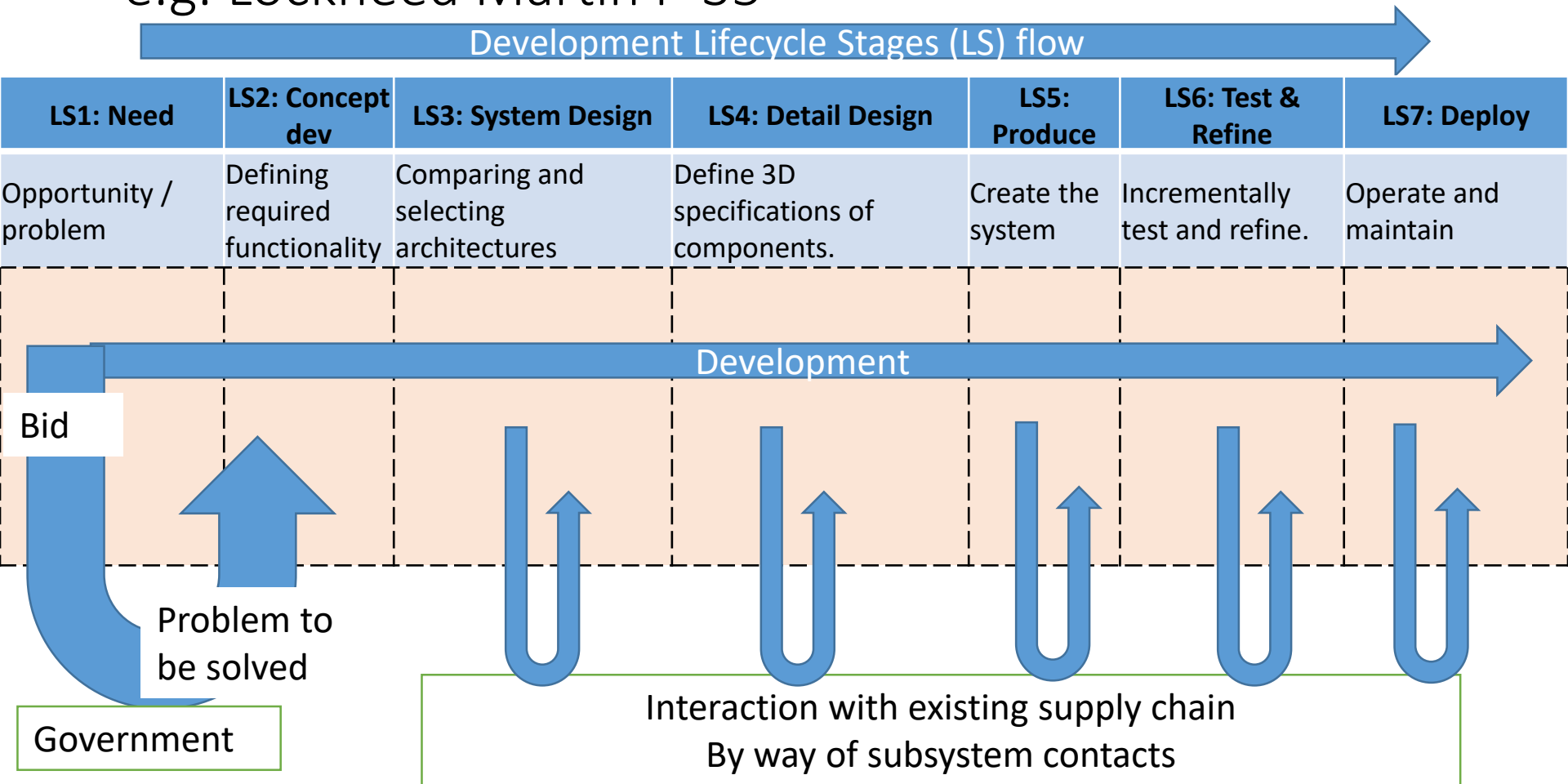
<https://herox.com/>

<https://tepcocuusoo.com/#about>

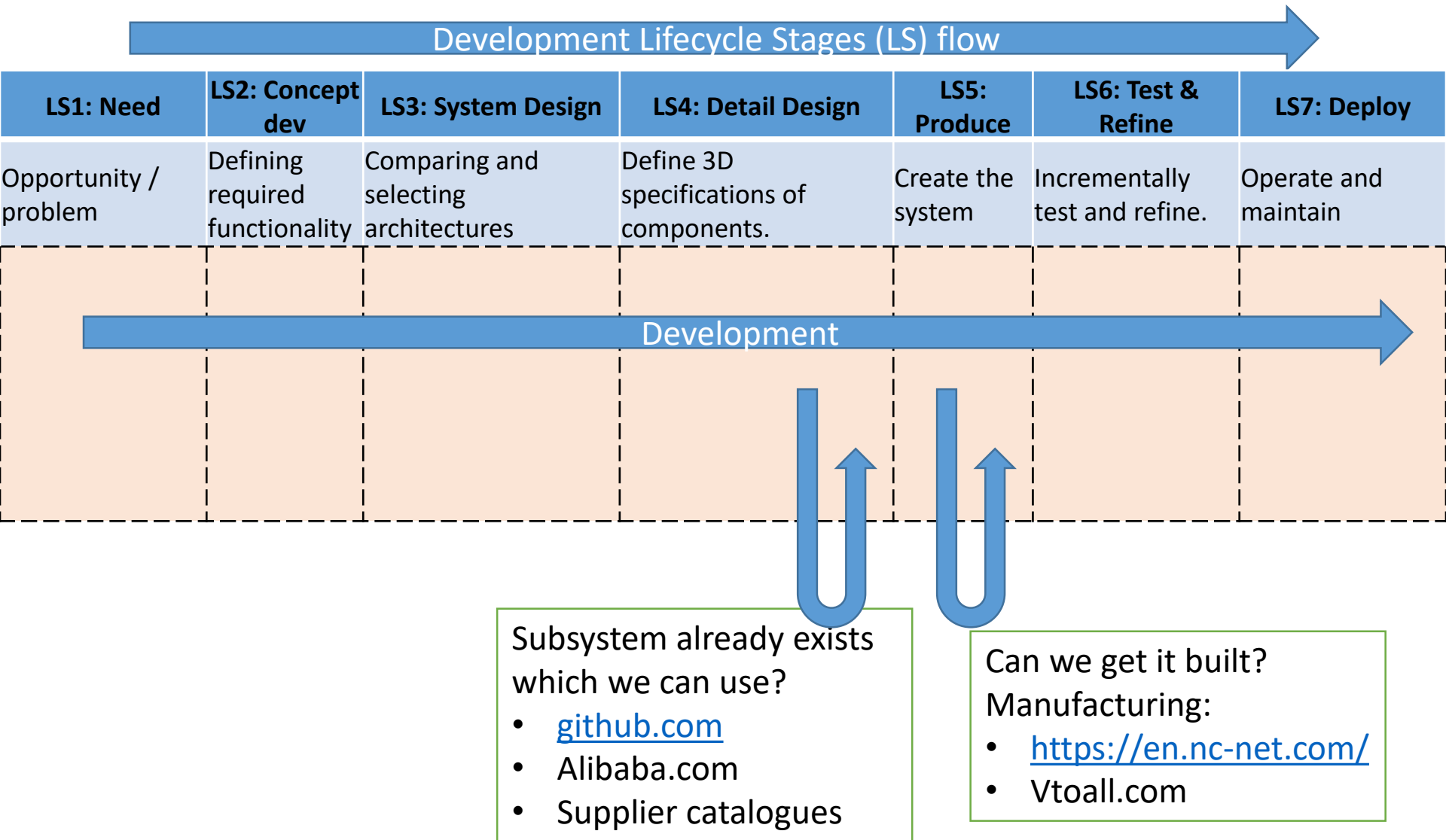
# Simple Open Innovation Approaches:

Big Systems Engineering Project:

e.g. Lockheed Martin F-35



# Simple Open Innovation Approaches for: Design focused companies who outsource manufacturing



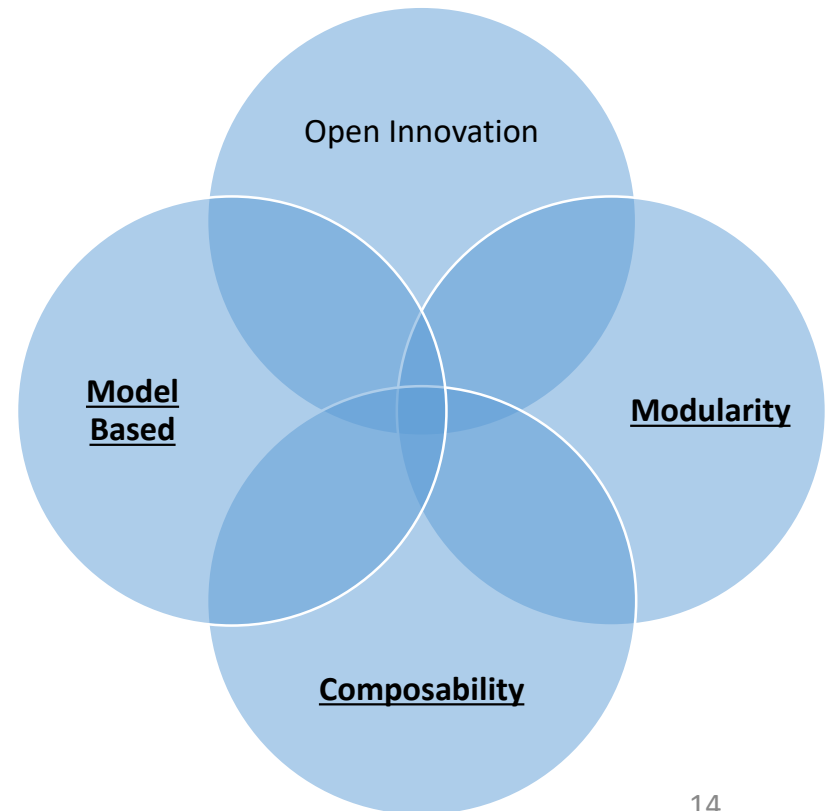


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communications

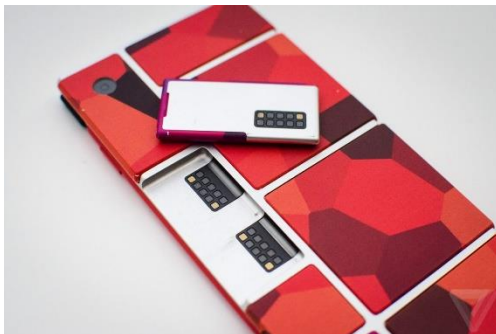
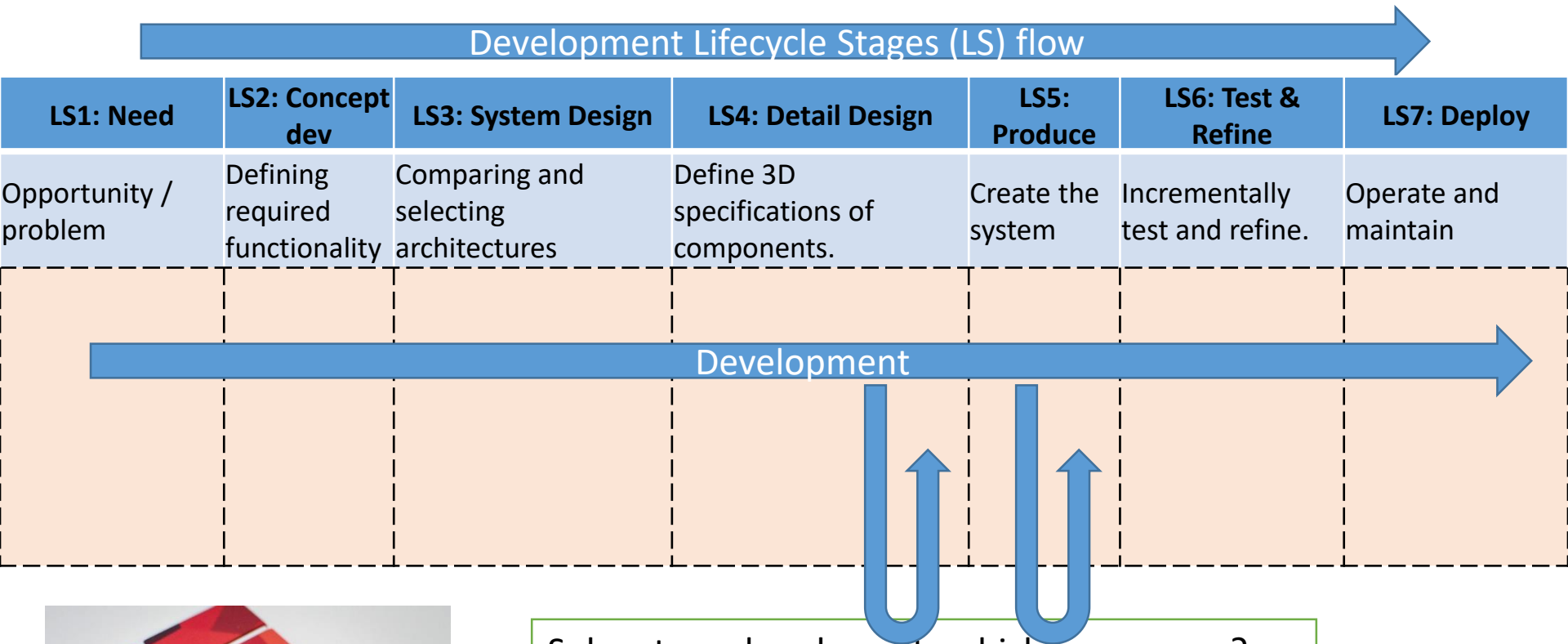
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# Open Innovation: Driven by modular platforms which enable composition



Subsystem already exists which we can use?

- Apple App store
- Google ARA Modular Phone
- Lego
- LittleBits
- DARPA make program



# “Freeform” Open Innovation vs. Modular Platforms for Composability

	“Freeform”	Modular Platforms
Search space for modules	Infinite	Finite to the platform
Guarantee subsystem can be used	No	The standard acts as a bridge between modules
Other limitations	Descriptions are as detailed as the providing organization wants them to be	Often volumetric efficiency is reduced

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Could we use the Modular Platforms for Composability on other areas of the development flow?

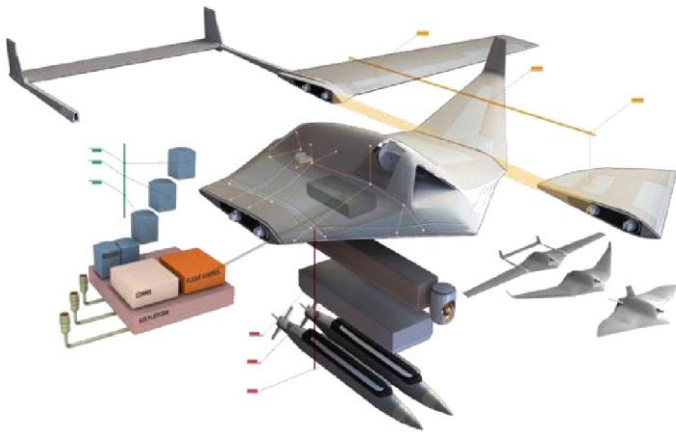


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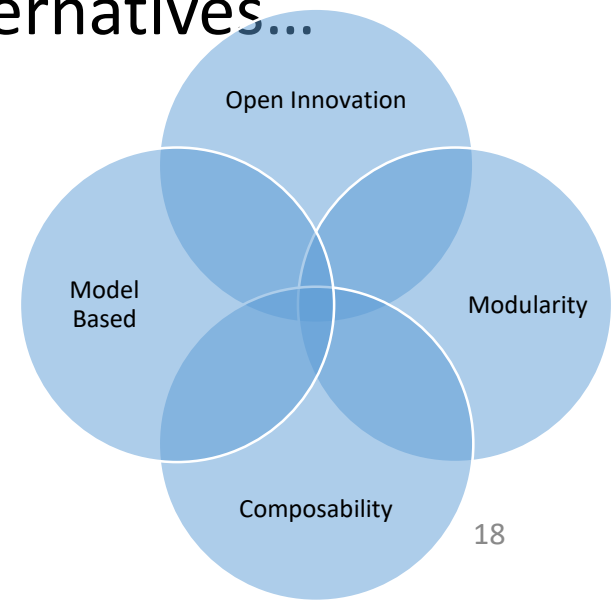
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# A more ideal state

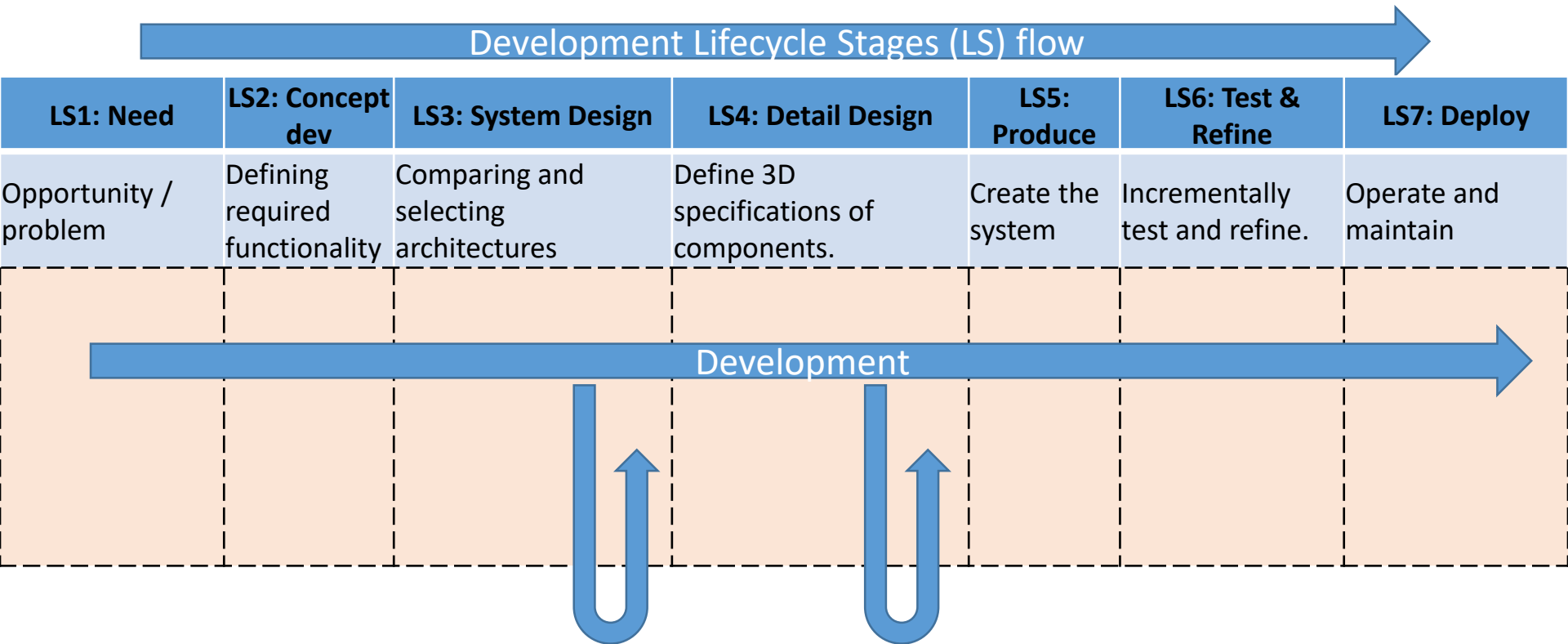
- All needs and industrial capacity clearly advertised such that they **can be combined with the appropriate other modules**
  - Of those quickly find the right parts which can aid development
- And **use simulation** to compare alternatives...



Eremenko 2013



# Open Innovation: Focusing on the design lifecycle stages



If we provide models:

What model should be used when provided by the supplier?

What detail? What language?

What aspect?? Behaviour? Geometry? Mass properties?

Past research:

Paul Eremenko (Now Airbus)

- 2013 DARPA Adaptive Vehicle Make (online system to build ground vehicles out of components):
  - Cancelled because hard to share military technology online and lack of engineering expertise in the participants
- 2016 Google / Motorola ARA:
  - Paused:
    - Difficult to verify too many combinations
    - Volumetric efficiency matters on phones

Seems like they chose the wrong domains

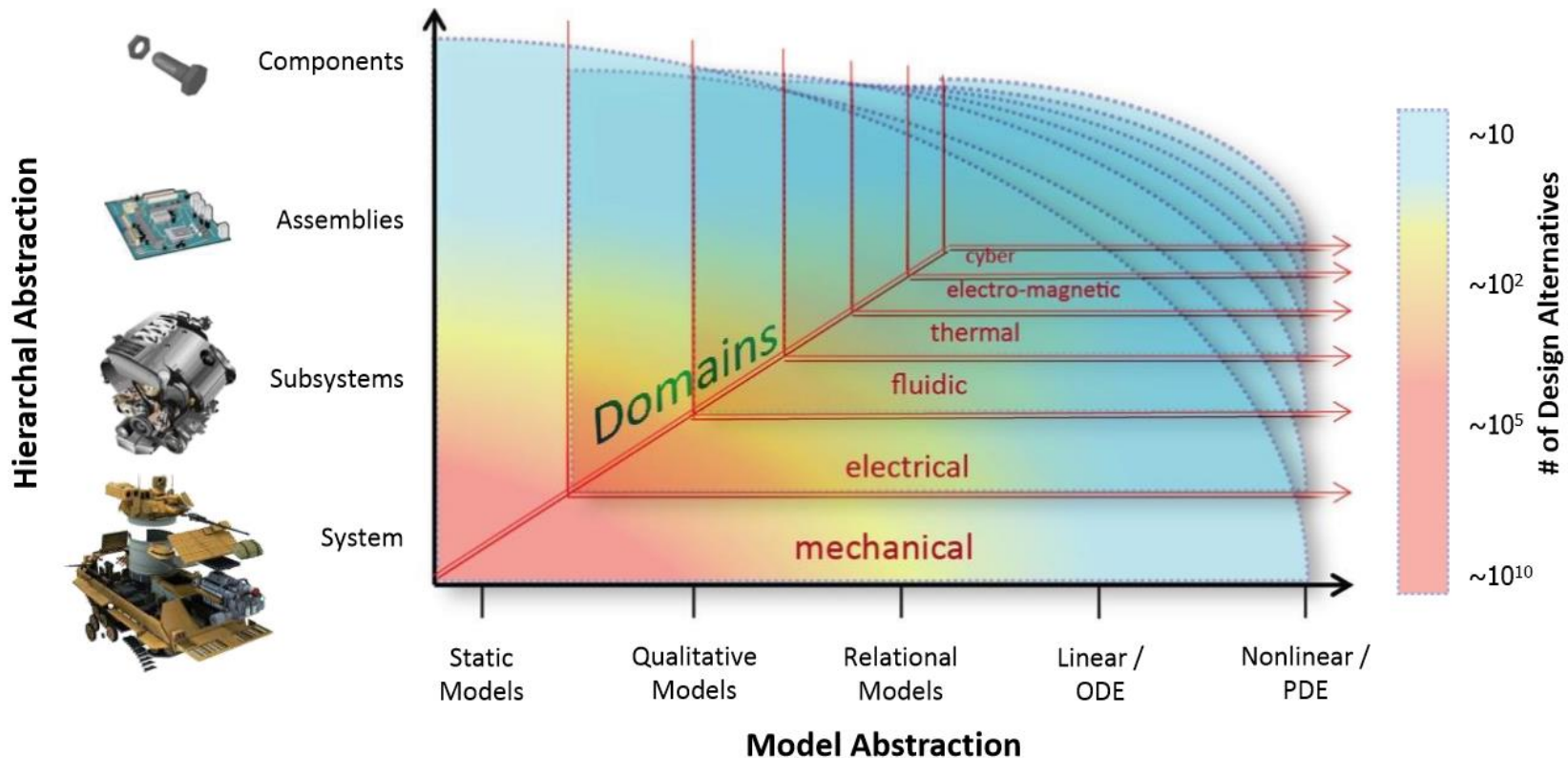
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# Main questions ~~and hypotheses~~

- What domains and can Modular Platforms for Composability be made to work well (other than lego...)?  
-> *The where and when*
- How much more effective is such an approach compared to “freeform”?  
-> *The why*
- What does the model need to be [contain]?  
-> *The how*

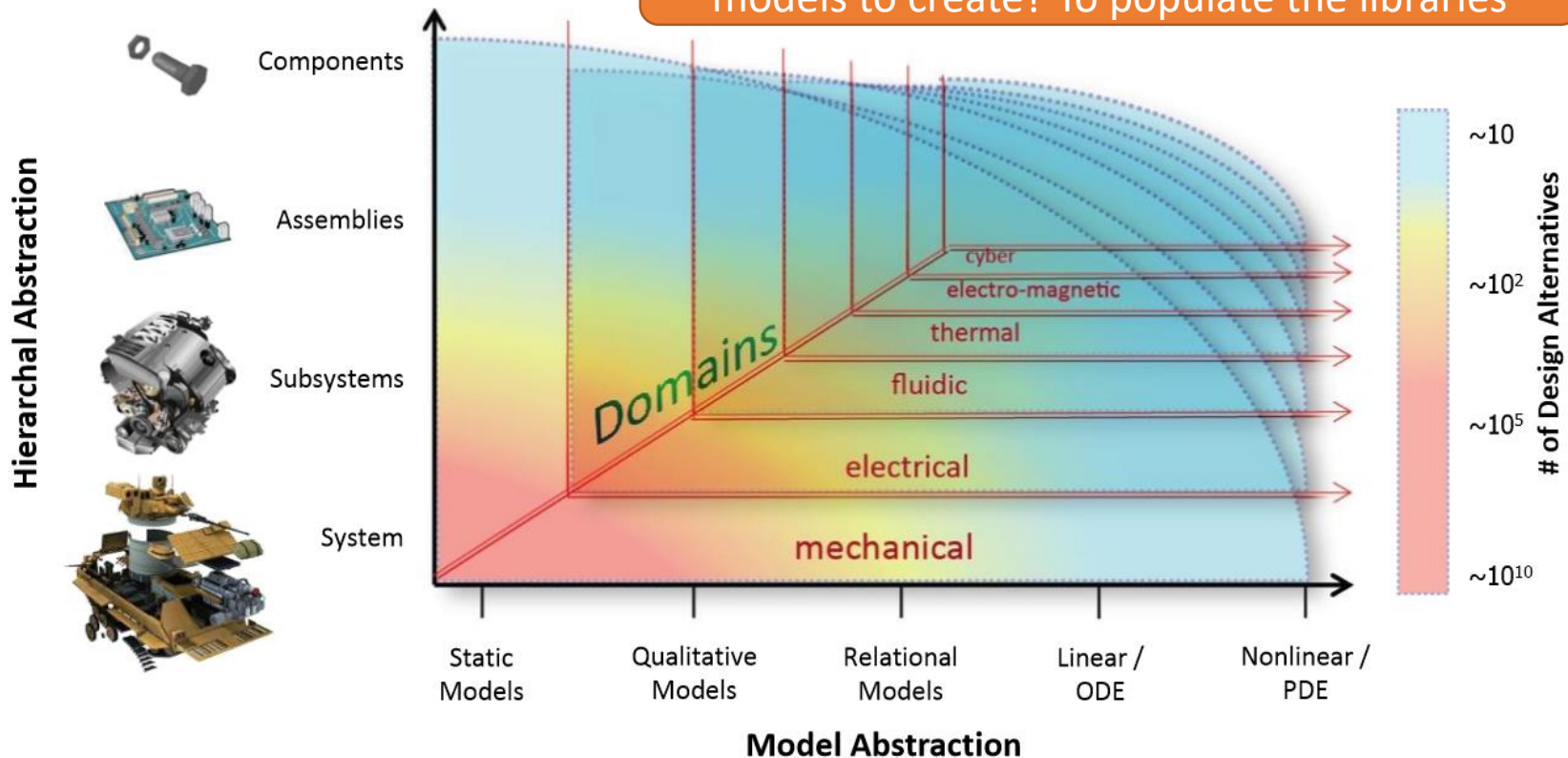
# What does the model need to be [contain]? -> *The how*



Eremenko, Paul. "Formal Model-Based Design & Manufacture: A Template for Managing Complexity in Large-Scale Cyber-Physical Systems." In *Conference on Systems Engineering Research*, (March 21, 2013), 2013.

# What does the model need to be [contain]? -> *The how*

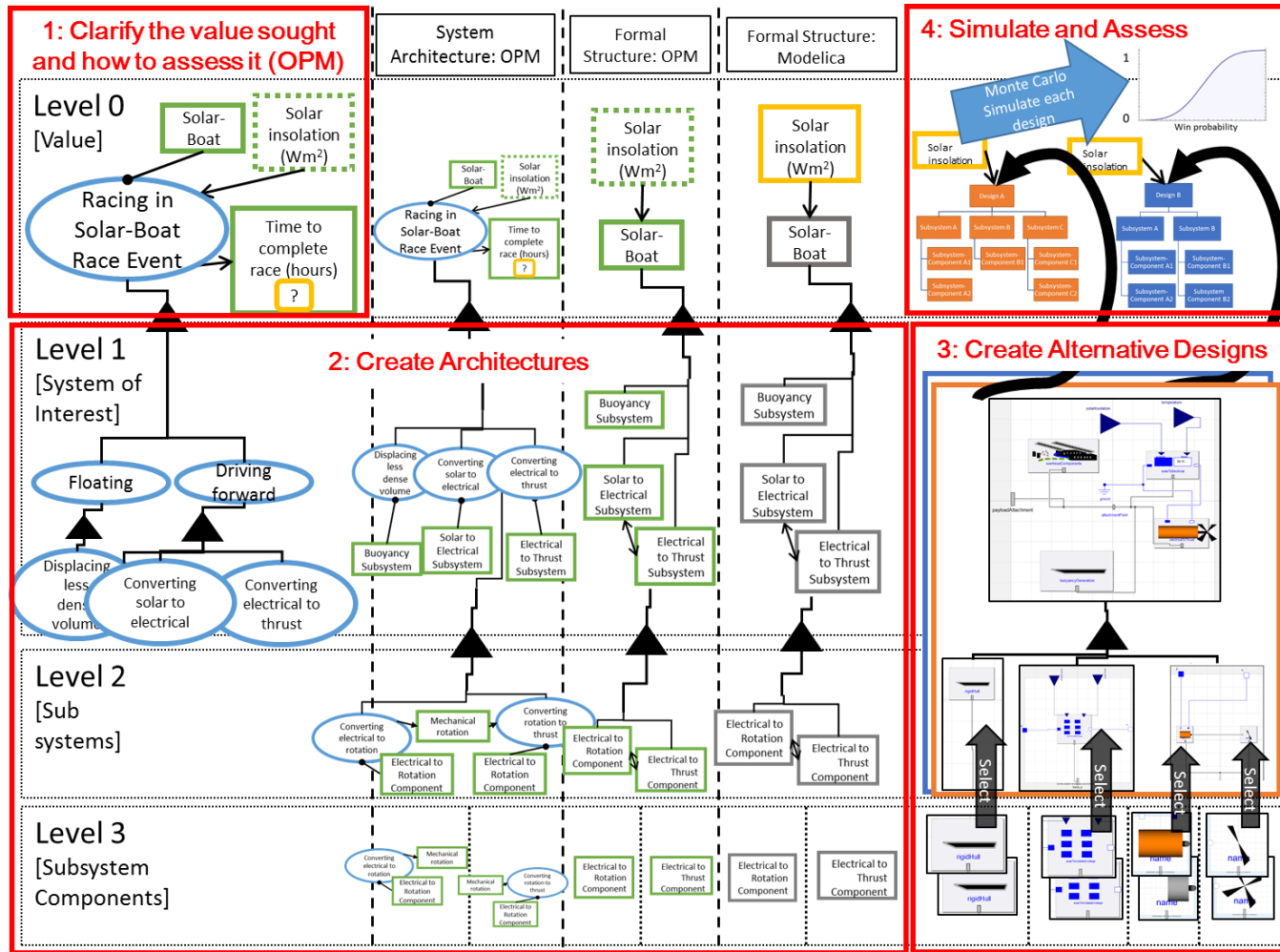
Basically: Can we offer any advice on what models to create? To populate the libraries



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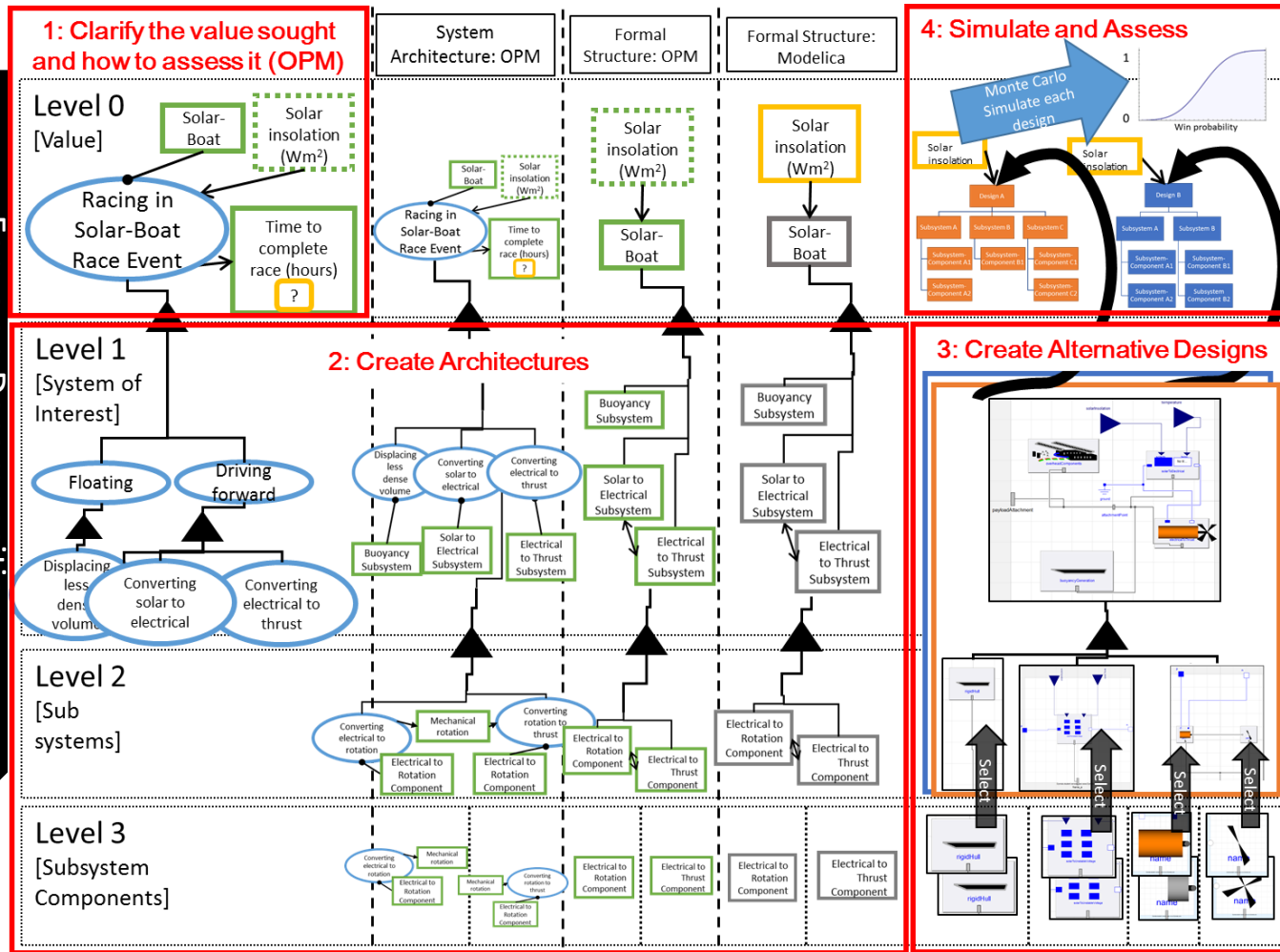


# My previous research



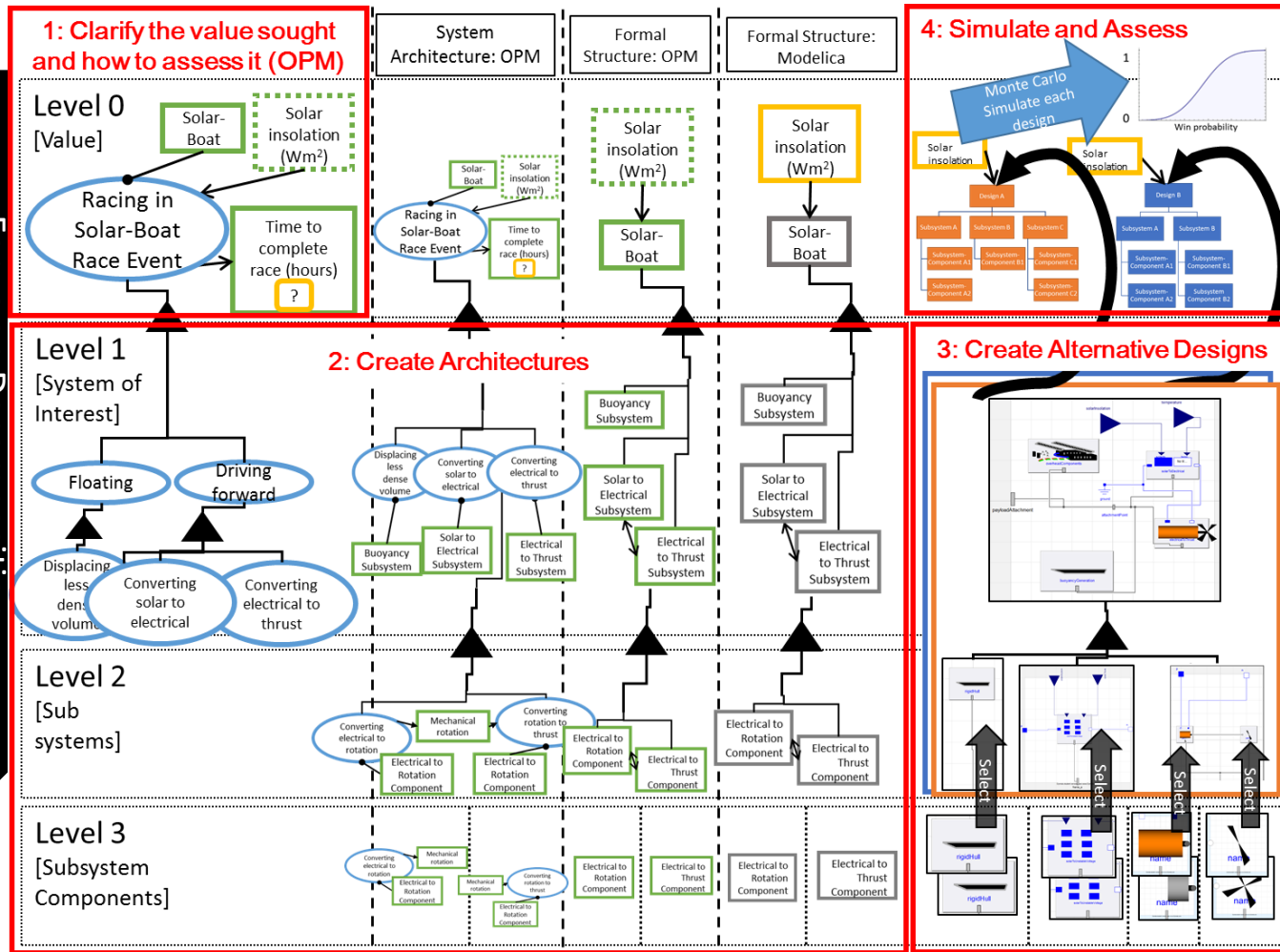
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Focus on Decomposition



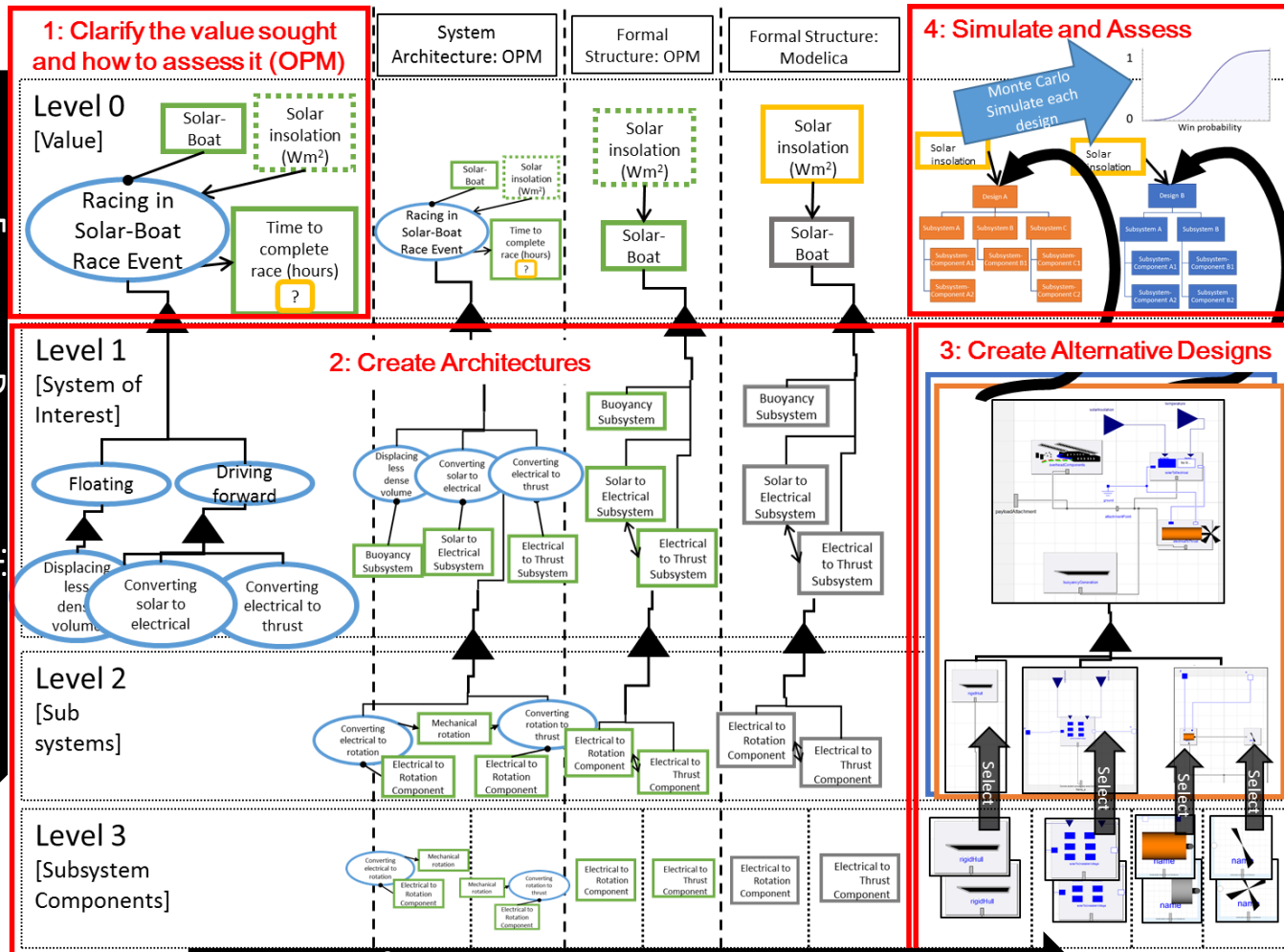
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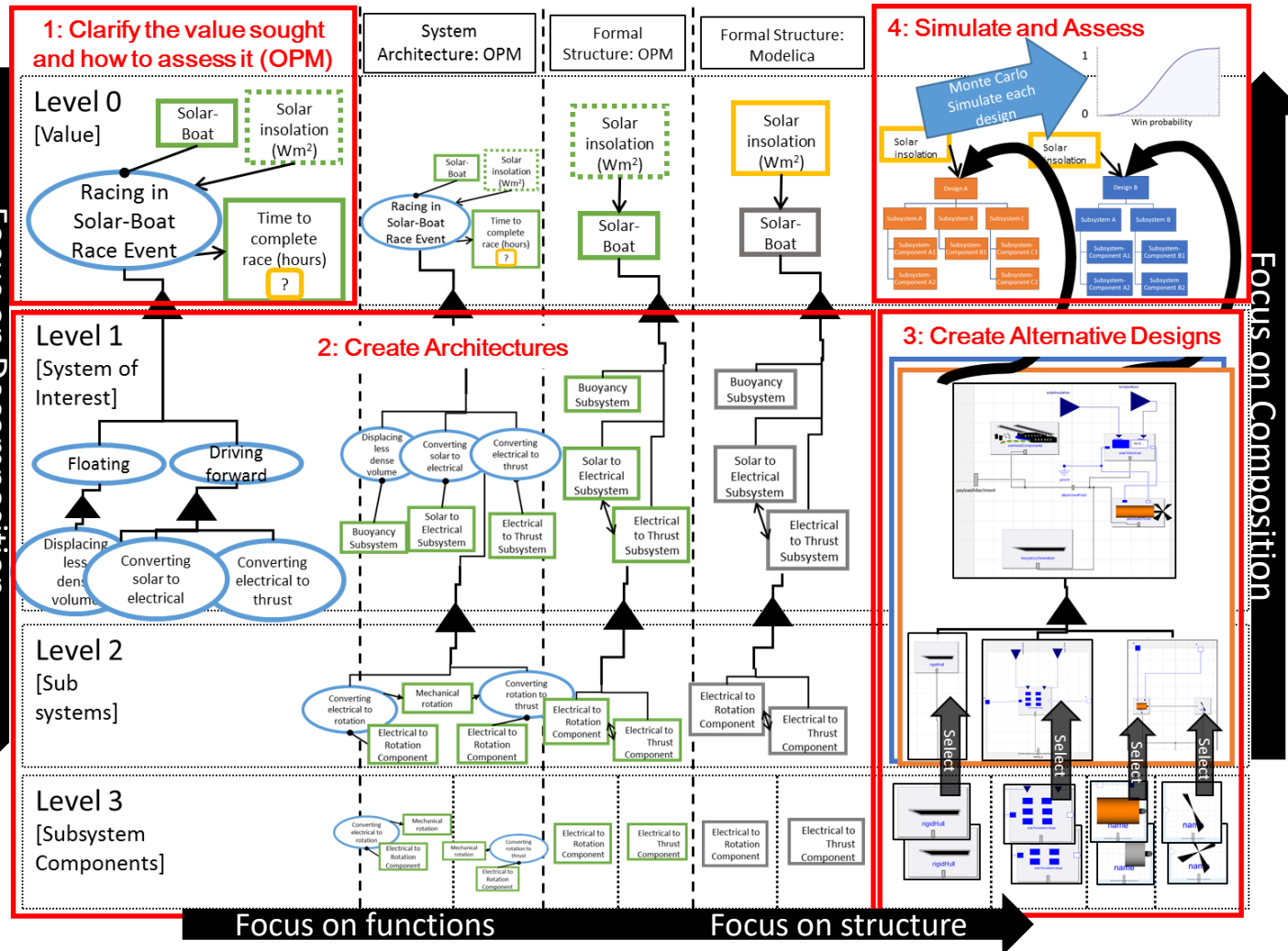


Focus on functions

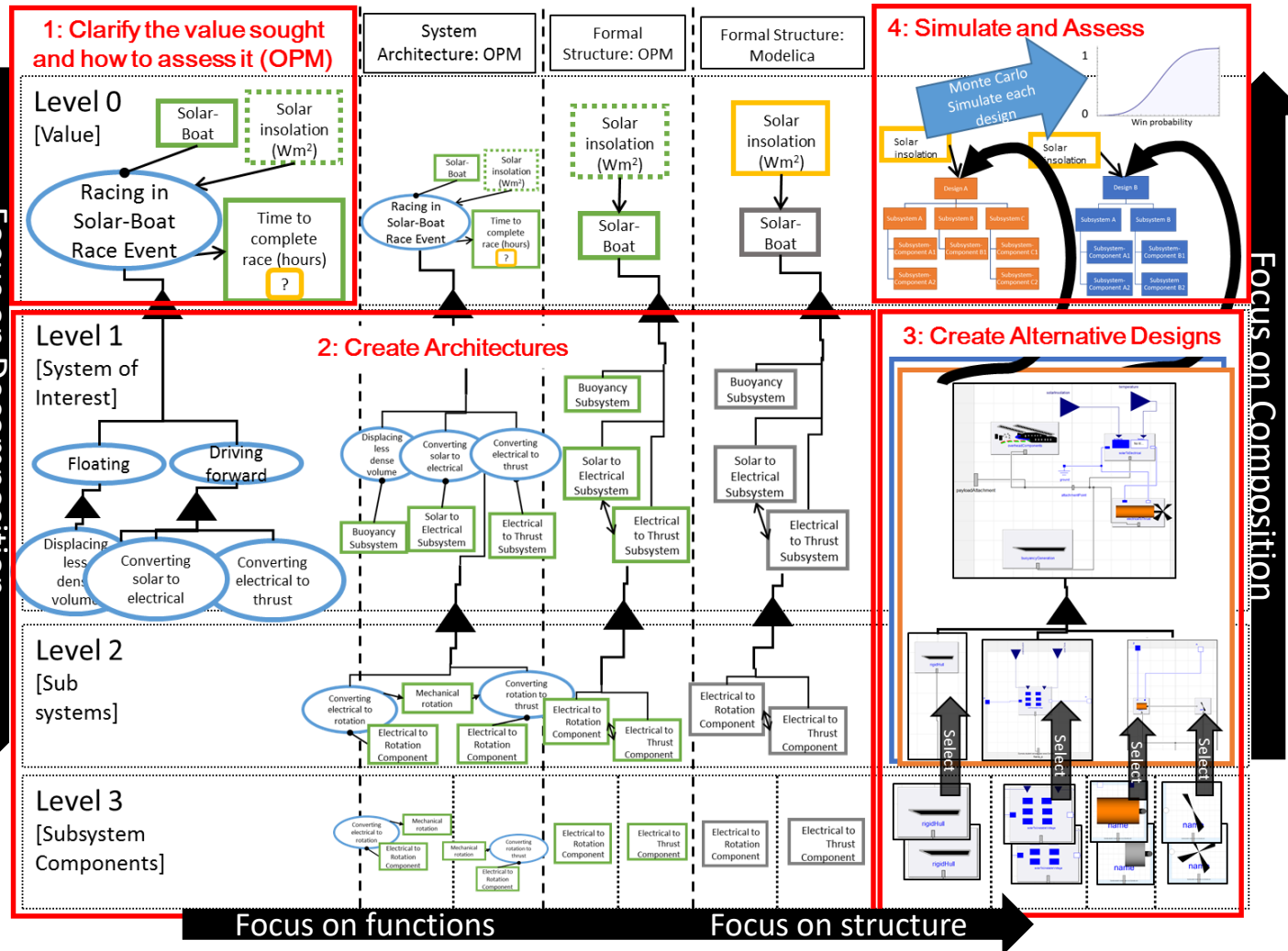
Focus on structure

Model types

# My previous research

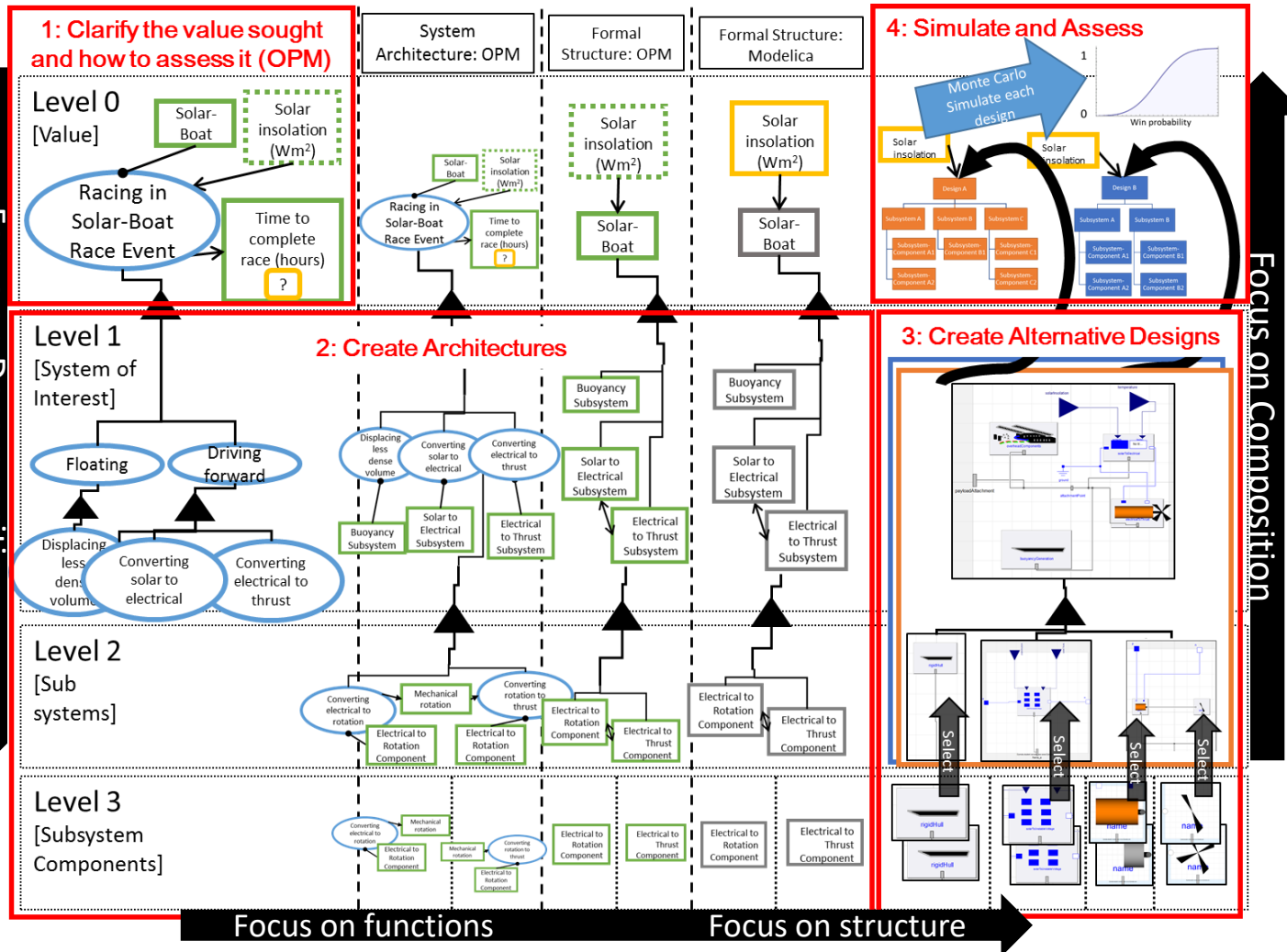


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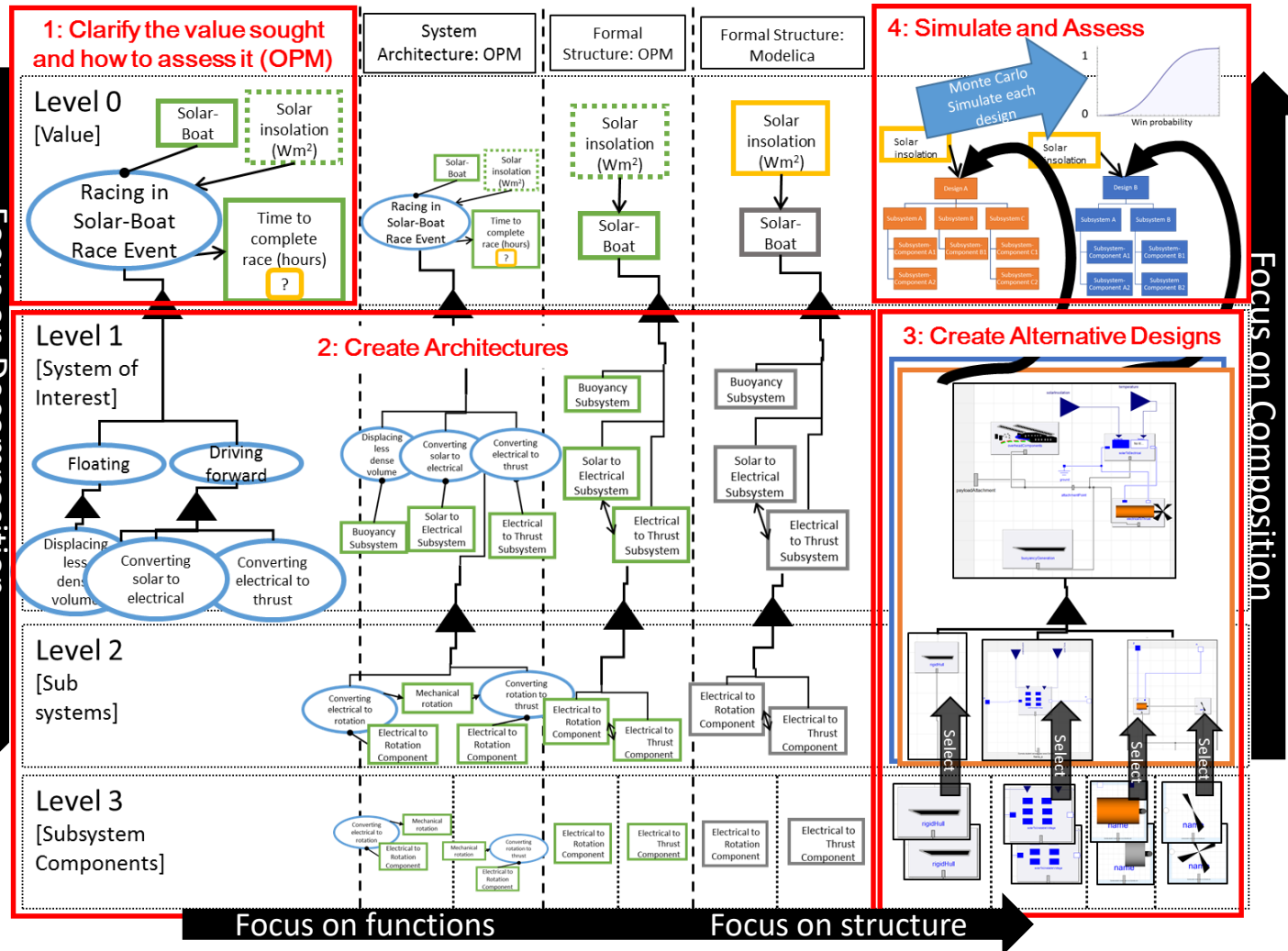




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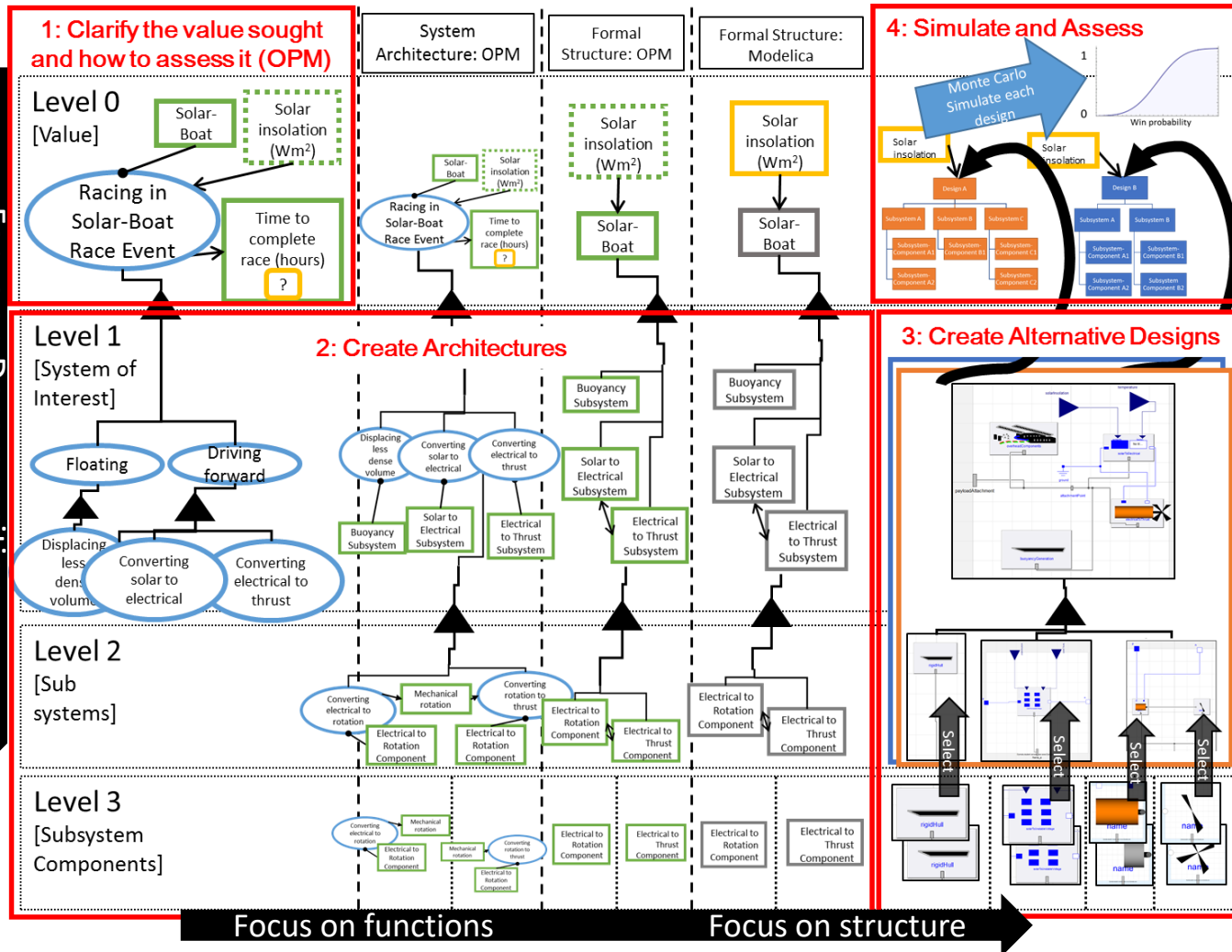
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Issues:



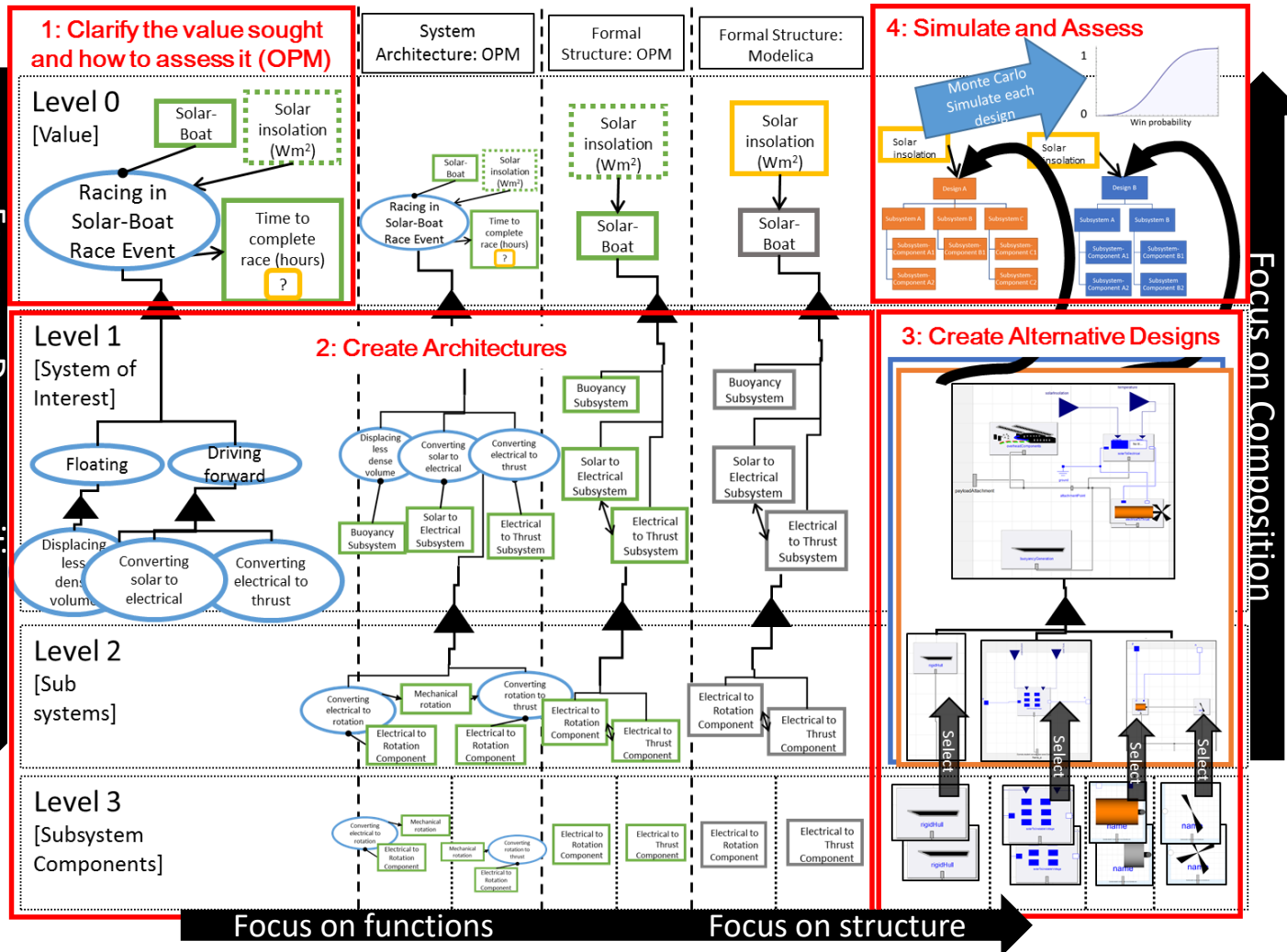
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- Just integrating different model types

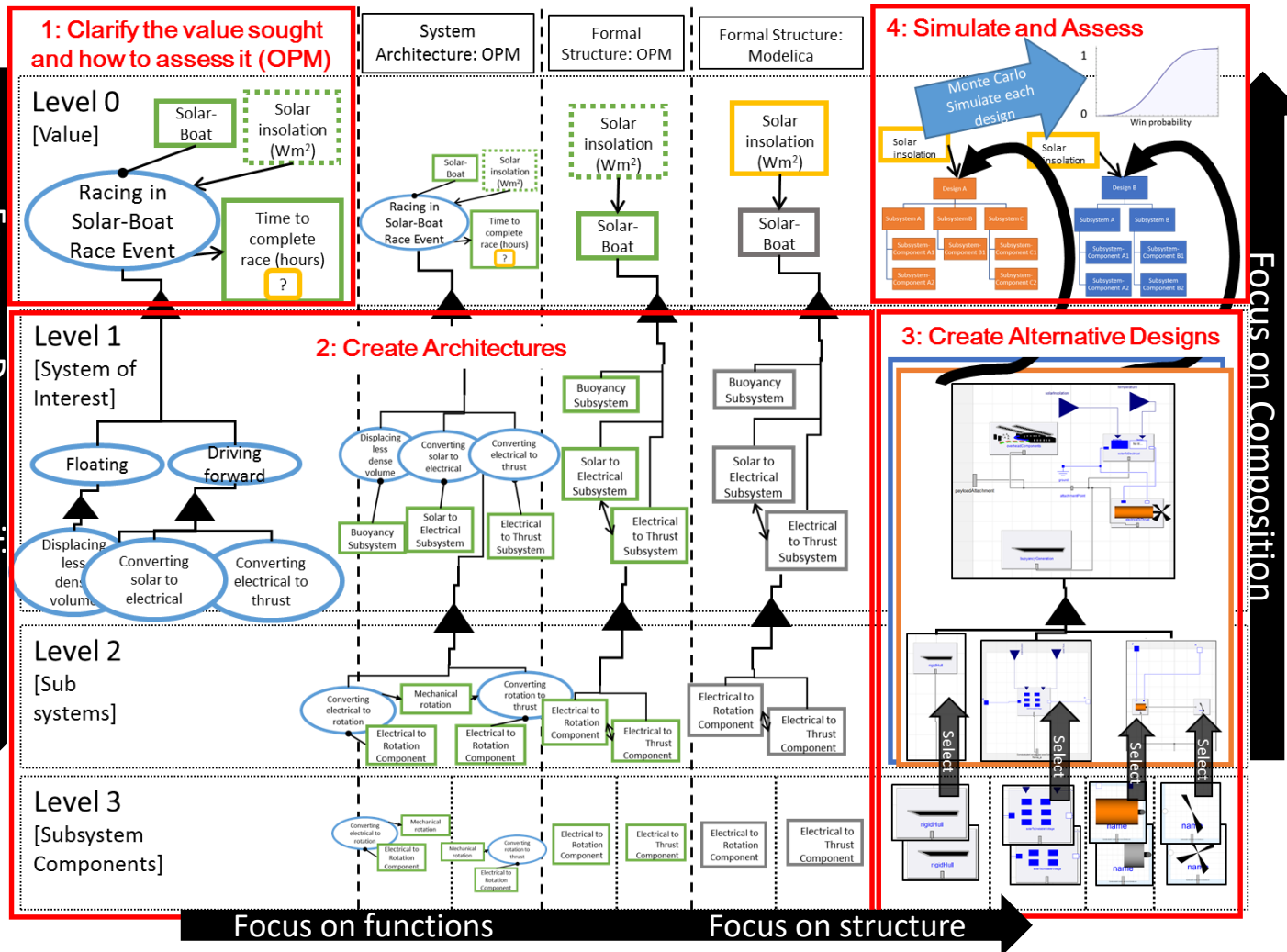
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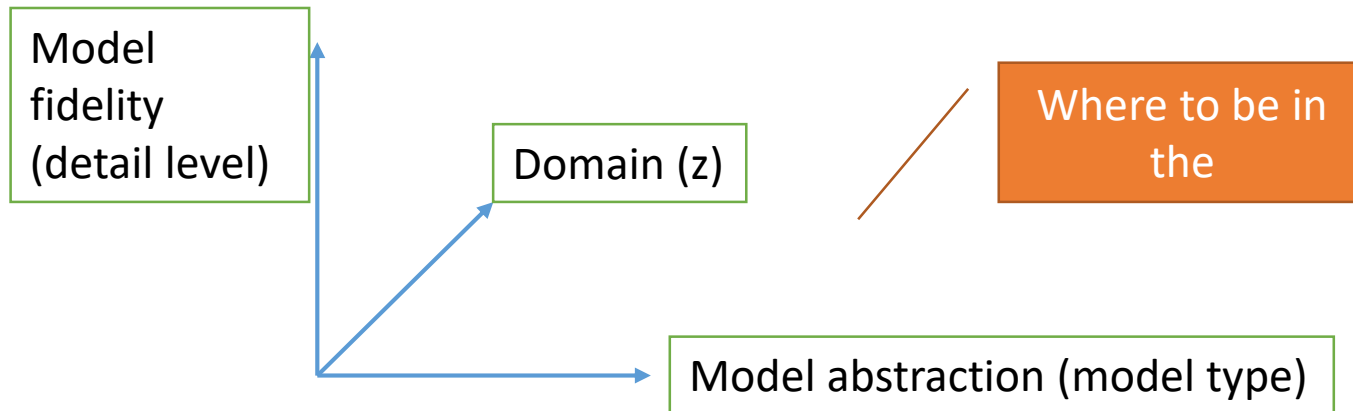


## Issues:

- Just integrating different model types
- No clear on the reasoning of why to integrate these model types

# Output goal

- Big goal:
  - Provide a **standard for models** to be made such that they can be more simply integrated with others. **Based on research** which says it is worthwhile.



- Current thoughts (to limit scope):
  - Start with Modelica modelling language
  - Stay with ground vehicles (cars and ships)

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Biggest challenge.  
Any help gladly appreciated.

# Selecting type of research

Research Clarification	Descriptive Study I	Prescriptive Study	Descriptive Study II
1. Review-based	→ Comprehensive		
2. Review-based	→ Comprehensive	→ Initial	
3. Review-based	→ Review-based	→ Comprehensive	→ Initial
4. Review-based	→ Review-based	→ Review-based Initial/ Comprehensive	→ Comprehensive ←
5. Review-based	→ Comprehensive	→ Comprehensive	→ Initial
6. Review-based	→ Review-based	→ Comprehensive	→ Comprehensive
	↑	↑	↑
7. Review-based	→ Comprehensive	→ Comprehensive	→ Comprehensive
	↑	↑	↑

**Figure 2.2** Types of design research projects and their main focus. (Iterations omitted)

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# Determining areas of relevance and contribution

## Relevance

- Open Innovation is viewed as a necessity to remain competitive
- **Modelling** opens the door for cost reduction and design improvements by prediction

## Contribution

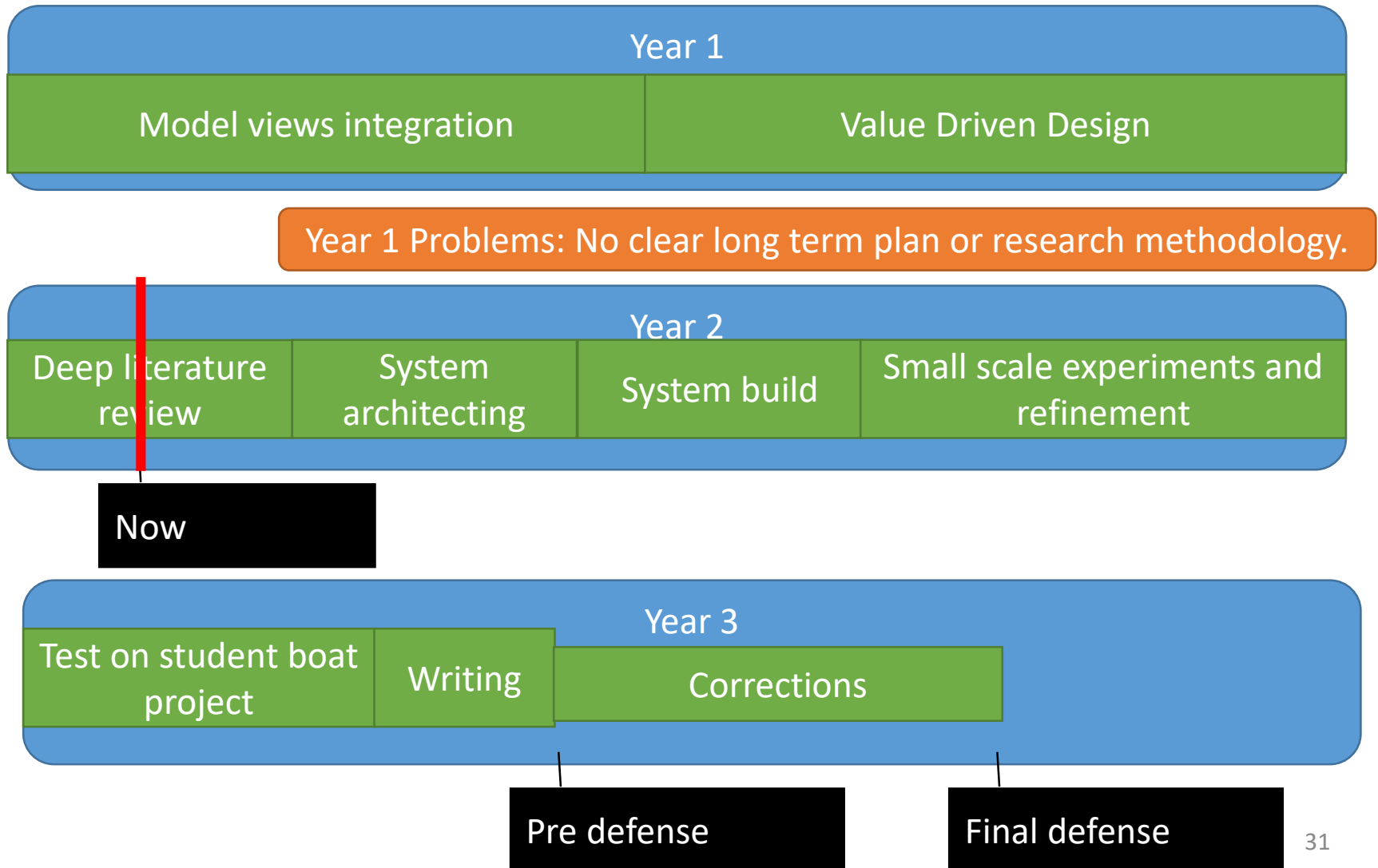
- Little work has gone into establishing **what models are needed for enabling Modular Platforms for Composability**



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# Research Plan



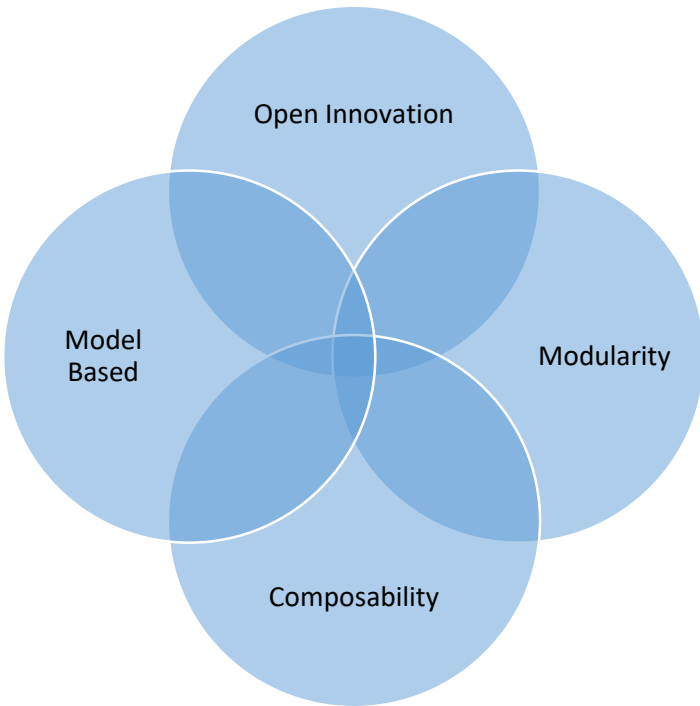
# Questions?

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