

# **Adaptive Vehicle Make**

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DARPA TTO

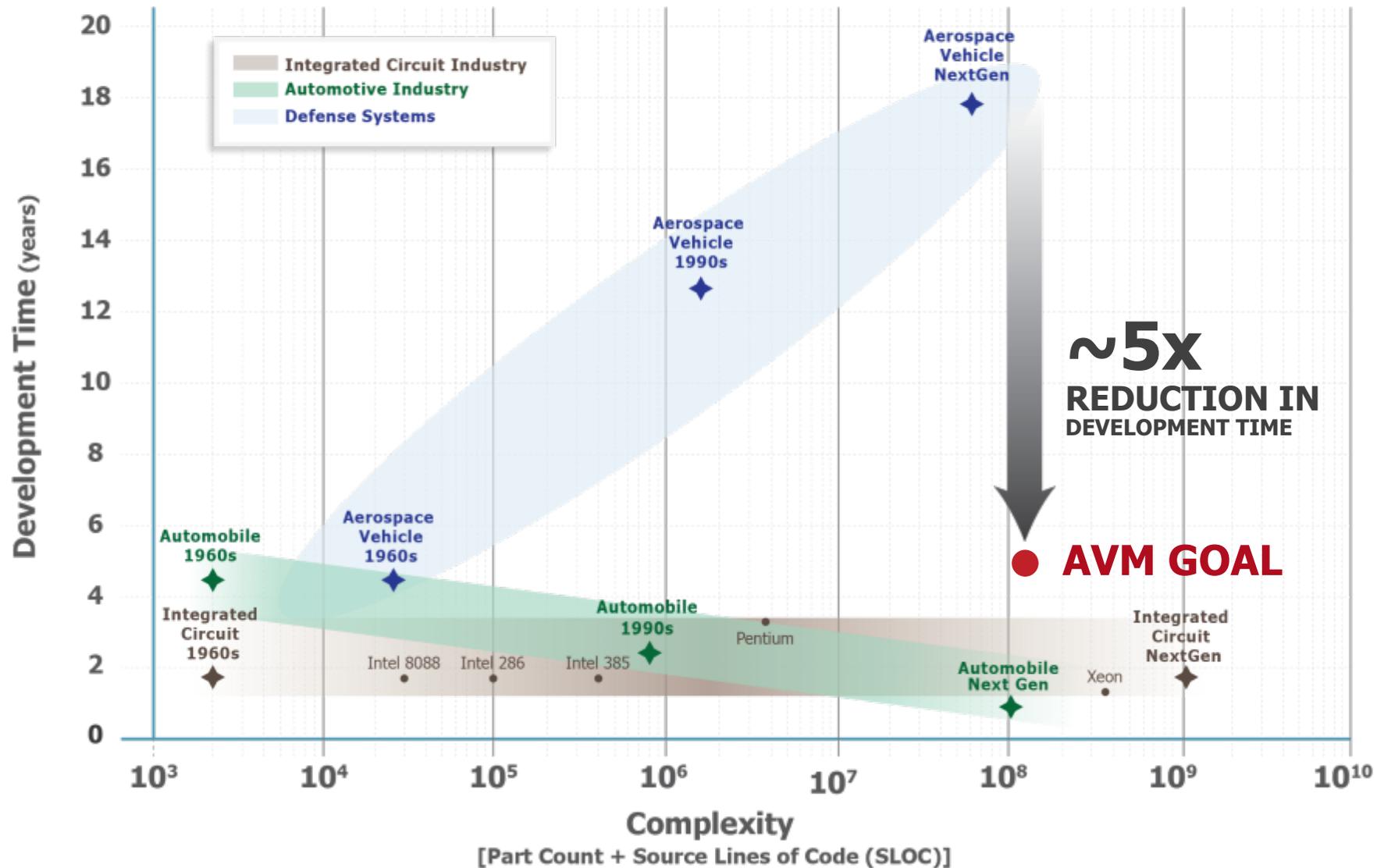
CPS PI Meeting

17 October 2013





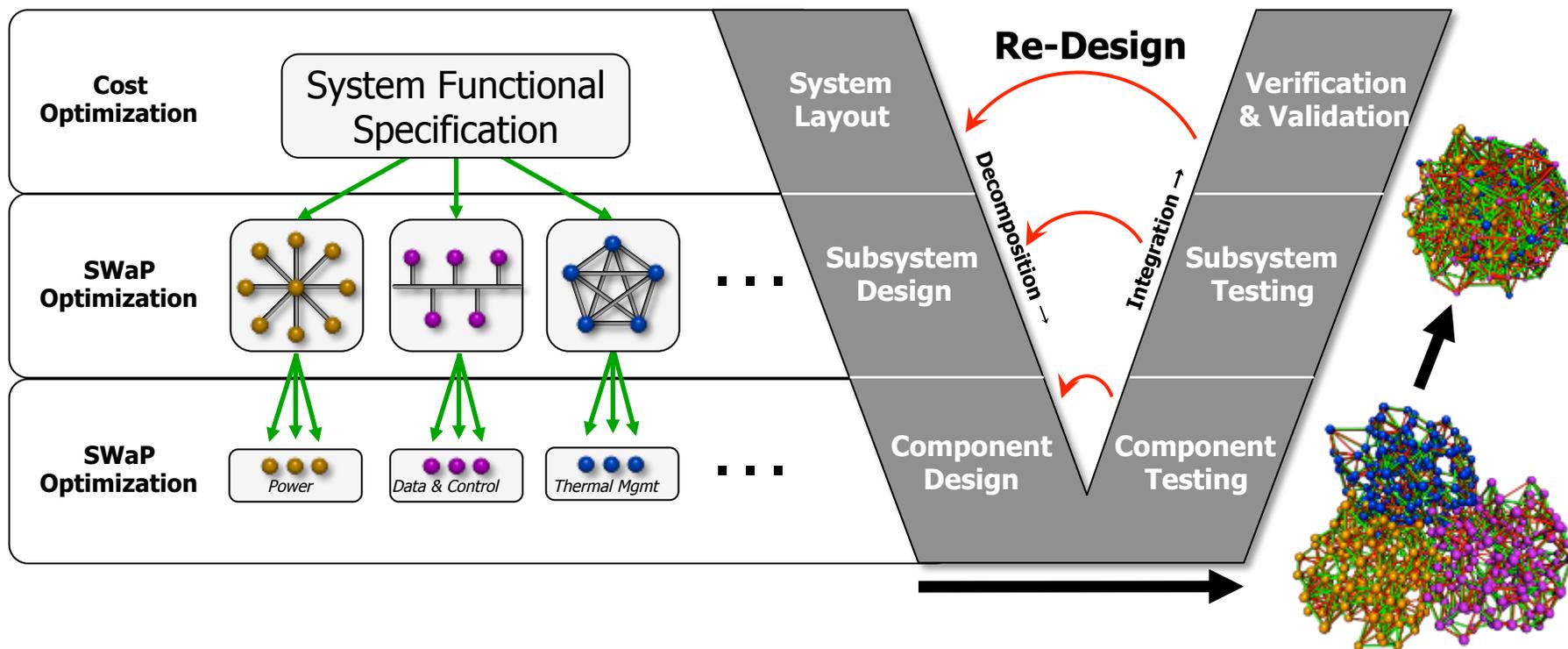
# Dealing With Complexity





# The process today

## MIL-STD-499A (1969) Systems Engineering Process



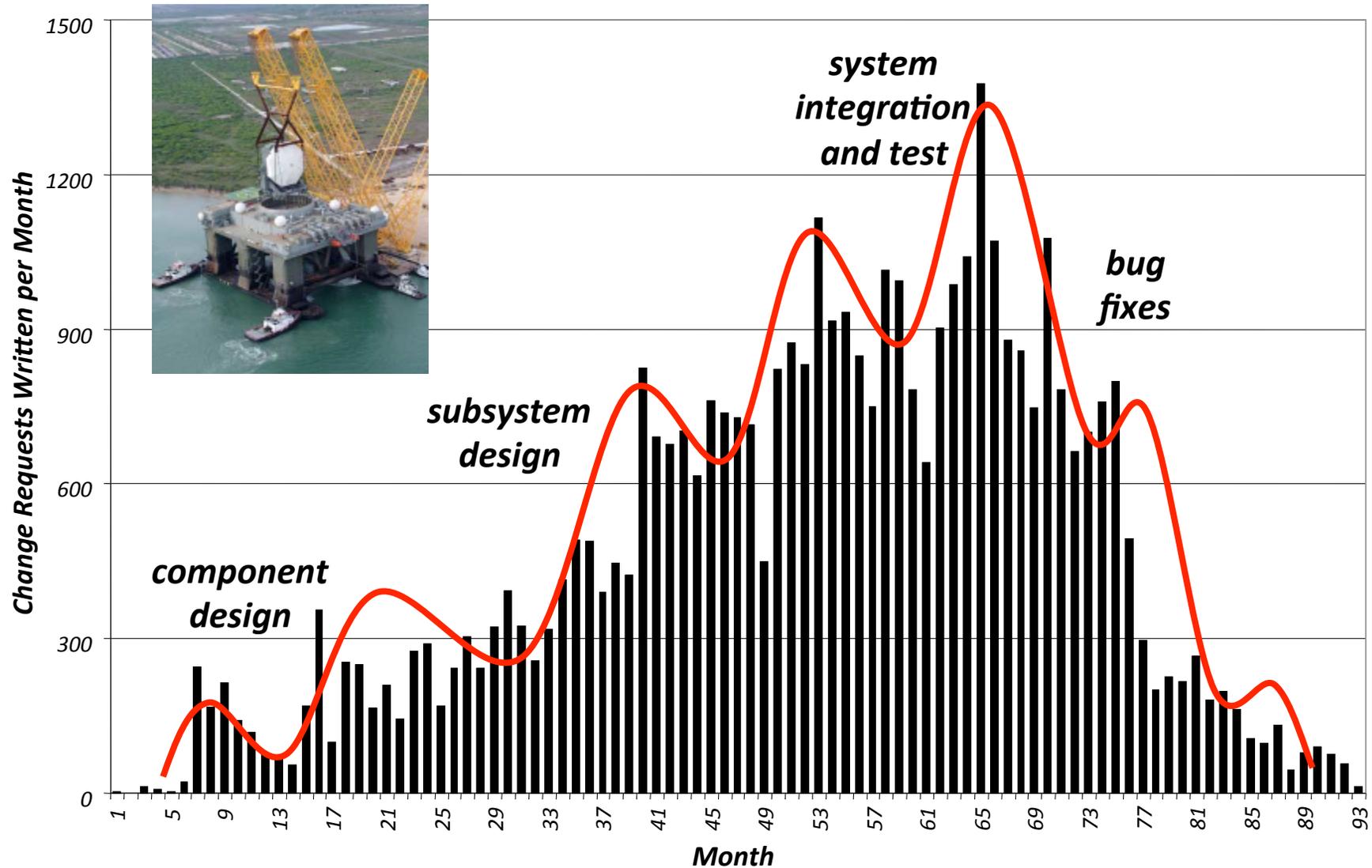
**SWaP = Size, Weight, and Power**  
**V&V = Verification & Validation**

**— Green — Desirable interactions (data, power, forces & torques)**  
**— Red — Undesirable interactions (thermal, vibrations, EMI)**



# Complexity in a real system

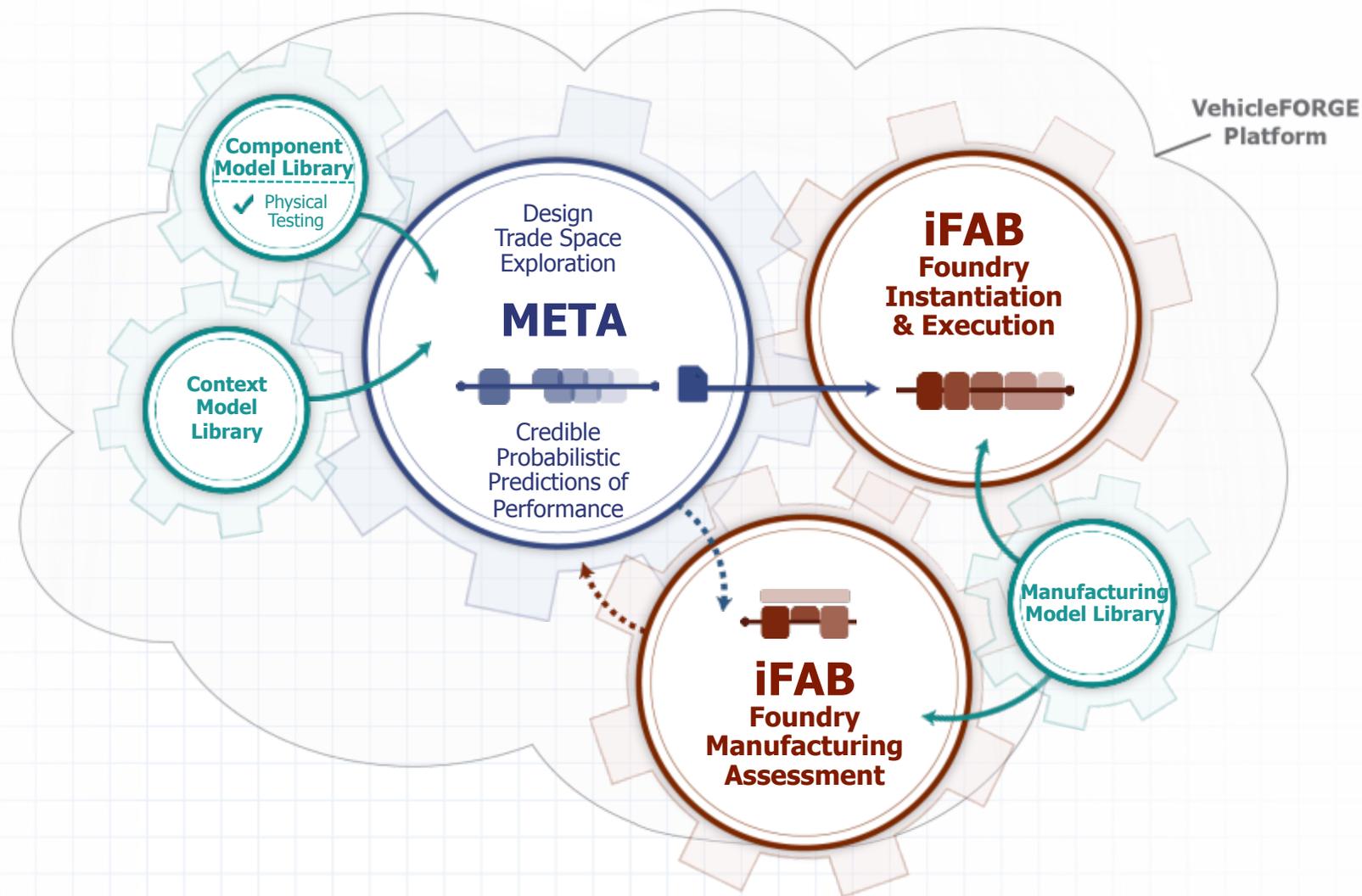
Source: Giffin M., de Weck O., et al., *Change Propagation Analysis in Complex Technical Systems*, Journal of Mechanical Design, **131** (8), 081010, August 2009



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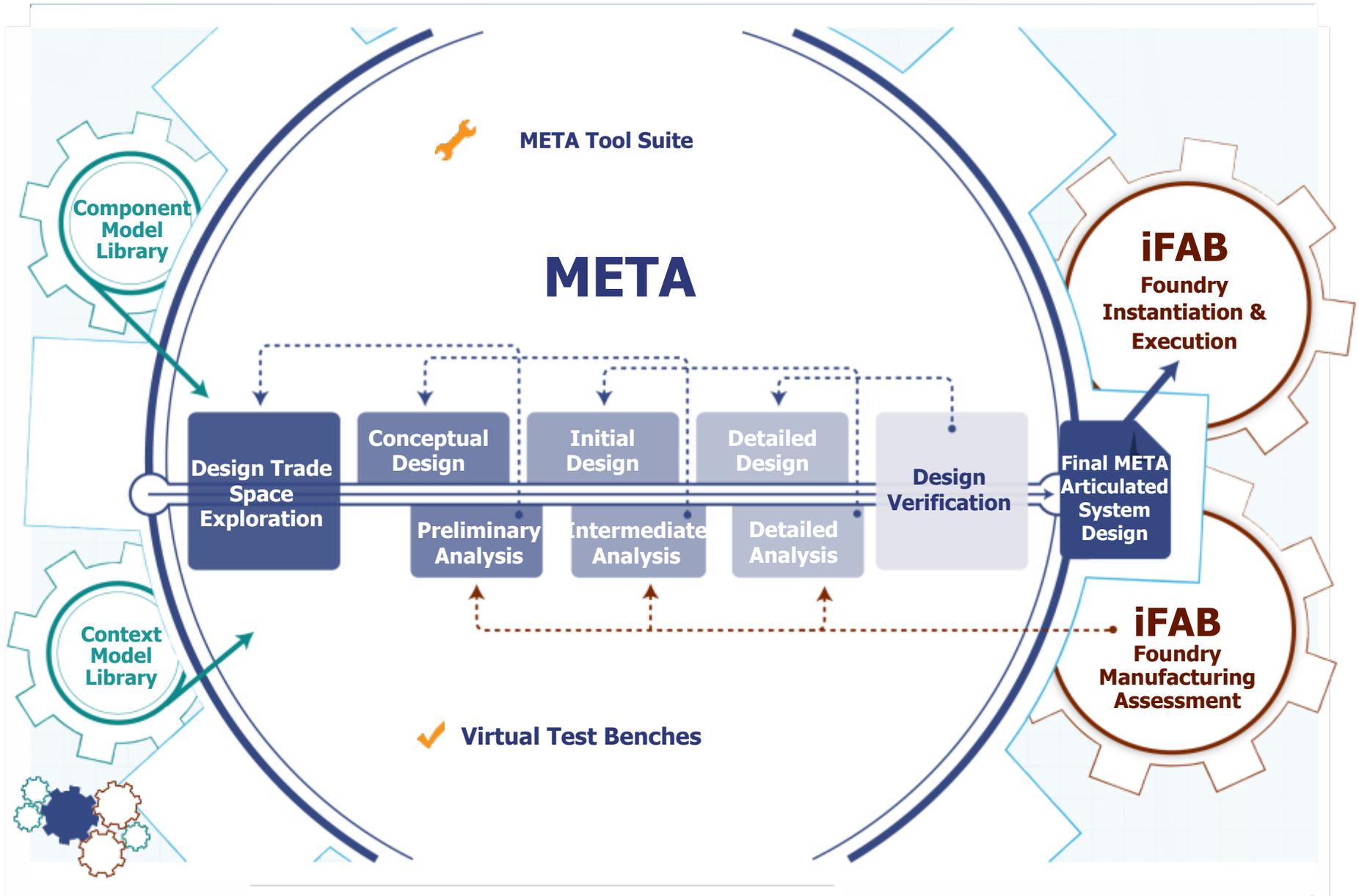


# AVM: Design & Manufacturing Process





# META Design Flow





# META Tools & Virtual Testing



**META Tool Suite**

**Automated Tradespace Generator**

**Static Constraint Applicator**

**DESERT**

**PET**

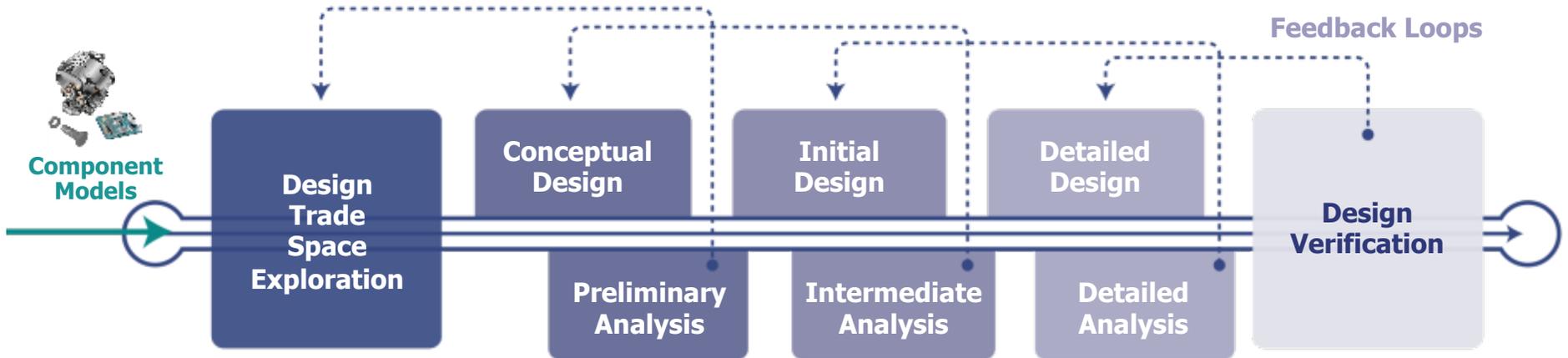
**SIMVIZ**

**Cyber Design**

**META Link**

**X-DATS**

**Component Models**



## Virtual Test Benches

**Context Models**

**Relational Abstraction**

**Qualitative Reasoning**

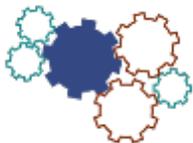
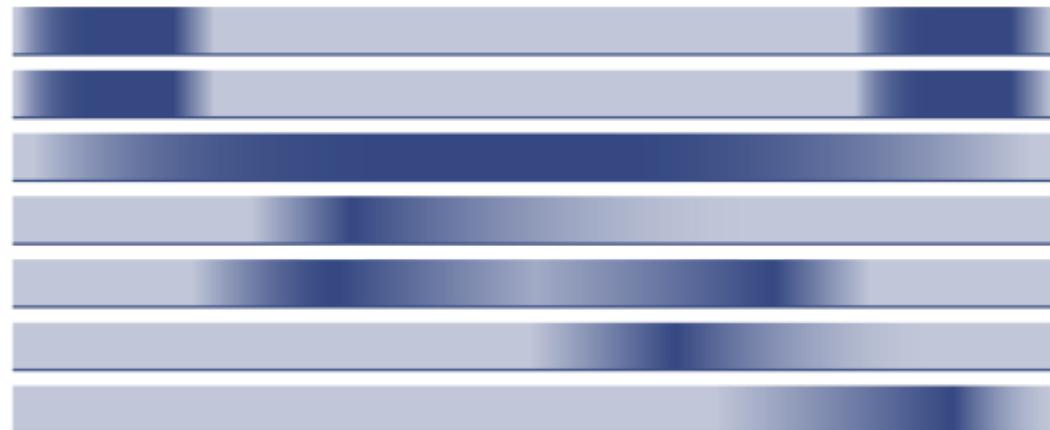
**iFAB Manufacturability Feedback**

**ODE Analysis**

**Fault Analysis & Degraded Operation**

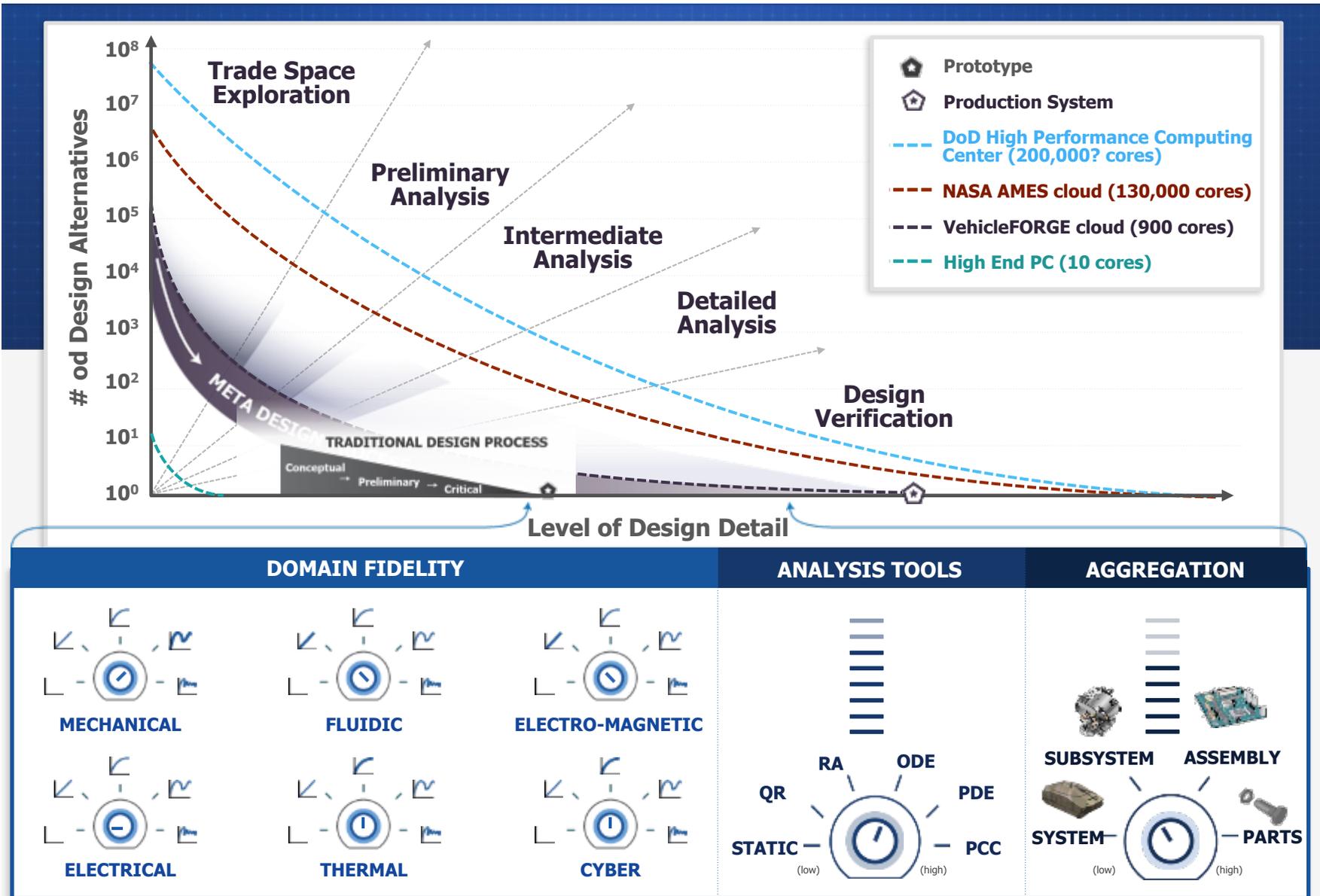
**PDE Analysis**

**Probabilistic Correctness**





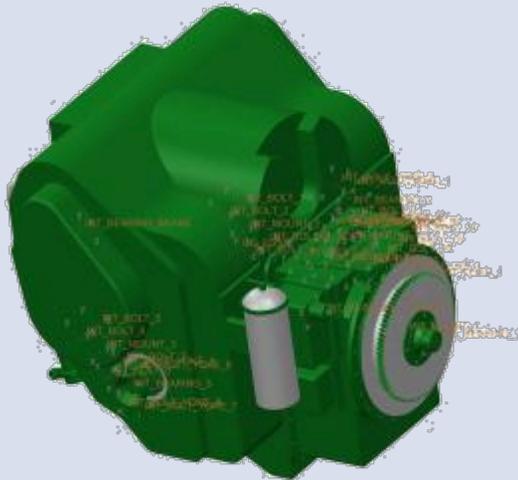
# Maximizing Designer Productivity Through Abstraction



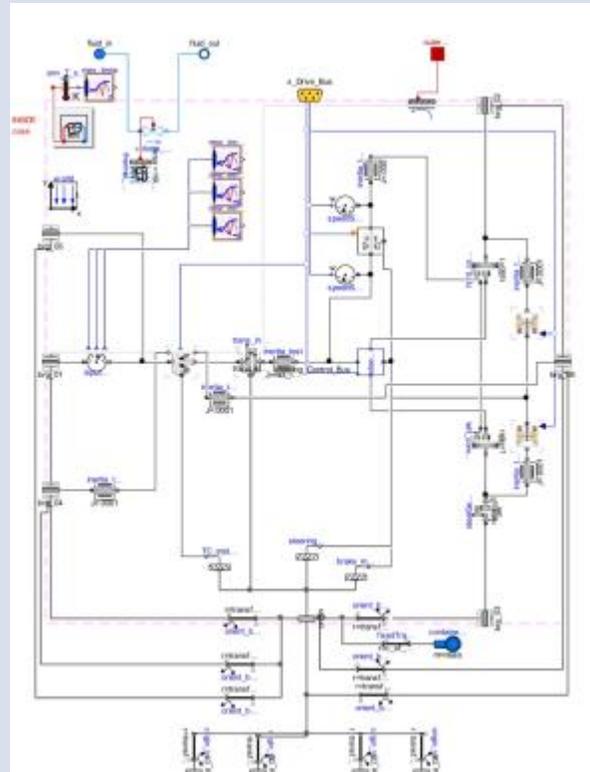


# Elements of a component model

## CAD (Spatial Data)

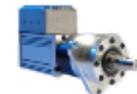
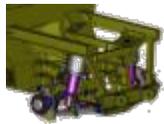


## Modelica (Physics Model)



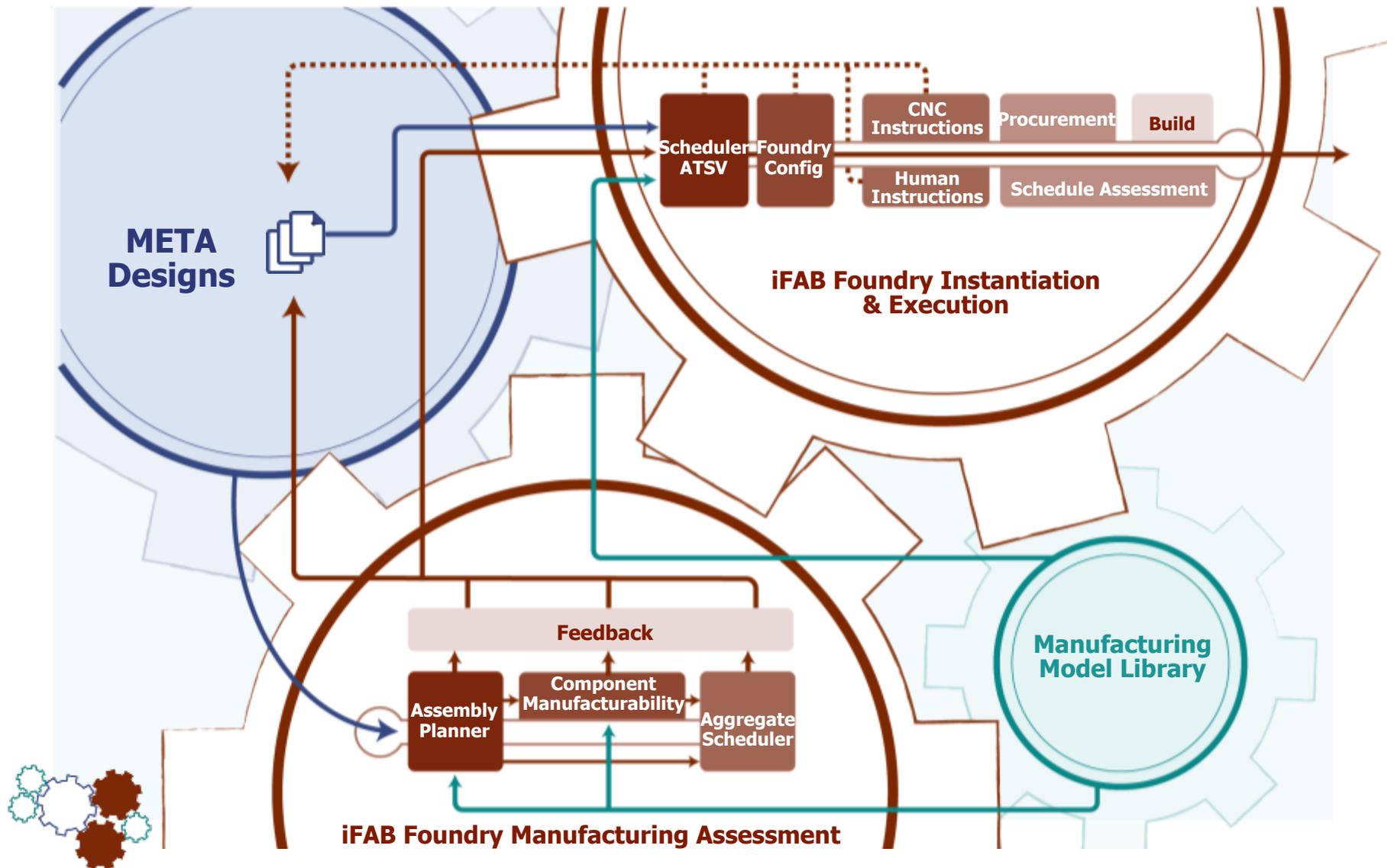
## XML (Instance Data)

Model Type	Parameter Data (BDD)	Model Source	Type Units
Modelica	Gear Ratios	Lookup dependent	Real
Modelica	Efficiency	Lookup dependent	Real
Modelica	Inertia	lookup (Mass Mor	Kg-m^2
Modelica	Inertia (mass moment of)	Value Parameter	Kg-m^2
Modelica	Max input power	Lookup	Kw
Modelica	Max input speed	Lookup	Real
Modelica	Max input torque	Lookup	N.m
Modelica	Range mode	Transform	String
Modelica	Input vibration (g's)	Value Parameter	g's
Modelica	Max Braking Power	Value Parameter	Real
Modelica	Max Braking Temperature	Value Parameter	Real
Modelica	Max Brake Capacity	Value Parameter	Real
Modelica	Weight (wet)	Value Parameter	Real
CAD	Weight (dry)	Value Parameter	Real
SysML	Cost \$	Value Parameter	Real
SysML	Delivery Time (weeks ARC	Value Parameter	Real
CAD	Center of Gravity	Value Parameter	x, y, z
	Output rotation direction		



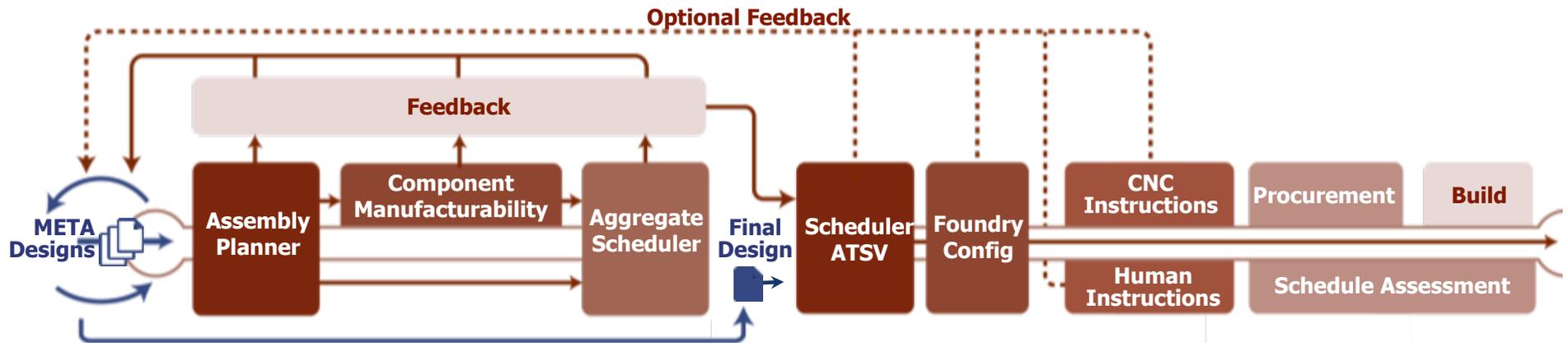


# iFAB Foundry



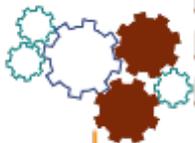


# iFAB Tools



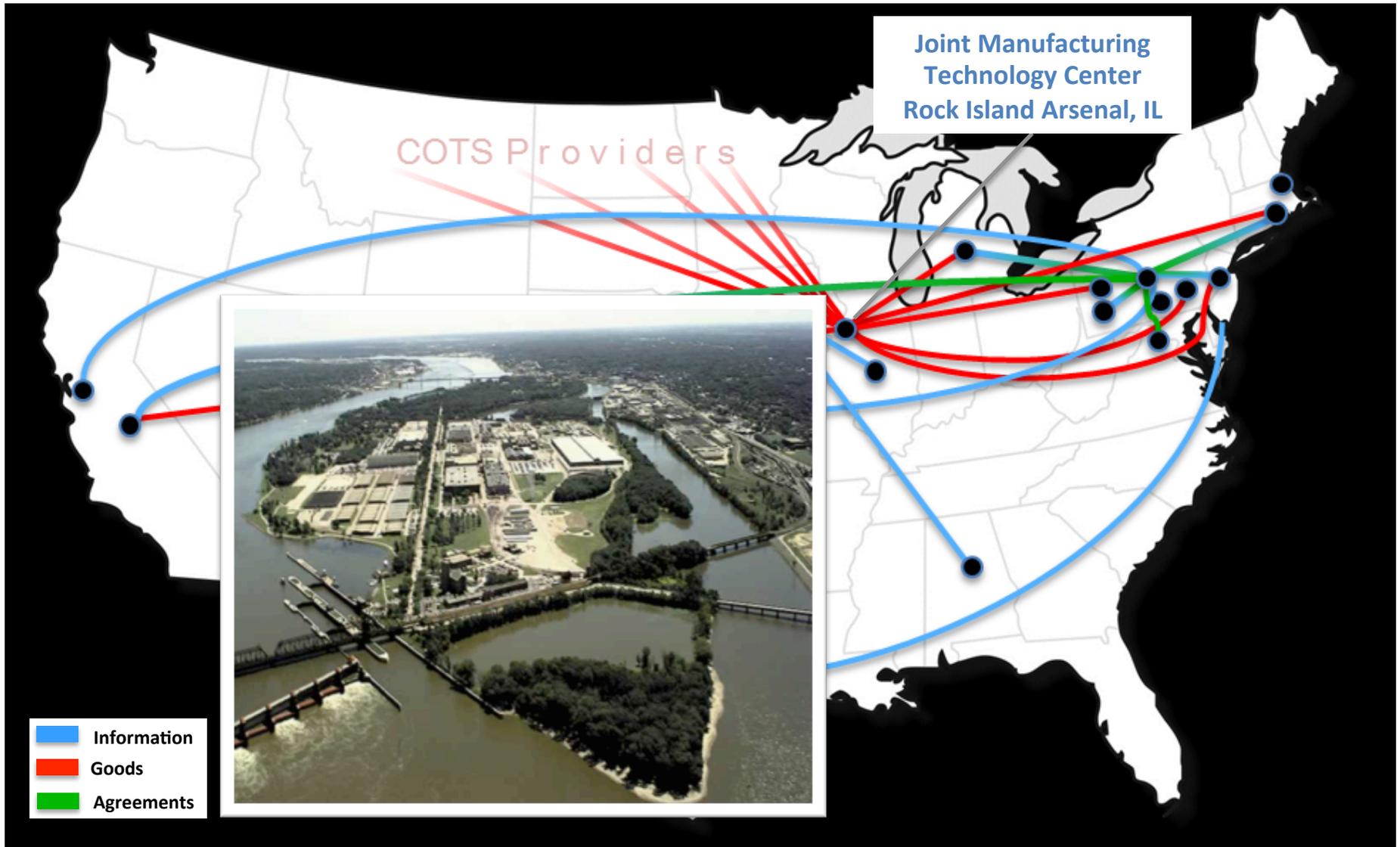
## iFAB Tools

Liaison Graph	
Subassembly Creation	
Assembly Analysis	
Design for Manufacturability Assist Tools	
Casting Analysis	
Machinability	
Tolerance Assessment	
Foundry Configuration	
Robustness of Configuration	
Fixture Configurations	
BOM Management	
CNC Instructions	
Human Instructions	
Product Lifecycle Management	



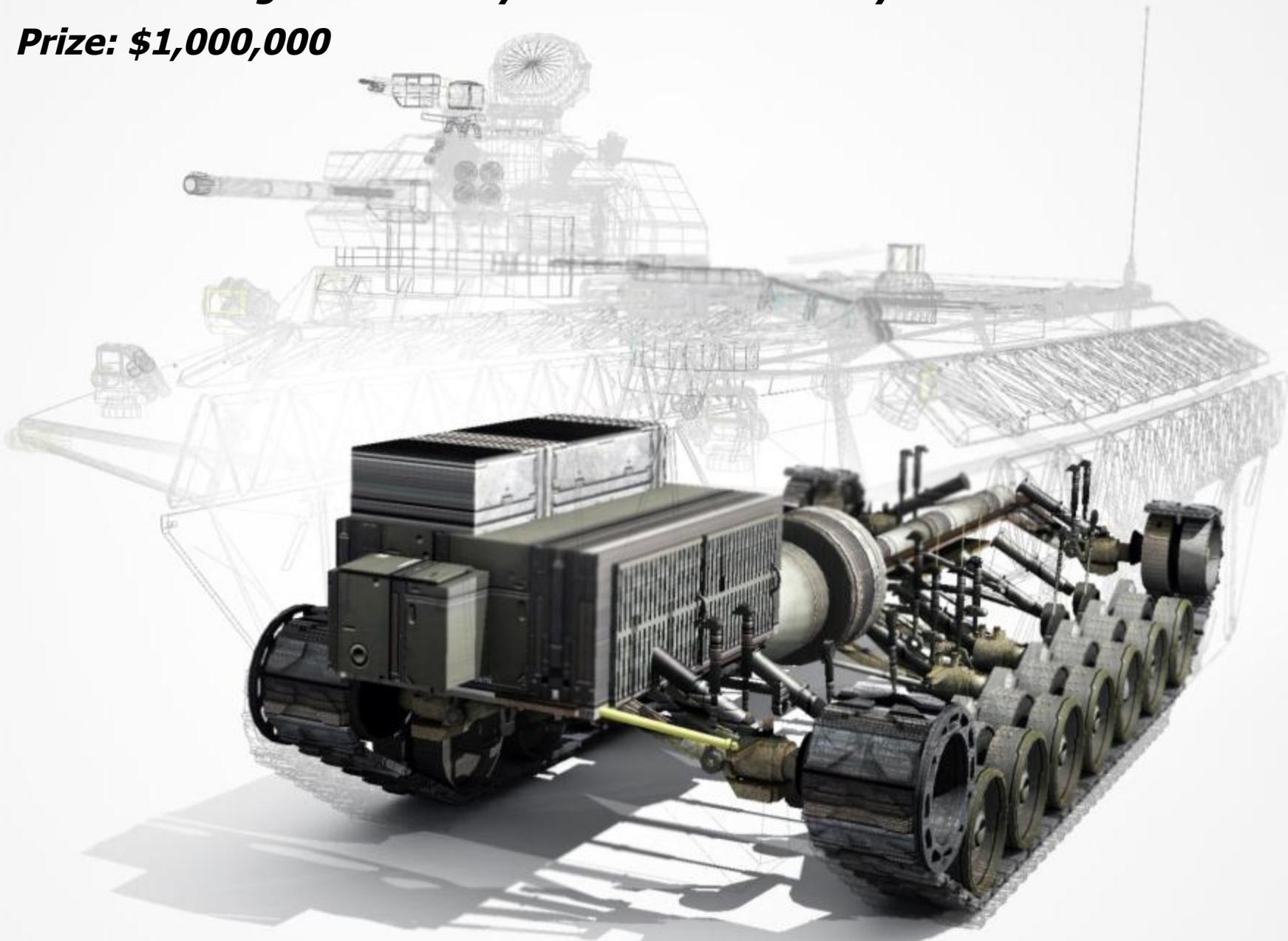


# The iFAB Foundry



***FANG Challenge 1 – Mobility and Drivetrain subsystems***

***Prize: \$1,000,000***



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***FANG 2 – Chassis and Structural subsystems***

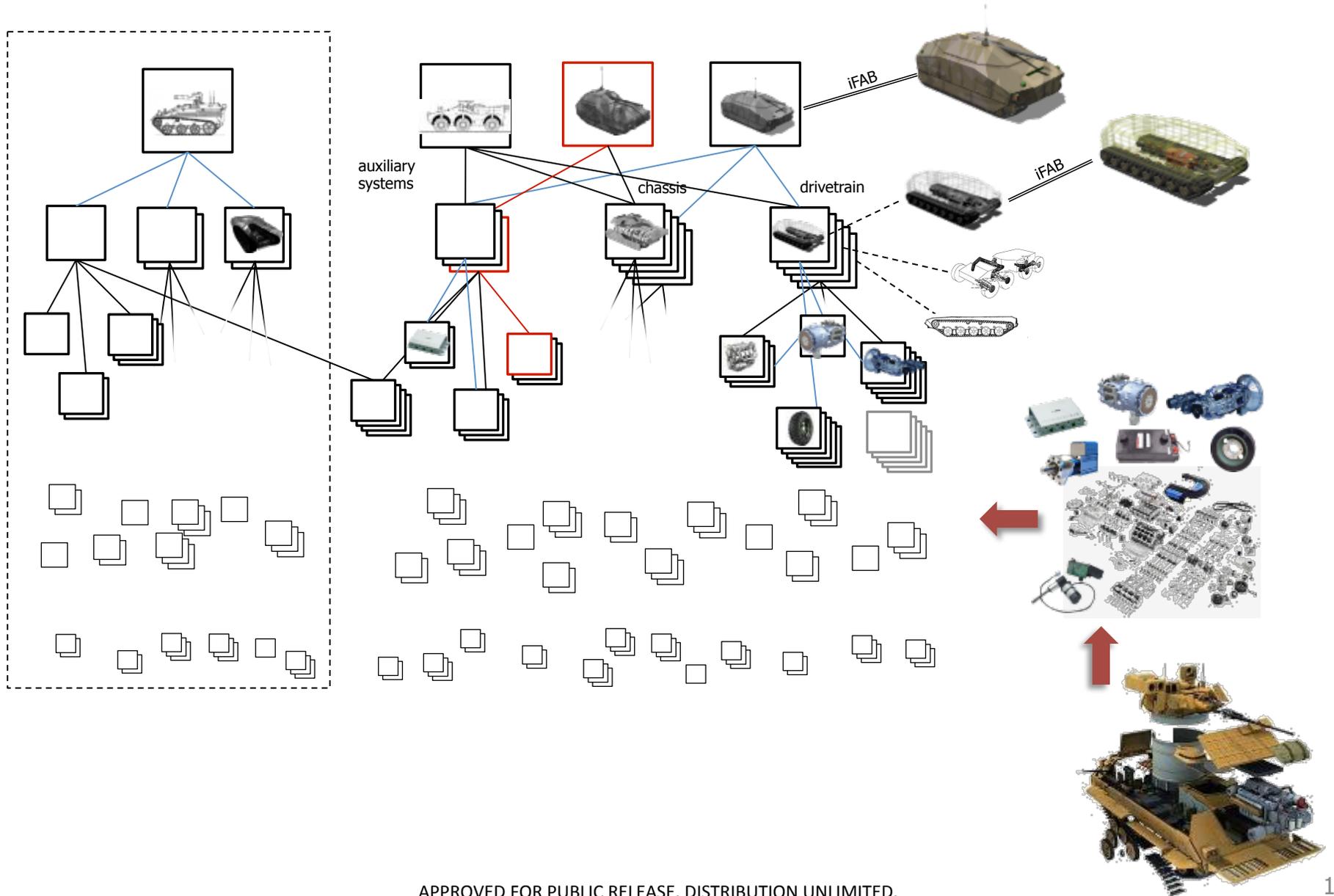


***FANG 3 – Full Vehicle Design***





# VehicleFORGE – Collaboration Platform





## Software transition

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- Request for information (DARPA Special Notice 14-04)
- Transition focused on adoption, maturation, insertion and integration of some subset of AVM products and/or technologies into existing commercial products
- Responses to RFI requested by 10/31, focused on:
  - Current commercial tool set functionality and applicability to AVM goals
  - Customer base
  - AVM tools of interest to you
  - Issues and concerns related to promulgation and adoption of standards
  - Target measures of maturity, quality, testing thoroughness
  - Potential cost/schedule/terms
- Resources available (<https://rfi.vehicleforge.org>):
  - FANG 1 tools/documentation available for download
  - VehicleFORGE open for exploration, with basic tutorial exercise
  - Videos demonstrating post-FANG 1 tool development also on VehicleFORGE
- Queries: [DARPA-SN-14-04@darpa.mil](mailto:DARPA-SN-14-04@darpa.mil)



[www.darpa.mil](http://www.darpa.mil)

**[rfi.vehicleforge.org](http://rfi.vehicleforge.org)**