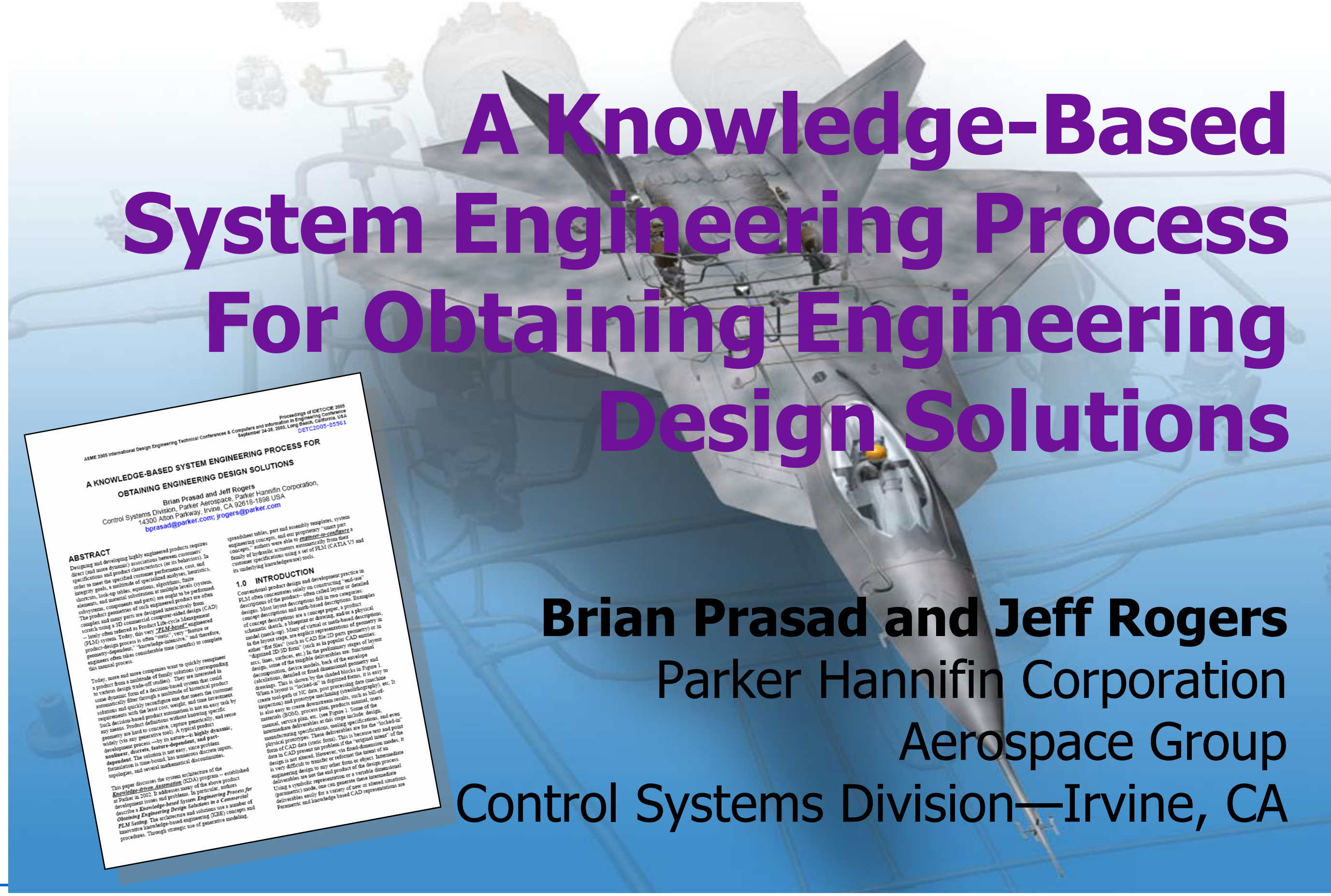

A Knowledge-Based System Engineering Process For Obtaining Engineering Design Solutions

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Aerospace Group

Control Systems Division—Irvine, CA

Mission

Our mission is to provide unequaled value through

superior performance
technical innovation
speed and responsiveness
premier customer service
financial strength

to our customers, company, team members, and community

Vision

JustOne TEAM

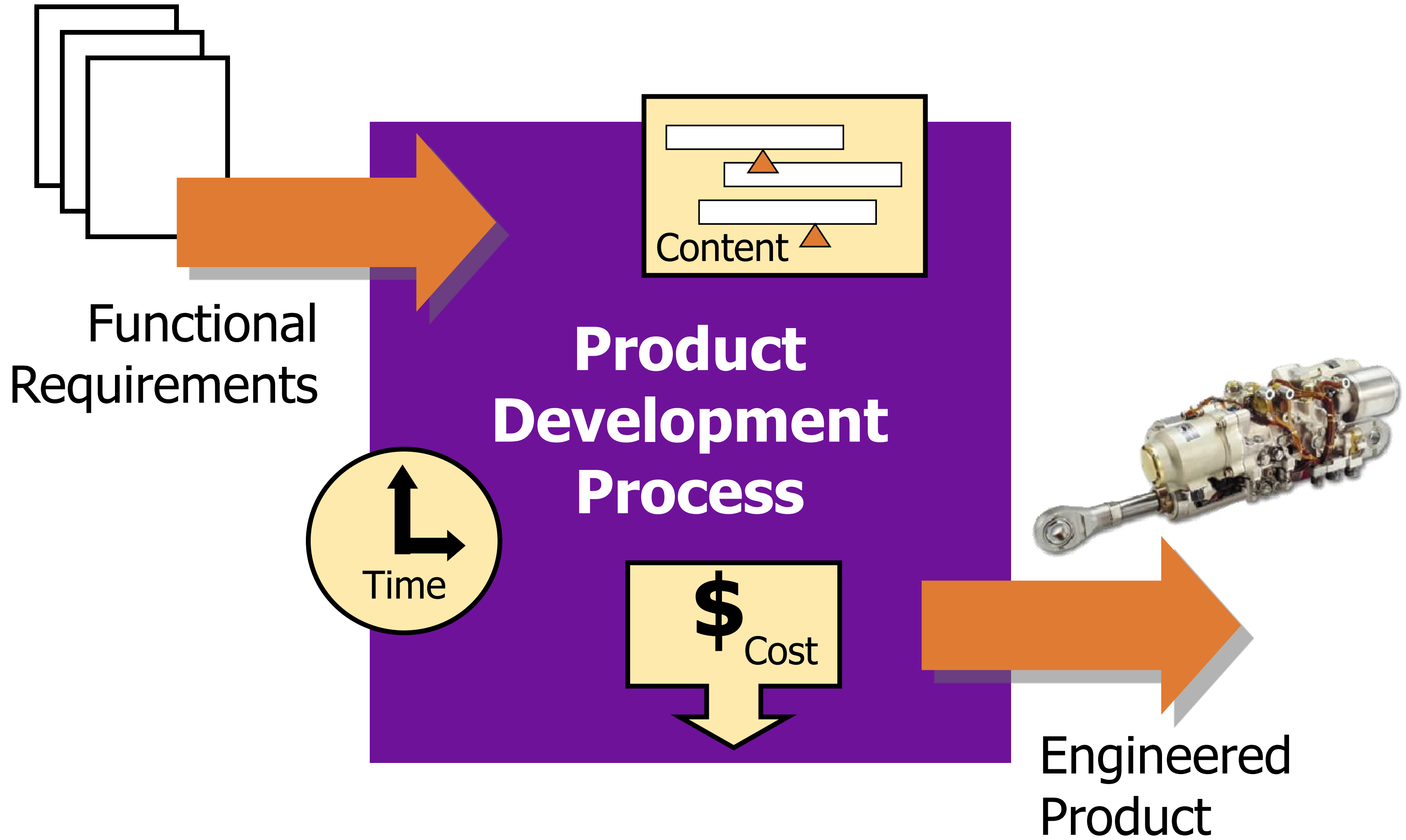
...our lean vision

Vision

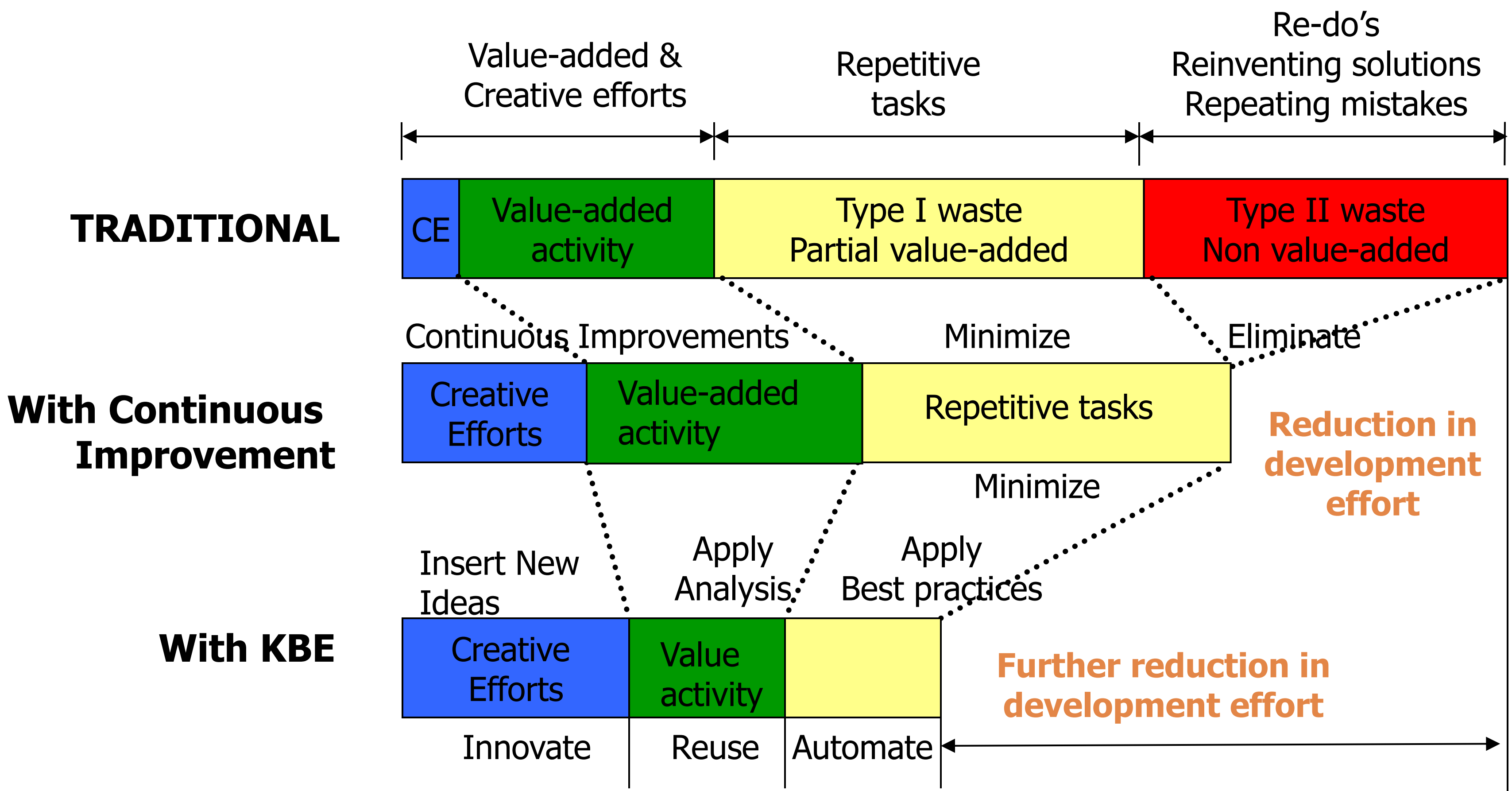
The Spirit of Innovation CSD

Continuous Improvement

Innovation

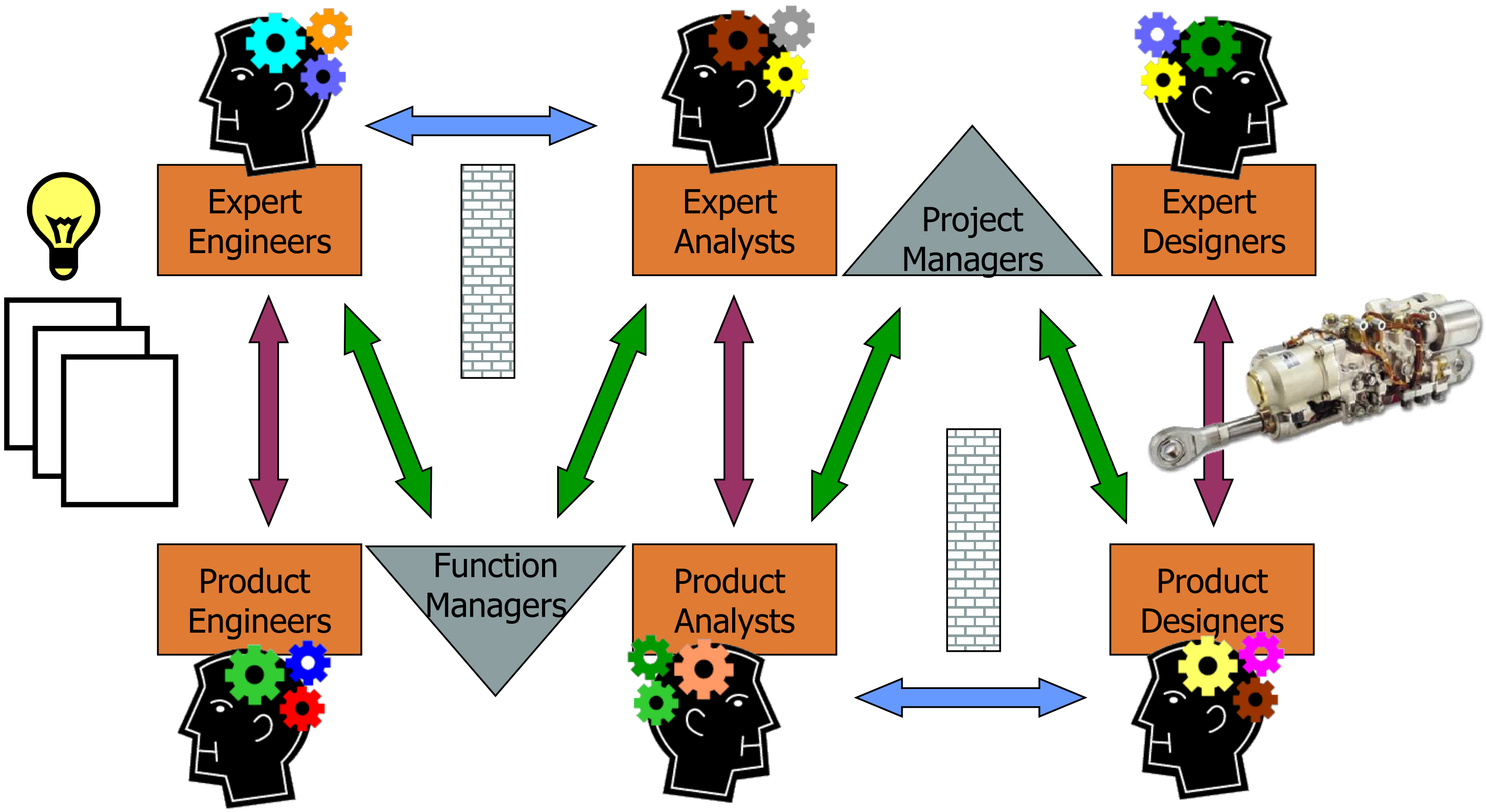

Functional
Requirements
Content
Product
Development
Process
Time
$
Cost
Engineered
Product

Product-development process

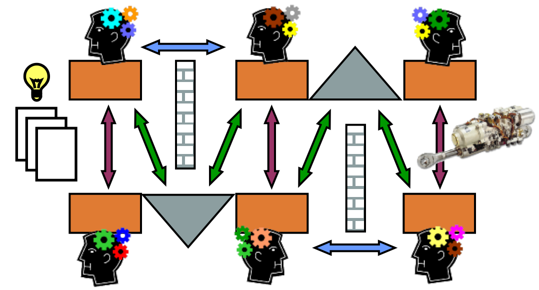


KBE: Knowledge-Based Engineering

Typical design scenario

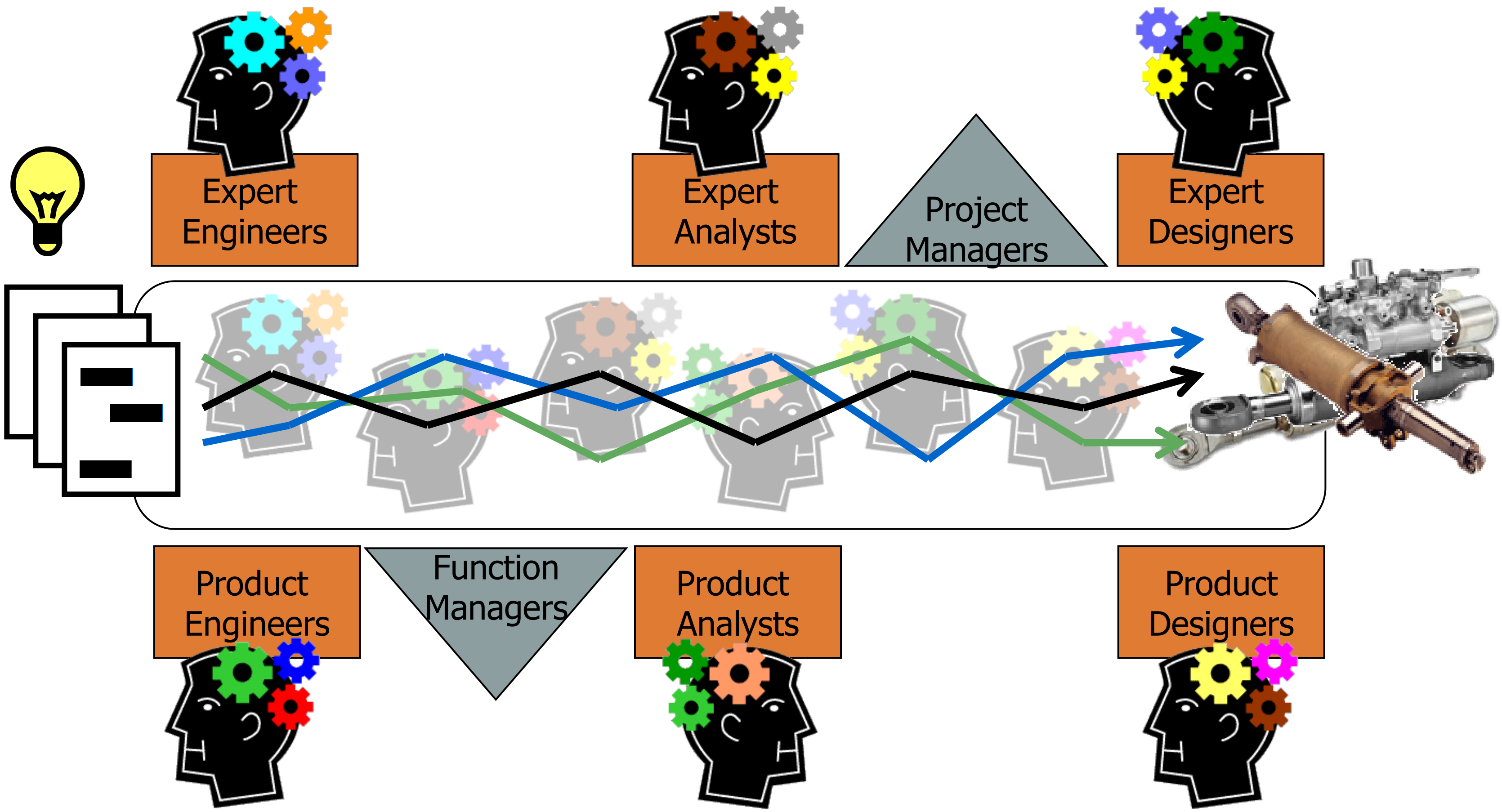


What's wrong with this?

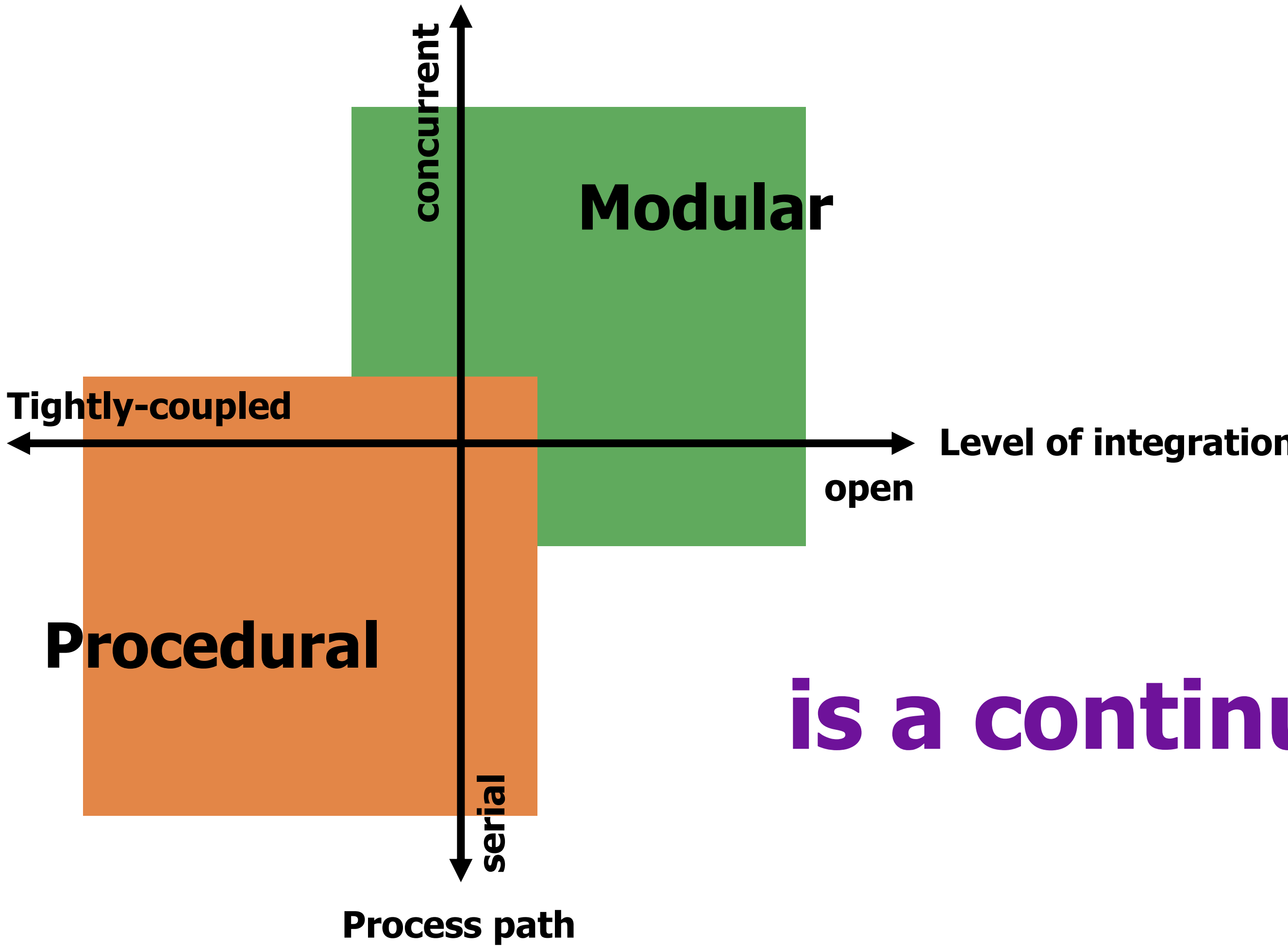


- Knowledge is fragmented
- Subject matter experts (SME) often scarce and busy
- Less uniformity and consistency
- Time-intensive, manpower dependent
- When people retire, information is lost
- Often design is done via trial and error—case-based reasoning

Knowledege-centric approach

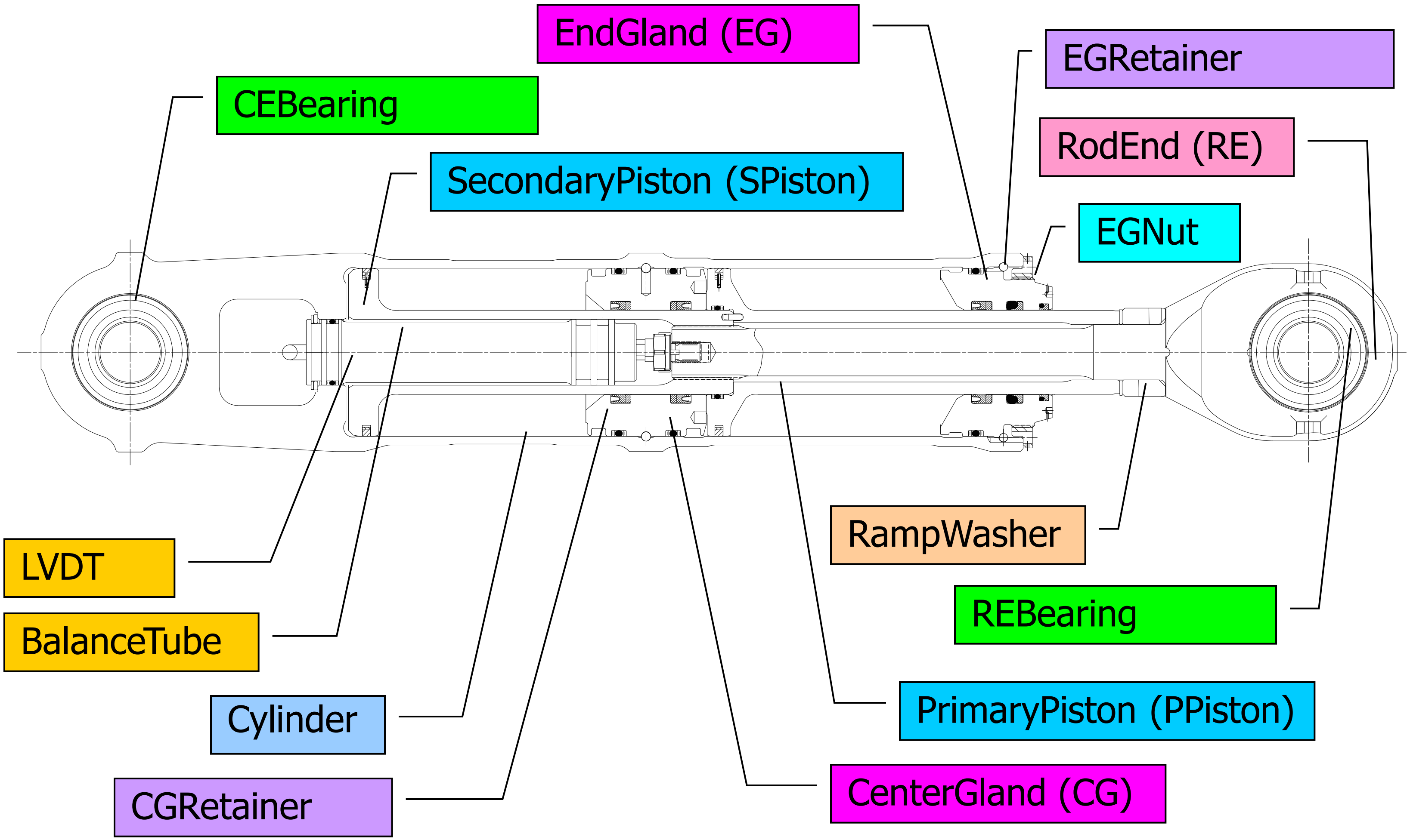


Enrichment of knowledge…

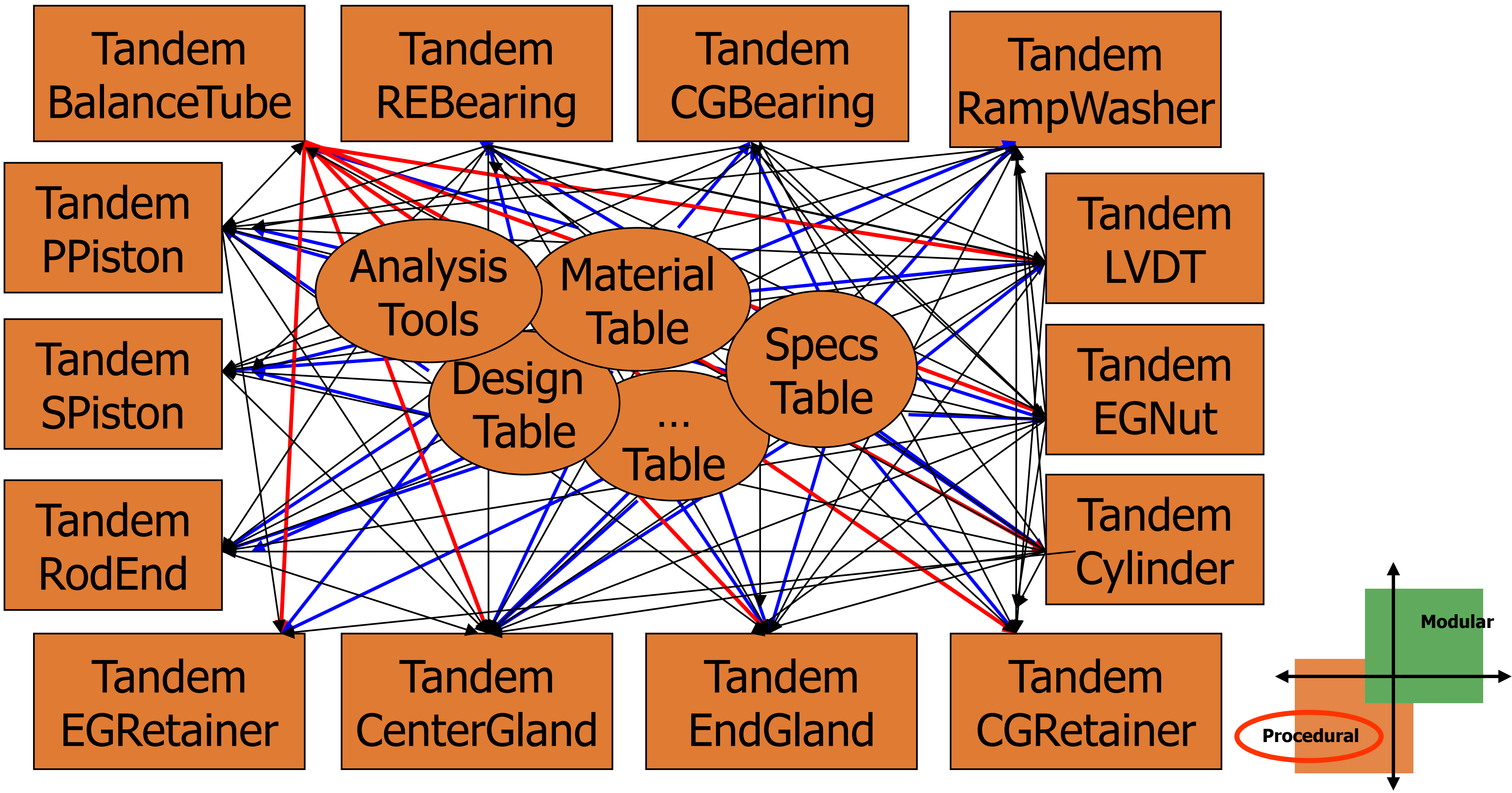


is a continuum

Let’s consider this situation

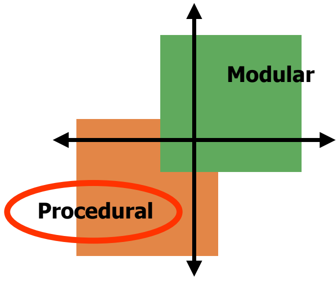


Serial, tightly-coupled KBE system



Drawbacks of procedural process

- Part and product specific
- Hard-coded interfaces
- Cumbersome to maintain
- Incompatible API's
- External parameter linking issues
- Very sensitive to interface changes (parameters, rules, features)
- Expansions are complex and error prone
- Inflexible

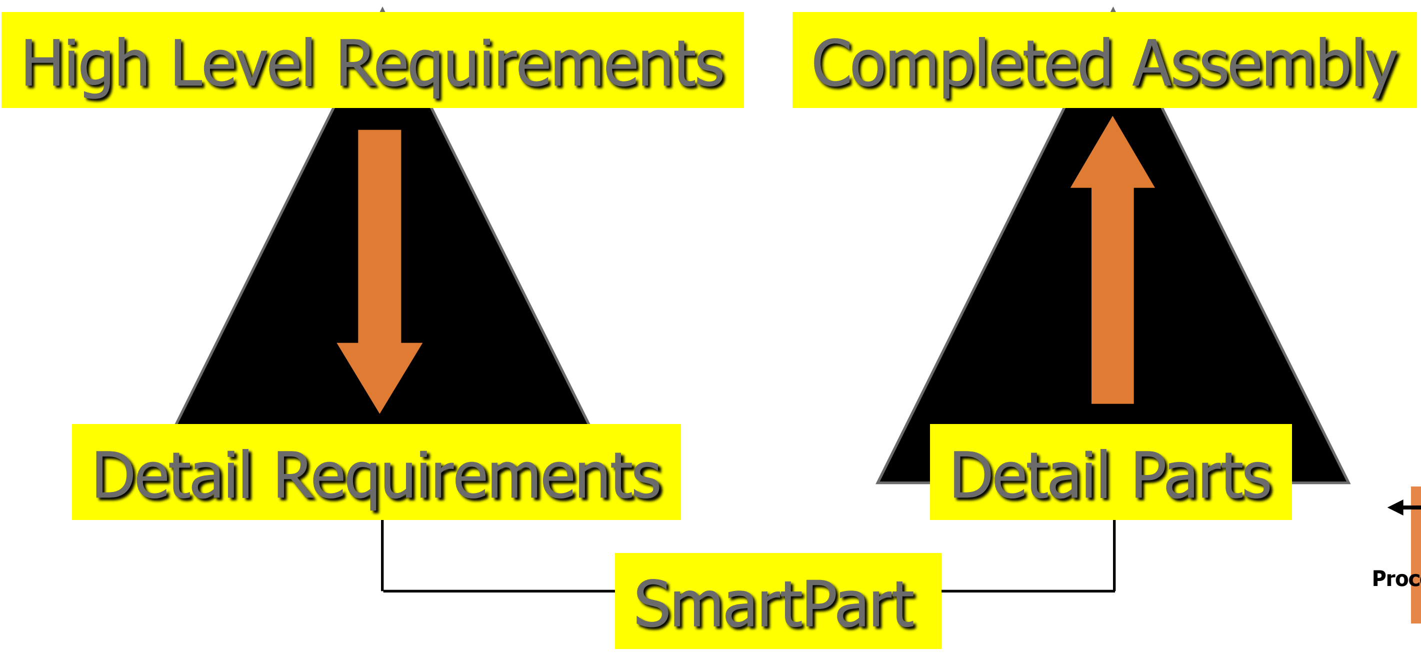


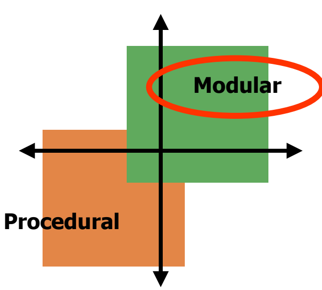
Modular, rule-based KBE system

An assembly of parametric parts, where dependence of one part to another is controlled by a “control structure logic”—whose primary function is to link relationships and attributes throughout a product hierarchy resulting in a product assembly that is associative.

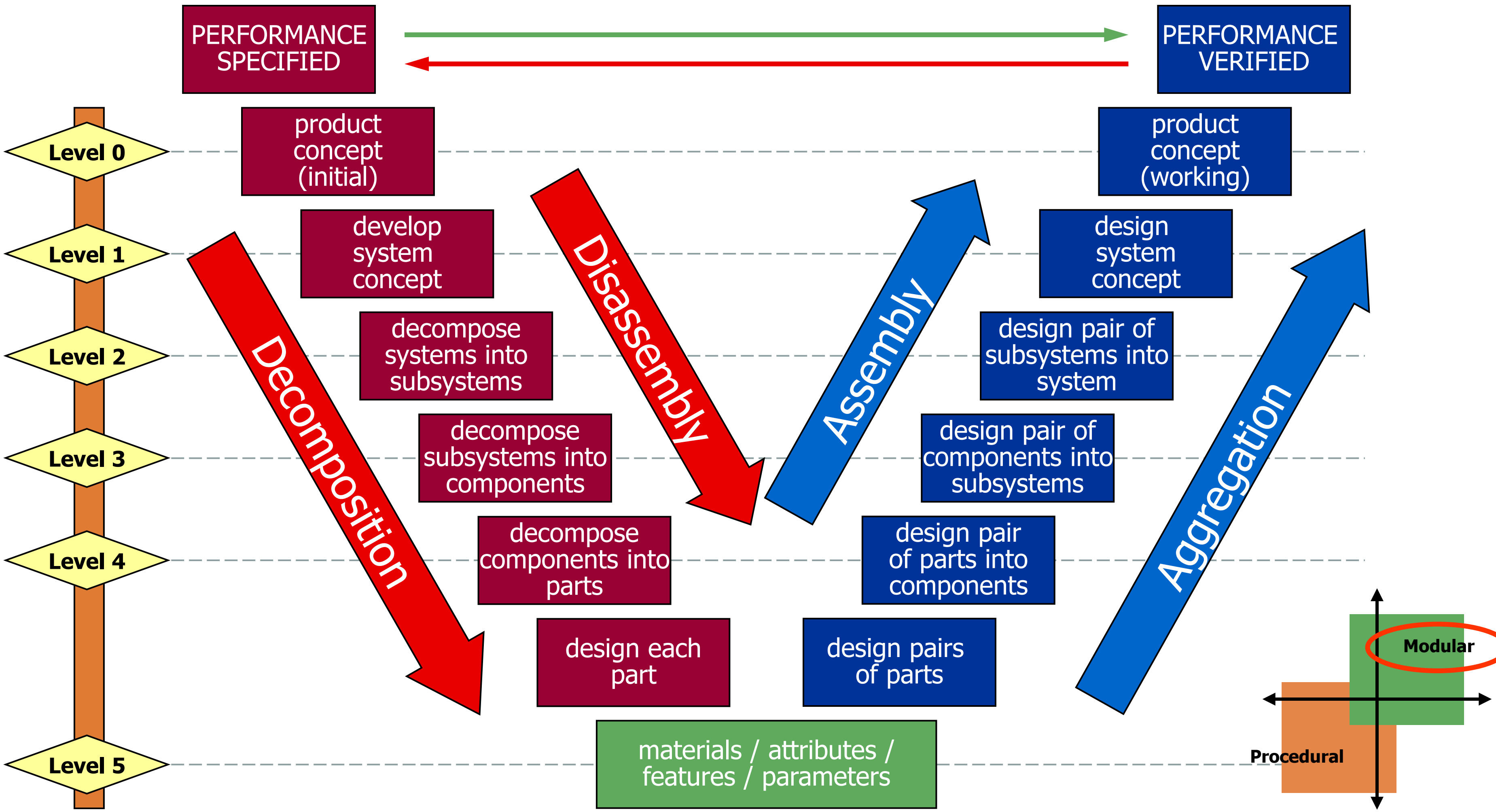
Control Structure

Product Assembly





Modular systems approach

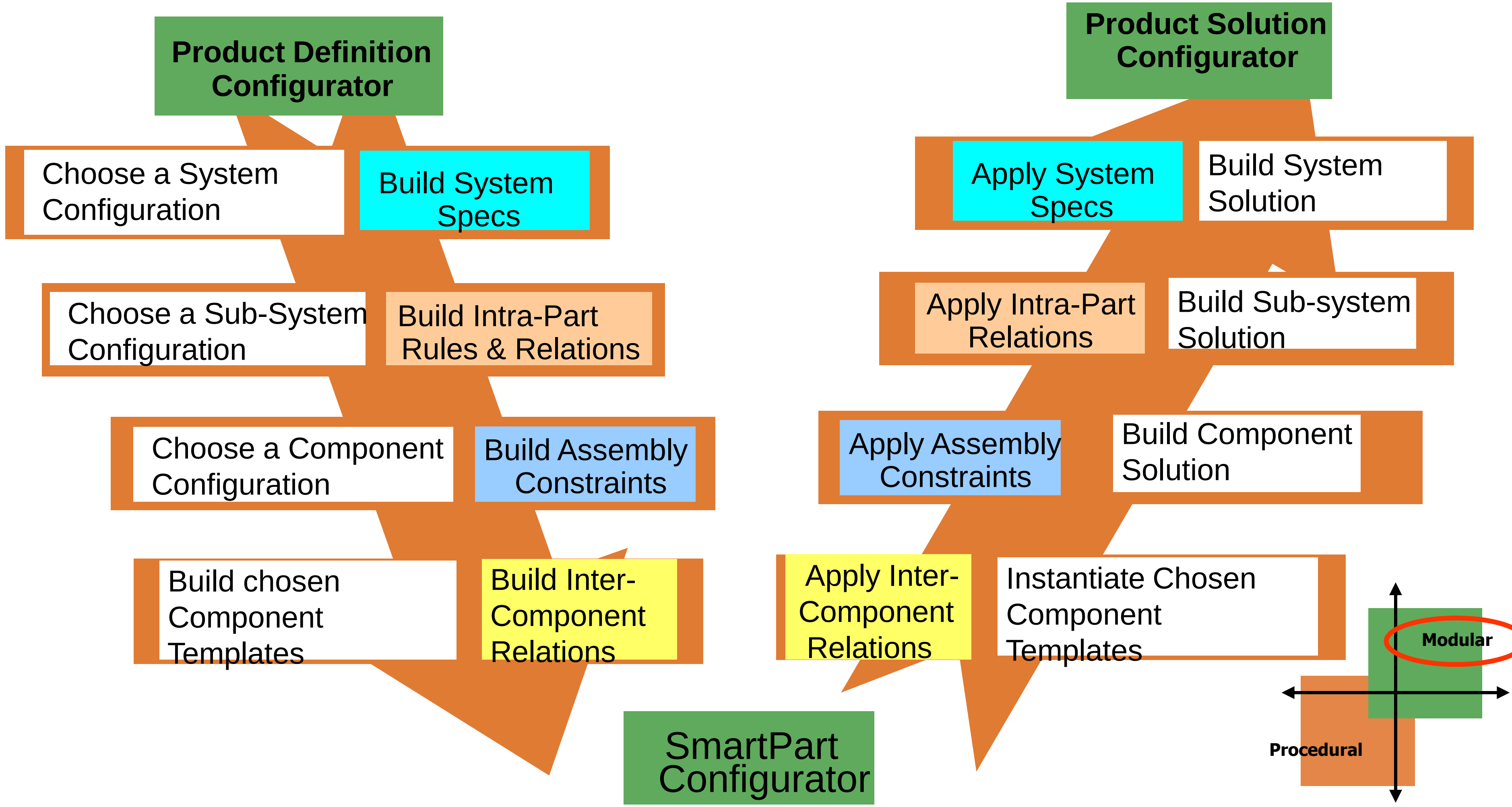


Modular KBE System

Product Lifecycle Management (PLM)

Implementation

Open, concurrent KBE system



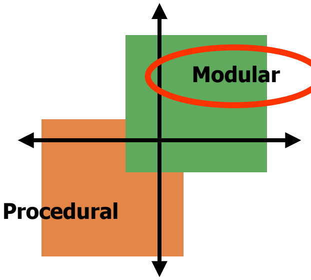
Merits of modular process

Product Definition Configurator

- Product-Independent
  - Architecture
- Part-Independent
  - Concept
- Tool-Independent
  - Method

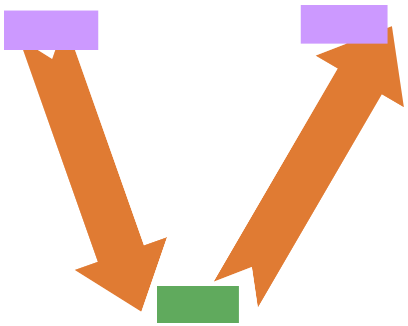
Product Solution Configurator

SmartPart Configurator



A CATIA V5 implementation

- System Architecture
  - JustOne system model and common tree structure
- Generative Rule Bodies
  - Rule bodies create more rules dynamically on the tree; asleep until awaken
  - Retrieve templates; no generative geometry
- Internal Linking
  - Two generalized automation methods to pass/exchange information intrapart and interpart



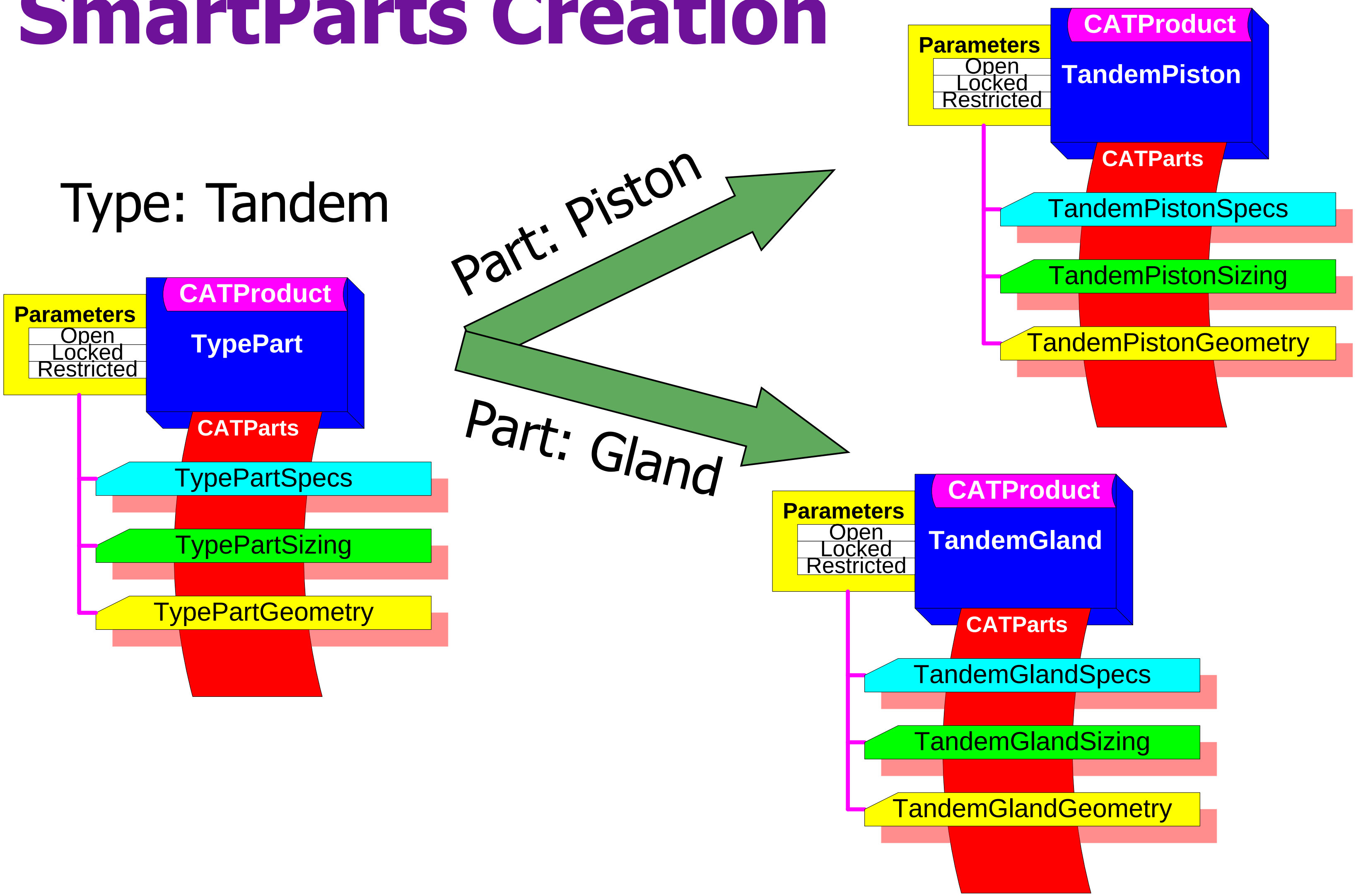
Specs Definitions (Excel Inputs)

	B	C	D	E	F	G	H	I	J
1	Constraint Name	Type	Value (ir	Constraint Orienta	First Product	First Publication	Second Pro	Second Publication	Compute
2	CY2PP_Axial_Coincidence	Coincidence		CatCstOrientUndefined	Cylinder	Cylinder_AxisLine	PPiston	PPiston_AxisLine	Y
3	CY2REEG_Axial_Coincidence	Coincidence		CatCstOrientUndefined	Cylinder	Cylinder_AxisLine	REEndGland	REEG_AxisLine	Y
4	CY2REEG_Transverse_Parallel	Parallel		CatCstOrientSame	Cylinder	Cylinder_TransverseLine	REEndGland	REEG_TransverseLine	Y
5	CY2REEG_Contact	Coincidence		CatCstOrientOpposite	Cylinder	CylinderNutBoreThread_REEndGland_Contac	REEndGland	REEGMiddleRing_Cylinder_ContactPla	Y
6	CY2EGLockNut_Axial_Coincidence	Coincidence		CatCstOrientUndefined	Cylinder	Cylinder_AxisLine	EGLockNut	EGLockNut_AxisLine	Y
7	CY2EGLockNut_Transverse_Parallel	Parallel		CatCstOrientSame	Cylinder	Cylinder_TransverseLine	EGLockNut	EGLockNut_TransverseLine	Y
8	CY2EGLockNut_Contact	Contact		N/A	Cylinder	Cylinder_EGLockNut_ContactFace	EGLockNut	EGLockNut_Cylinder_ContactFace	N
9	CY2CEEG_Axial_Coincidence	Coincidence		CatCstOrientUndefined	Cylinder	Cylinder_AxisLine	CEEndGland	CEEG_AxisLine	Y
10	CY2CEEG_Transverse_Parallel	Parallel		CatCstOrientSame	Cylinder	Cylinder_TransverseLine	CEEndGland	CEEG_TransverseLine	Y

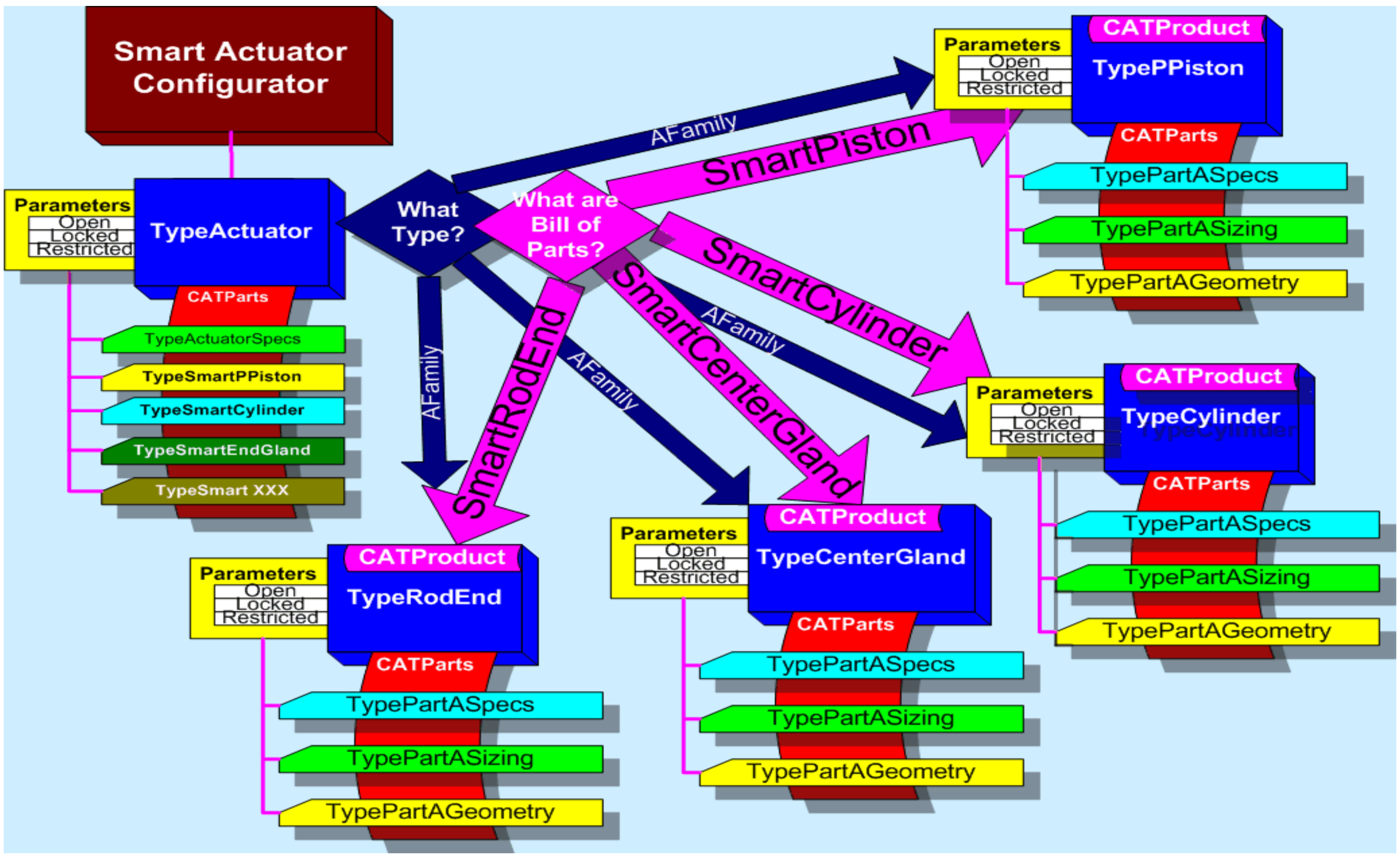
12	Nom_PTank_Pressure (psi)	175.001	150.001	600.001
13	Nom_STank_Pressure (psi)	100.001	150.001	600.001
14	Limit_Load_Compression (lbf)	120060.001	180060.001	61600.001
15	Limit_Load_Tension (lbf)	112140.001	112140.001	61600.001
16	Ultimate_Load_Compression (l	180090.001	180090.001	92401.001
17	Ultimate_Load_Tension (lbf)	168210.001	168210.001	92401.001
18	Ultimate_Load_Side (lbf)	800	800	400
19	Endurance_Load_Fatigue (lbf)	104400.001	104400.001	51334.001
20	Proof_Supply_Pressure (psi)	6000.001	6000.001	6500.001
21	Burst_Supply_Pressure (psi)	10000.001	10000.001	10820.001
22	Impulse_Supply_Pressure (psi)	6000.001	6000.001	6100.001
23	Proof_Tank_Pressure (psi)	4000.001	4000.001	1275.001
24	Burst_Tank_Pressure (psi)	6000.001	6000.001	2125.001
25	Impulse_Tank_Pressure (psi)	2000.001	2000.001	700.001
26	Impulse_Load_Cycles_Fatigue	1000.001	1000.001	5000.001
27	Stroke_Nominal (in)	9.487	9.487	8.592
28	Retract_Length (in)	24	34.957	33.394
29	Bearing_Friction_Coeff_Proof	0.15	0.15	0.15
30	Bearing_Friction_Coeff_Burst	0.2	0.2	0.2
31	Bearing_Friction_Coeff_Fatigue	0.1	0.1	0.1

& SH	160	600000.001	0	3		
	160	600000.001	0	3		
NG	160	50000.001	0	3	5c4	4a0
ORMS	160	600000.001	0	2		
	160	600000.001	0.25	3		
)	160	50000.001	0.25	2.5		
NG	160	50000.001	0.25	2.5		
	160	50000.001	0.25	2.5		
NG	160	50000.001	0.25	2.5		
NG	160	50000.001	0.25	2.5		
NG	160	50000.001	0.25	2.5		
)	160	50000.001	0.25	2.5		
NG	160	50000.001	0.25	3		

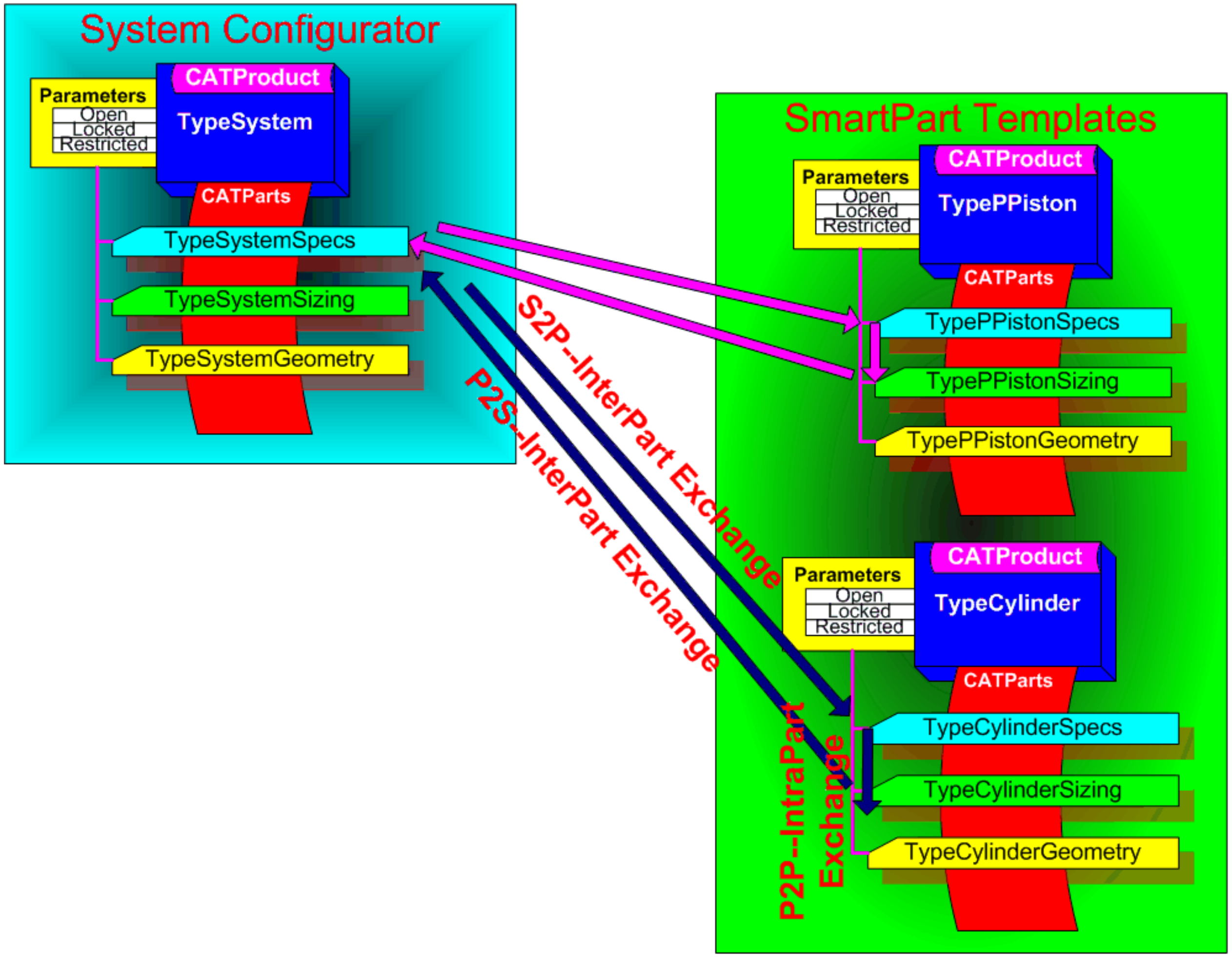
SmartParts Creation



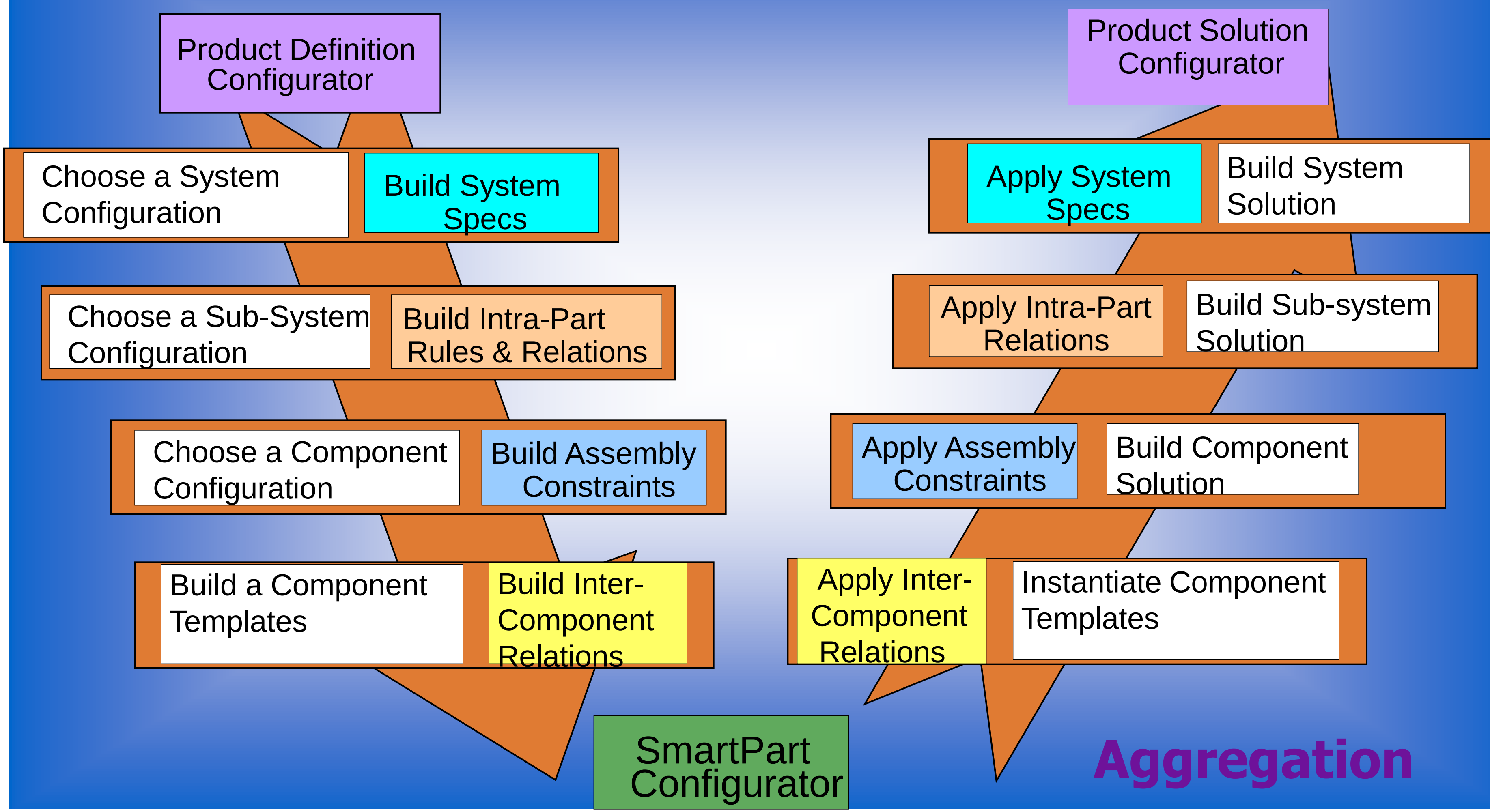
Achieving a Product Solution



Inter- & Intrapart communications

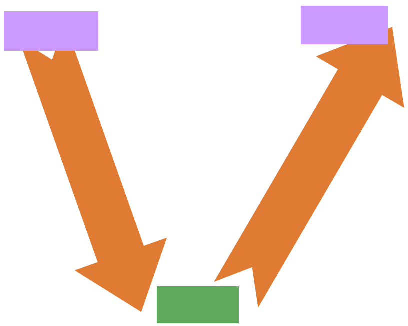


Demo


Product Definition Configurator
Choose a System Configuration
Build System Specs
Choose a Sub-System Configuration
Build Intra-Part Rules & Relations
Choose a Component Configuration
Build Assembly Constraints
Build a Component Templates
Build Inter-Component Relations
SmartPart Configurator
Product Solution Configurator
Apply System Specs
Build System Solution
Apply Intra-Part Relations
Build Sub-system Solution
Apply Assembly Constraints
Build Component Solution
Apply Inter-Component Relations
Instantiate Component Templates
Aggregation

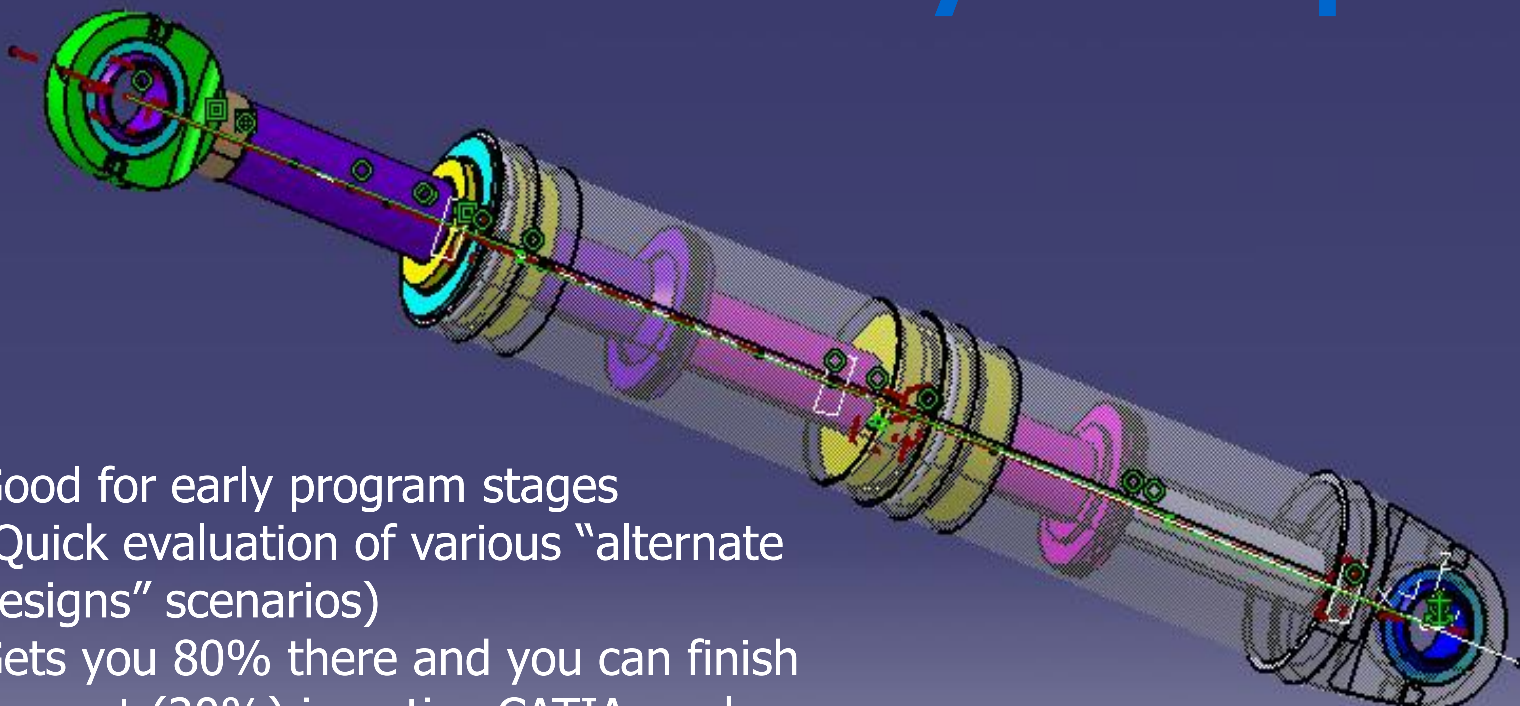
Demo–Salient points

- Initialize parameters
- SmartParts pulled and Rules added
- Specs parameters & constraints passed from "systems" to "subsystems", to "components," to "parts" during "decomposition" and vice versa during "aggregation"
- SmartParts were "instantiated" and constraints satisfied
- Solution is reconfigurable for changing spec requirements



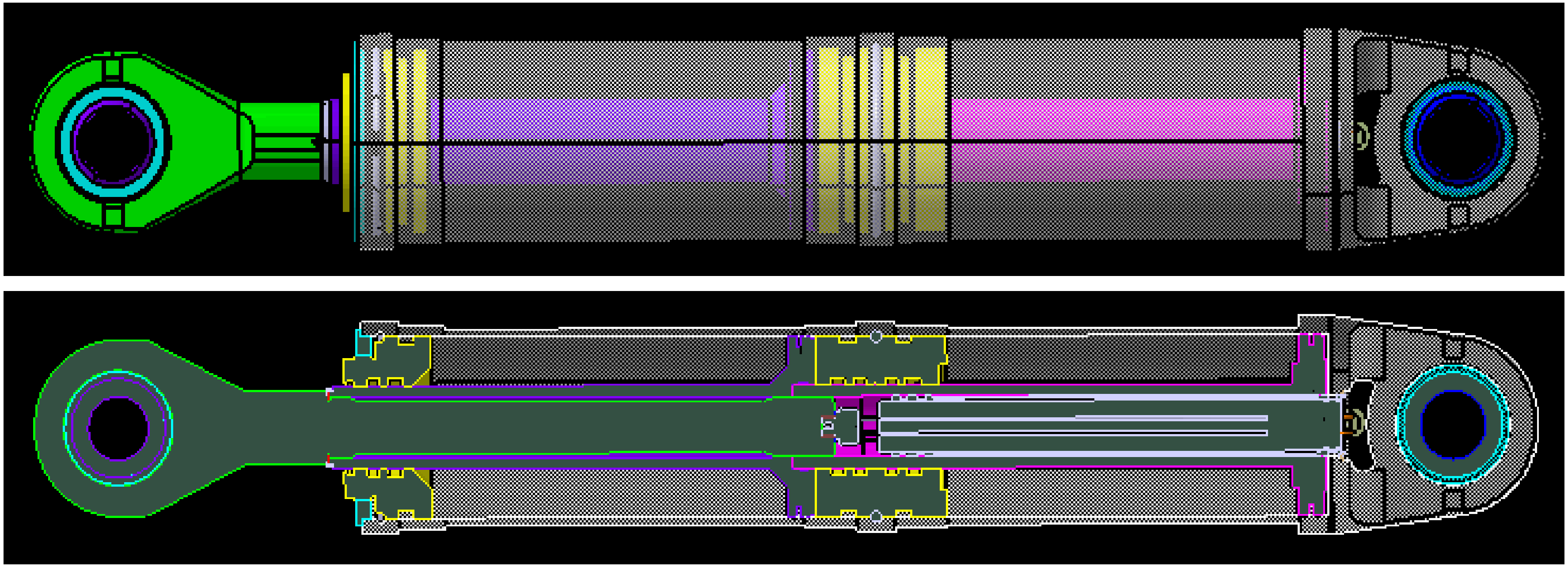
Engineered design…

…directly from spec



- Good for early program stages (Quick evaluation of various “alternate designs” scenarios)
- Gets you 80% there and you can finish the rest (20%) in native CATIA mode

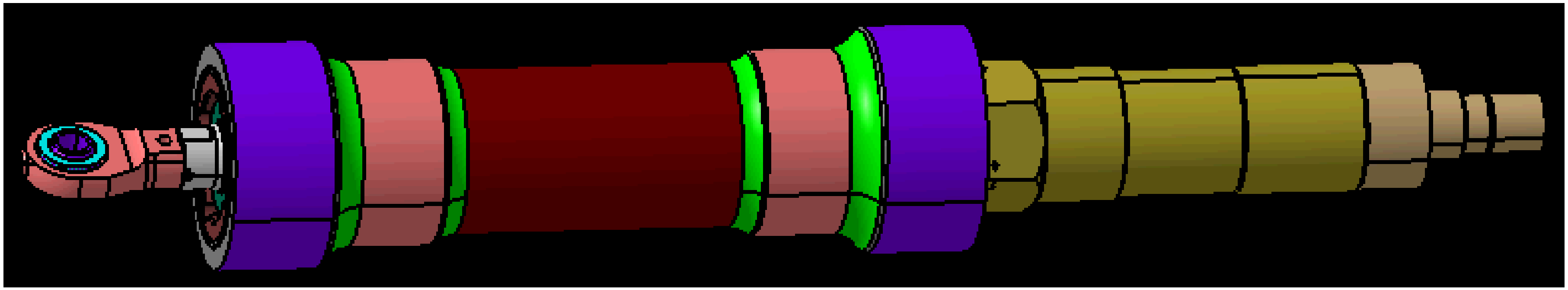
Engineered design…

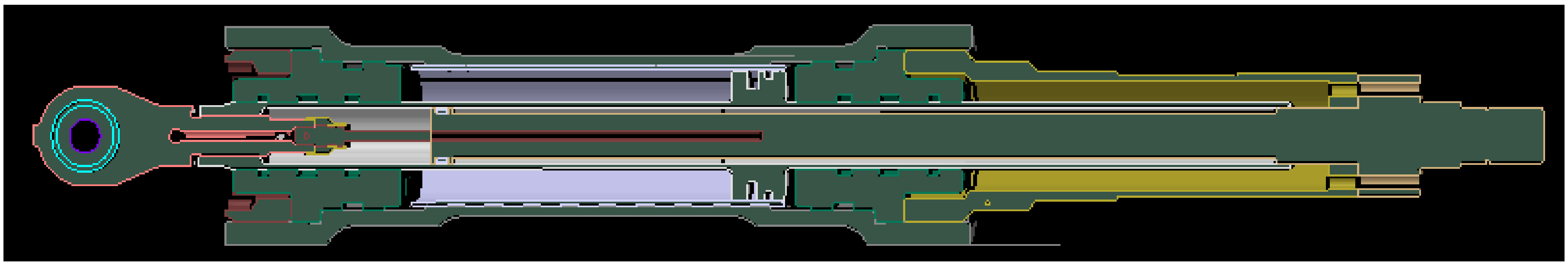


- ***Unbalanced tandem actuator with 4100 psi supply pressure and 9.49 inch stroke.***

…directly from spec

Engineered design…





- Balanced simplex actuator with 3050 psi supply pressure and 3.89 inch stroke.

…directly from spec

Key Benefits

- Knowledge resides in one system and reused widely across the enterprise
- Order of magnitude savings (1:10 ~ 1:100)
- Promotes collaboration & knowledge sharing
- Product independent architecture
- Experts now become knowledge-keepers
- Promotes innovations and creativity
- Good for preliminary studies & portfolio mgt
- Knowledge inside, Lean inside, standards inside, analysis inside, best practices inside

Keys to maximizing KDA gains …

- KBE has its own life. Think about integration and interfaces. They are big deal for KBE.
- Holistic view of product development process
- Employ a modular, open, and concurrent strategy for building KBE systems
- Think engineering centric versus geometry-centric; analysis driven, geometry is a by-product
- Follow a knowledge management framework for applying KBE

Questions?

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