Advancing PLM through Multi-disciplinary Design Optimization

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I. Project Overview

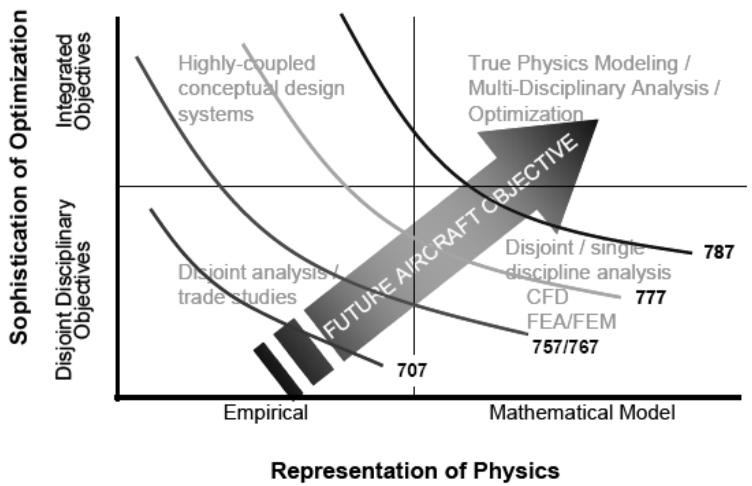
- CAM Seed Project, “Advancing PLM through Multi-disciplinary Design Optimization”
  - Proposed to advance the MDO and Knowledge Management in PLM environment.
- The goal is to develop the MDO in multi-CAD and multi-simulation software environment, and to establish the strategy to manage the knowledge interchanged in the multi-software environment.
- Key Technology:
  - Integration of Multi-CAD software
  - Data and Process Consistency across Multiple Engineering Disciplines
  - Knowledge expression/management
  - Simulation based MDO strategy
  - Enterprise perspective for comprehensive product design

II. MDO & PLM

- PLM —— more like a knowledge management solution
  - Knowledge: organized, validated information that can be used purposefully in problem solving.

- MDO——a field of engineering that uses optimization methods to solve design problems incorporating a number of disciplines.
  - Features:
    1. allows designers to inco simultaneously.
    2. exploits the interactions
    3. The optimum of the sim found by optimizing eac
    4.

Industrial Sector	Component/Activity
Aircraft	Vertical fin major aircraft
Aircraft	Nacelle configuration
Aircraft	Flight test program
Automotive	Optimized structural design for crash worthiness



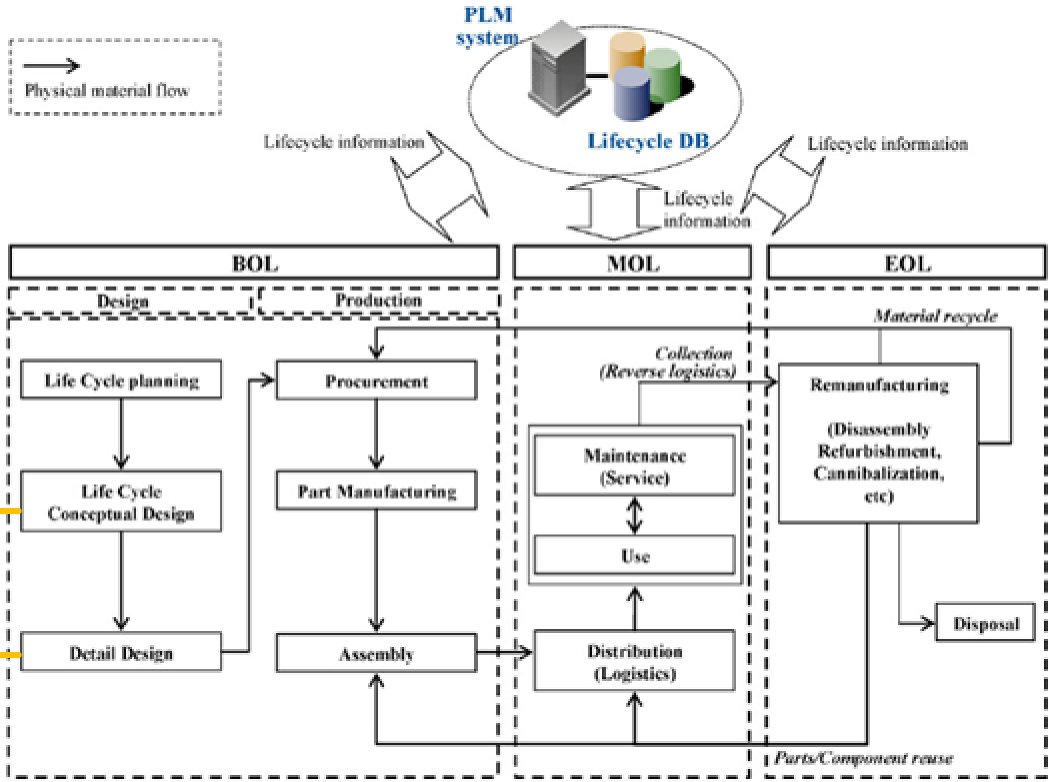
re 4: Reaching towards full Aircraft MDO across successive aircraft families. lapted from Boeing, 2006 European-U.S. MDO Colloquium Proceedings[1])

II. MDO & PLM

MDO in PLM

Low Fidelity Model

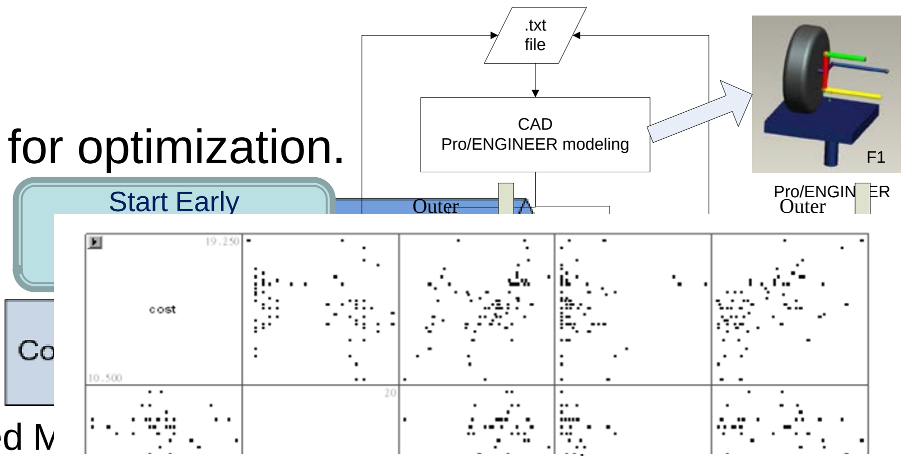
High Fidelity Model



II. MDO & PLM

Difficulties of MDO

- limited time window in the lifecycle for optimization.
  - Knowledge recycle
  - Pre-optimization, predictive analysis
- Complex coupled problems
  - Collaborative Optimization
  - Integrated simulation & Stochastic based M
- Time and Resource Consuming
  - Design space refinement
  - approximate models methods
- Numerical Untraceable
  - Engineering robust test
  - Multi-Methodology



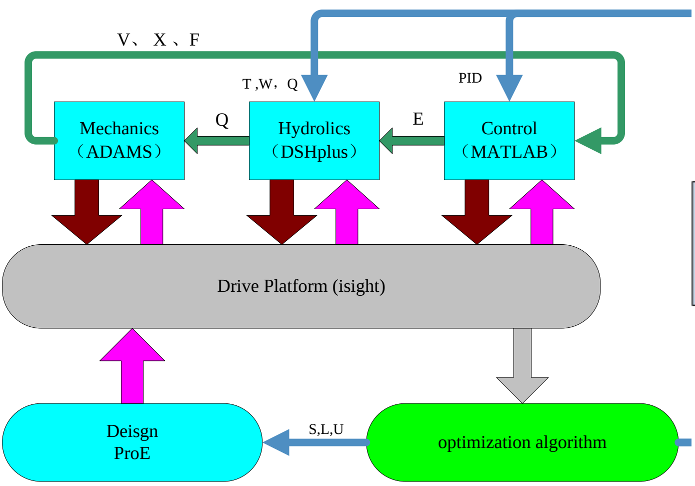
Algorithm	Mean value (Δm)	Standard deviation (σ)	No. of opt. (n)
Monte Carlo	-14.6	1.4	8
Kriging	-9.3	1.6	3
SA	-10.1	1.6	3
GA	-12.2	2.1	3
Mutative evolution	-14.0	1.4	8
Derandomized evolution	-15.5	1.7	15
EA-DR/single parent	-15.2	1.1	12
EA-DR/multiple parent	15.3	1.0	11
EA-DR (λ, μ)	-15.8	1.7	15
EA-DR ($\lambda + \mu$)	-14.4	1.3	8

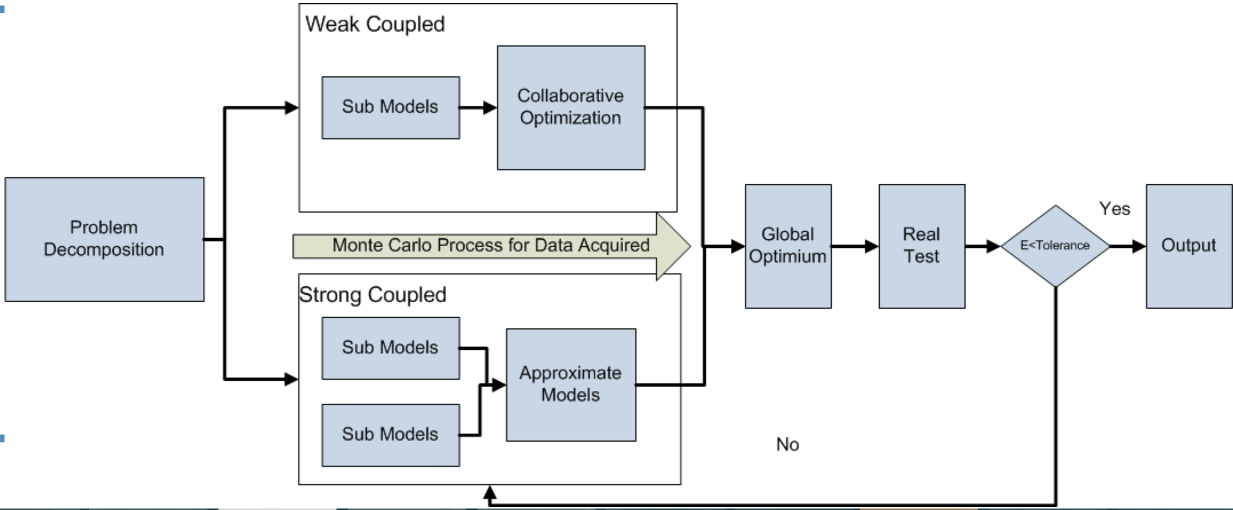
III. Integrated Simulation, Analysis and Optimization

- **Tools can be classified into three broad categories:**
  - **General purpose optimization tools,**
  - **Embedded optimization tools, and**
  - **Dedicated process integration and design optimization (PIDO) tools**

General Purpose Tools	*Embedded Optimization*	*Process Integration Tools*
Excel (Microsoft)	SolidWorks-Cosmos	ModelCenter, CenterLink (Phoenix Int.)
Matlab (Mathworks)	GENESIS (VRD)	iSIGHT, FIPER (Engineous)
Mathematica (Wolfram)		modeFRONTIER (Esteco)

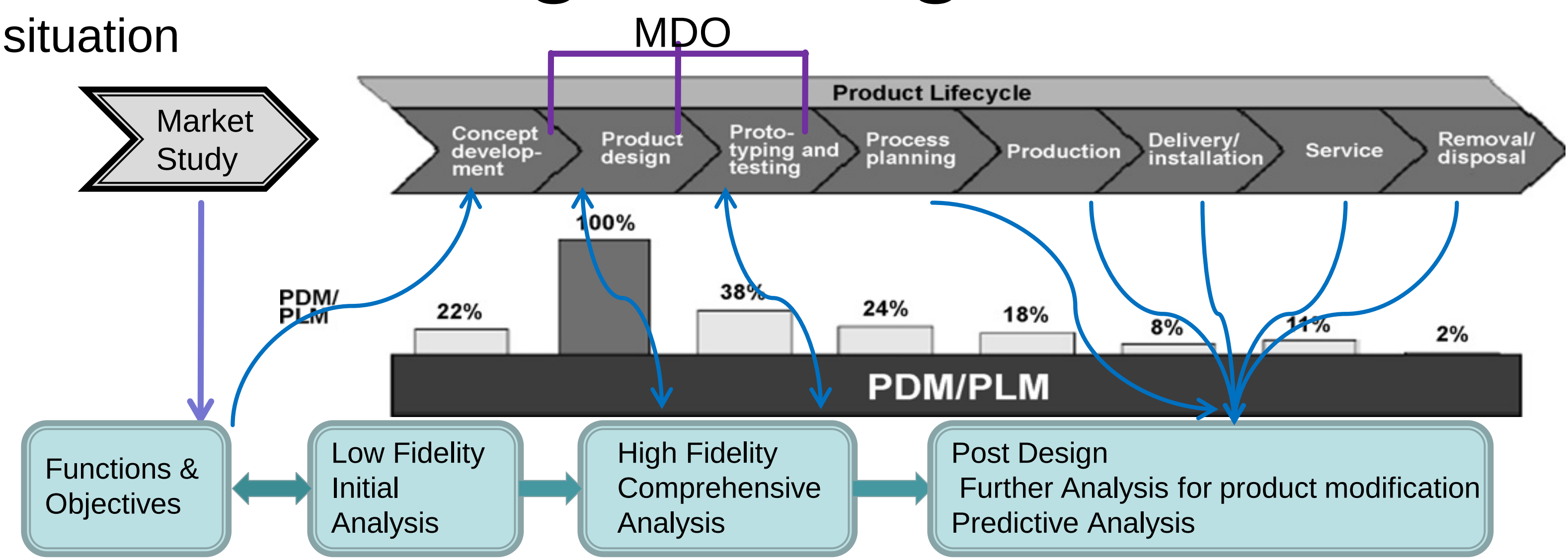
- **Integrated with CAD/CAE packages, MDO platform can be developed**





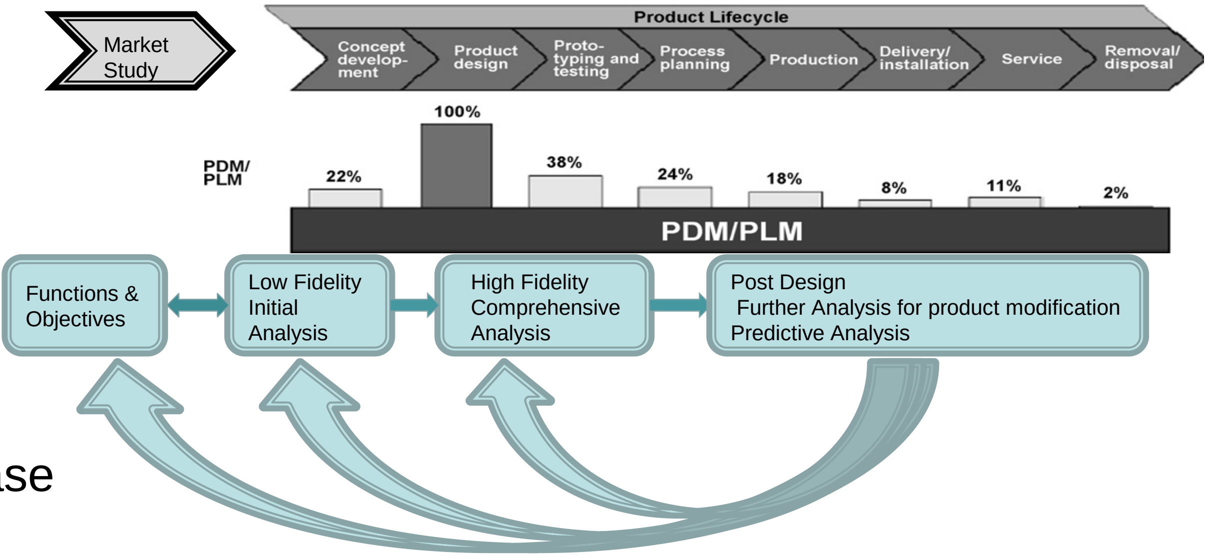
IV. Knowledge Management

- Current situation



- Integrated MDO in to Product development
  - Useful data [illegible] purpose
    - Different fidelity model prototype
    - Design variables influence
    - Conflicts, Constraints and Correlations
    - Mathematical and statistical Methodology
  - Knowledge flow

V. Expended Optimization & Advanced Analysis



1. Enlarged Scope
   a) Pre-and Post-design phase
   b) Fidelity level influence
2. Advanced Analysis
   a) Predictive & Reliable
   b) Based on existed product knowledge
   c) Statistical foundation, confidence intervals
3. Enhance the quality of PLM, explore the future road map.

VI. Summary

- MDO integration through PLM
  - Process integration, MDO into product development process
  - Integration framework, and CAD/CAE tools
  - Design space refinement: sampling and reducing.
  - Mathematical and statistical analysis methodologies, tools
- Knowledge expression and management
  - Knowledge in PLM featured MDO
  - Knowledge access & flow
- Research Papers
  - Advancing PLM through Multi-disciplinary Design Optimization

VII. Acknowledgement

- The project “Advancing PLM through Multi-disciplinary Design Optimization” was approved on the IAB meeting in November, 2007, and it is funded by Center of Advanced Manufacture, Purdue.
  - Thanks to IAB, and thanks to CAM!
- The project proceeds under the supervision and Instruction by Prof. Richard M. French, and Prof. Melita M. Tomovic, also, colleagues in Purdue PLM center of excellence offered a lot of help.
  - Thanks to professors, and thanks to my colleagues!