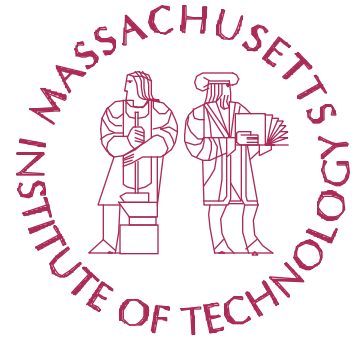
Lean Aerospace Initiative

Design Methods in the Aerospace Industry: Looking for Evidence of Set-Based Methods



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Research Sponsored by the Lean Aerospace Initiative

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Overview

- **Introduction**
- **What is set-based concurrent engineering (SBCE)?**
- **Investigating aerospace industry design practices**
- **Lessons and recommendations**

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Project Genesis and Research Goals

- **Project Genesis**
  - Initial literature review on product design and risk management
  - Significant interest in set-based methods after Al Ward's Plenary talk (October, 1997)
  - Research moved to assess set-based methods for aerospace applications

- **Research Goals**
  - Understand set-based concurrent engineering (SBCE)
  - What elements of SBCE already exist in the aerospace industry?
  - Should companies attempt to implement more set-based practices?

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Why Investigate SBCE?

- **Primary example to date is Toyota**

- **Uses approximately 50% fewer person years for development than Chrysler**
- **Delays finalizing body hardpoints**
- **Communicates less frequently with suppliers**

- **But…**
  - **Develops a larger number of prototypes**

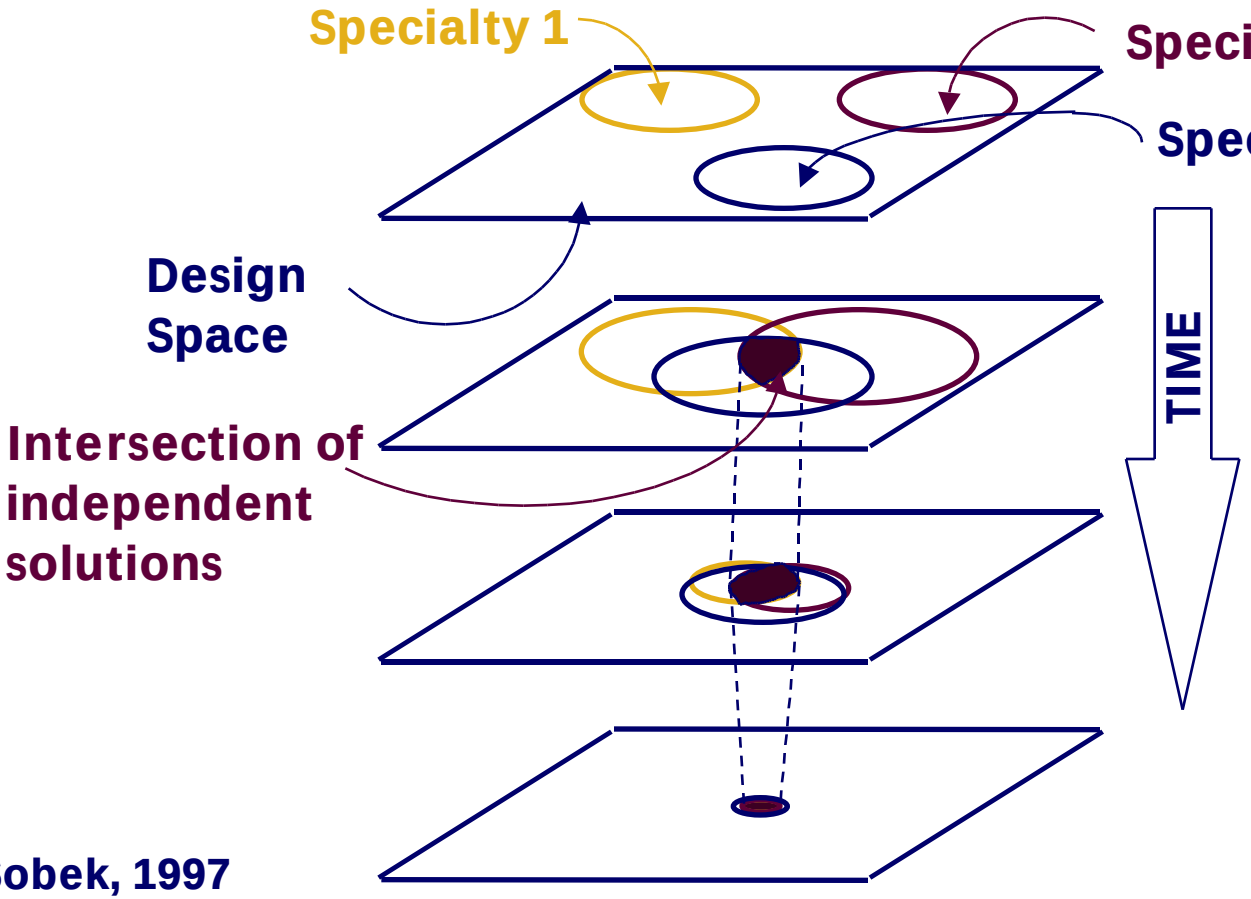
➔ ***Can aerospace see the same benefits?***

Toyota examples from "The Second Toyota Paradox…" by Ward et al.

What is Set-Based Concurrent Engineering?

SBCE Basics

"reasoning, developing, and communicating about sets of solutions in parallel and relatively independently"*



*Sobek, 1997

Illustration concept developed with Dr. William Finch

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Set-Based Techniques

- **Requirements: ranges or minimum constraints**
- **Define limits rather than “best” designs**
- **Delay selecting a single concept**
- **Stay within sets once committed**
- **Seek conceptual robustness**
- **Integrate using intersections between sets**

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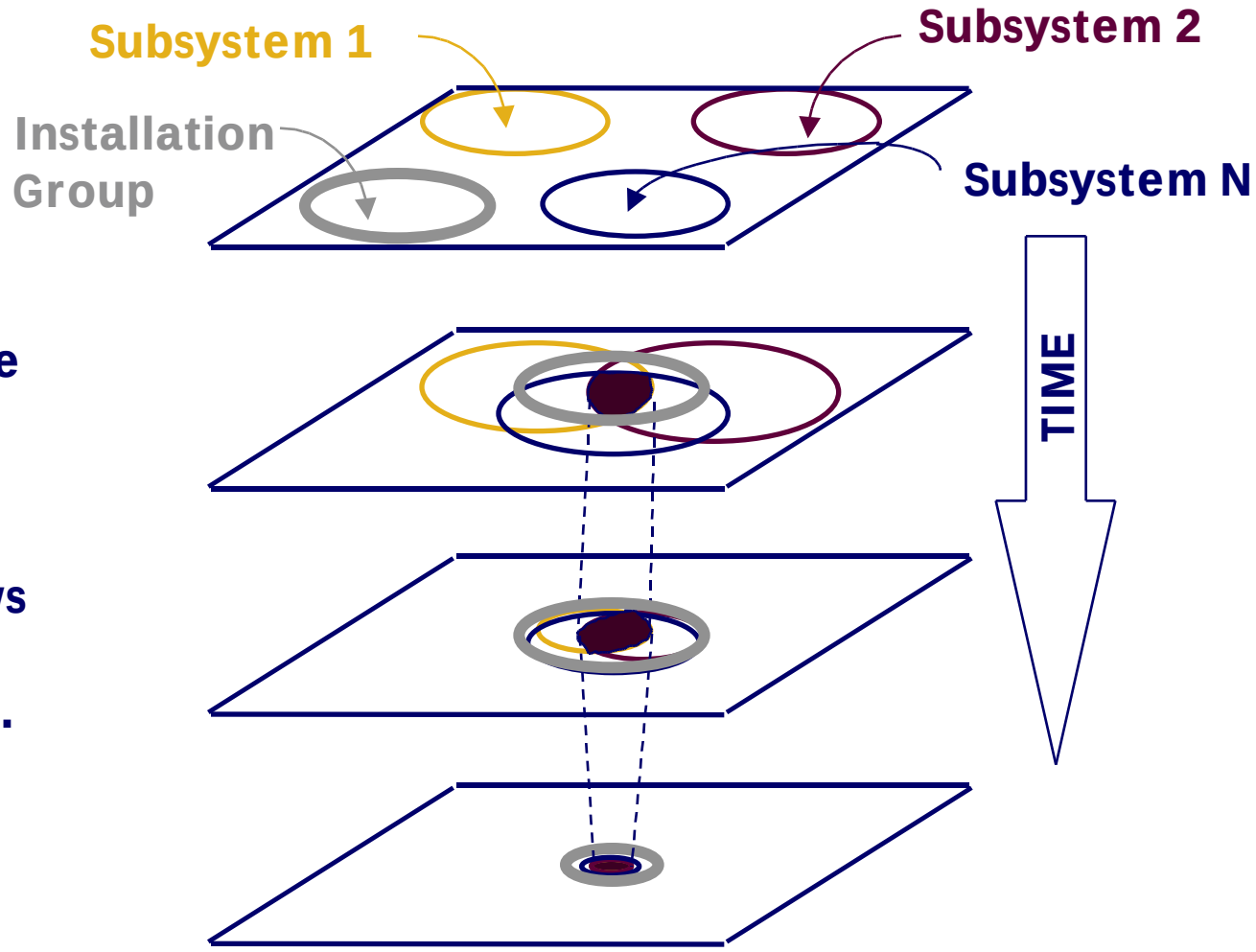
An Example: Subsystem Installation

1. Each subsystem chooses a location.

2. Subsystems provide tolerance limits.

3. Installation narrows locations based on routing requirements.

4. Final design.



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SBCE vs. Platform Design

- **Platform Design**
  - ***Product* strategy**
  - **Design the product so that several variations can be easily produced and marketed**

- **Set-Based Concurrent Engineering**
  - ***Design* strategy**
  - **Consider a large number of design options in order to develop the best final product**

SBCE can be used to develop a platform family or a single product

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Investigating aerospace industry design practices

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Scope of Study

Number of sites visited	9
Sectors represented	Aircraft, Missiles, Electronics, Space
Total number of Interviews	88
Number of interviewees with title of Manager, Director, Leader, or Chief Engineer	65 (74% of total)
Number of interviewees with title of Engineer	23 (26% of total)

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Distinguishing Traits of SBCE

- **2 criteria to qualify as SBCE:**

  ① **Consider a large number of design alternatives**

  ② **Allow specialties to consider a design from their own perspectives, using the intersection between sets to integrate a design**

Results

- In general, few clear examples of SBCE
- Several examples of use of sets...
  - ✓ Descriptions of narrowing
  - ✗ Usually confined to conceptual design
  - ✗ Involved limited numbers of designers
  - ✗ Constrained sharing of options
  - ✗ Searches for “best” design rather than limits
- Many companies in the process of reforming design methods
  - ➡ Complicated data collection efforts

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Obstacles to SBCE in Aerospace

- **Suppliers and lead times**
- **Environmental Testing**
- **Design and analysis cycles**
- **Limits of parametric models**
- ➠ ***Working with the customer***

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Lessons and recommendations

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Lessons: When to Apply SBCE

If the development project is characterized by:	*Then apply:*
· **A large number of design variables** · **Tight coupling between variables** · **Conflicting requirements** · **Flexibility in requirements to allow trades** · **Technologies or design problems that are not well understood and require rapid learning**	**Set-based techniques**
· **Requirements for specific technologies** · **Requirements to optimize the design along only one or two parameters** · **Well-understood technologies or design problems**	**Point-based techniques**

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Recommendations: Customer-Designer Relations

- **Customer attitudes can have significant effects on development methods**
- **Engineers' perceptions of customer attitudes**
- **Historical bid processes…**
- **…Evidence of changes coming**

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Recommendations: Data Generation

Can SBCE have the same benefits for the aerospace industry as it does for Toyota?

- **This effort found no good points for comparison**

➡ **Lean Forum or similar activity could provide the needed data**

I invite you to ask questions...

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For Further Reading...

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