

Analog Documents to Executable Compliance: Building an AI-Ready Digital Thread in Aerospace

Darwin Petersen Boeing/*Spirit AeroSystems*

PLM Road Map™ & PDT North America 2026

AI in PLM: A Disruptive Opportunity and Challenge

Turning AI disruption into enterprise value:

Strategic insights for the PLM professional

6-7 May 2026

CIMdata

www.CIMdata.com

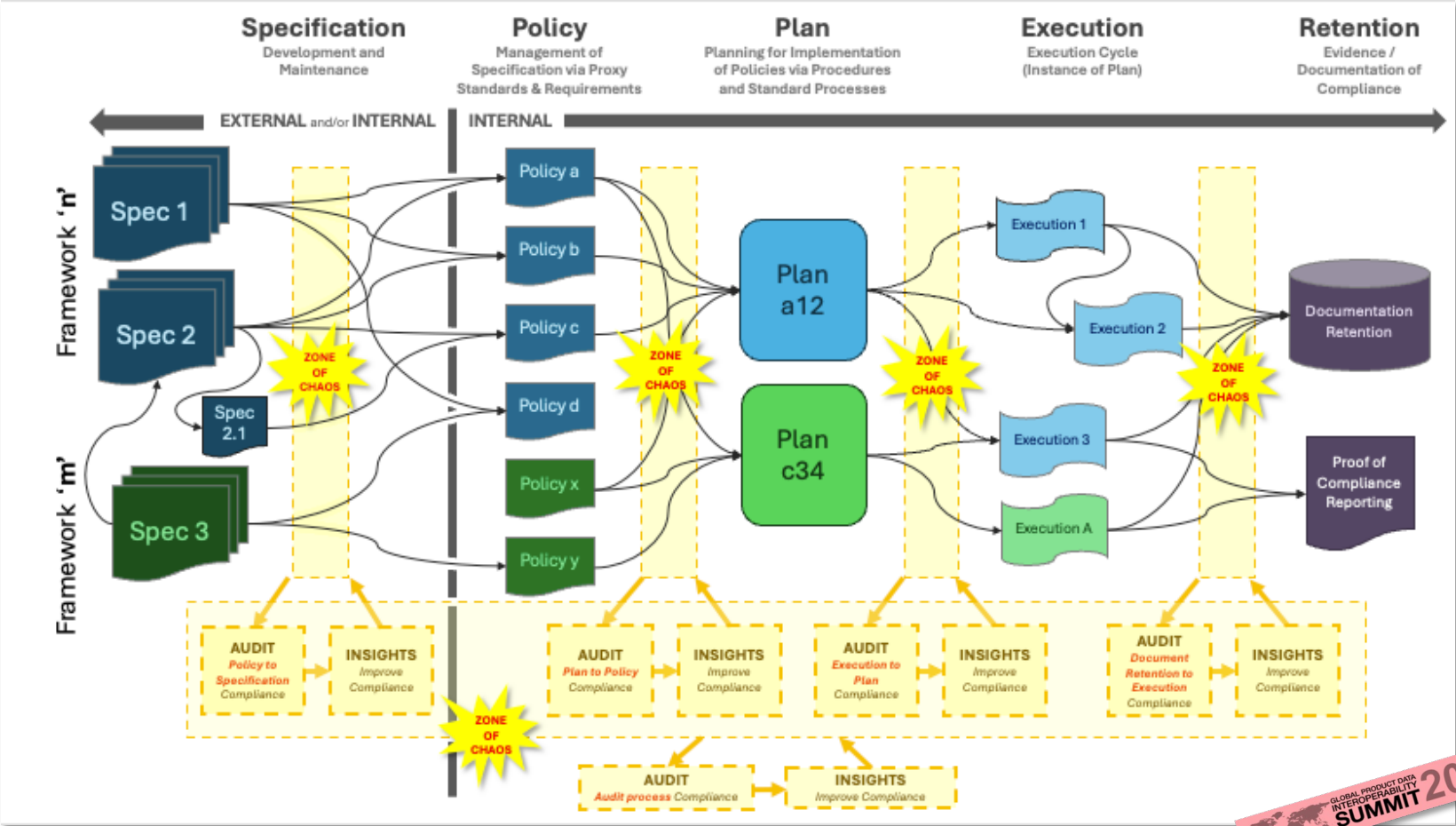
DARWIN
PETERSEN



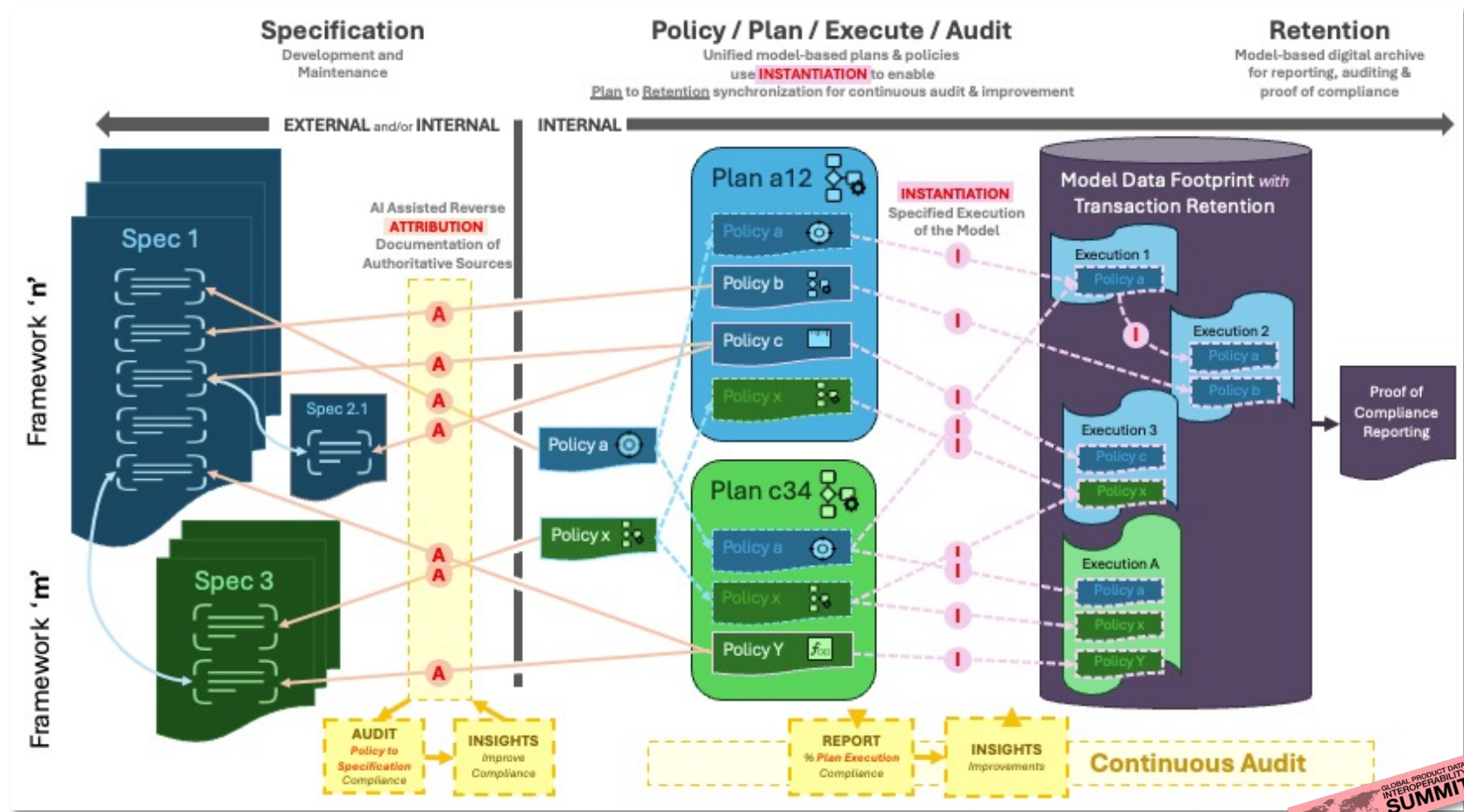
- DIGITAL THREAD
 - DATA PROCESS & ARCHITECTURE
 - KNOWLEDGE MODELING FOR AUTOMATION
- Boeing/Spirit 37 Years*
 - Manufacturing Engineer*
 - Associate Technical Fellow*
 - Tools, Processes & Governance*



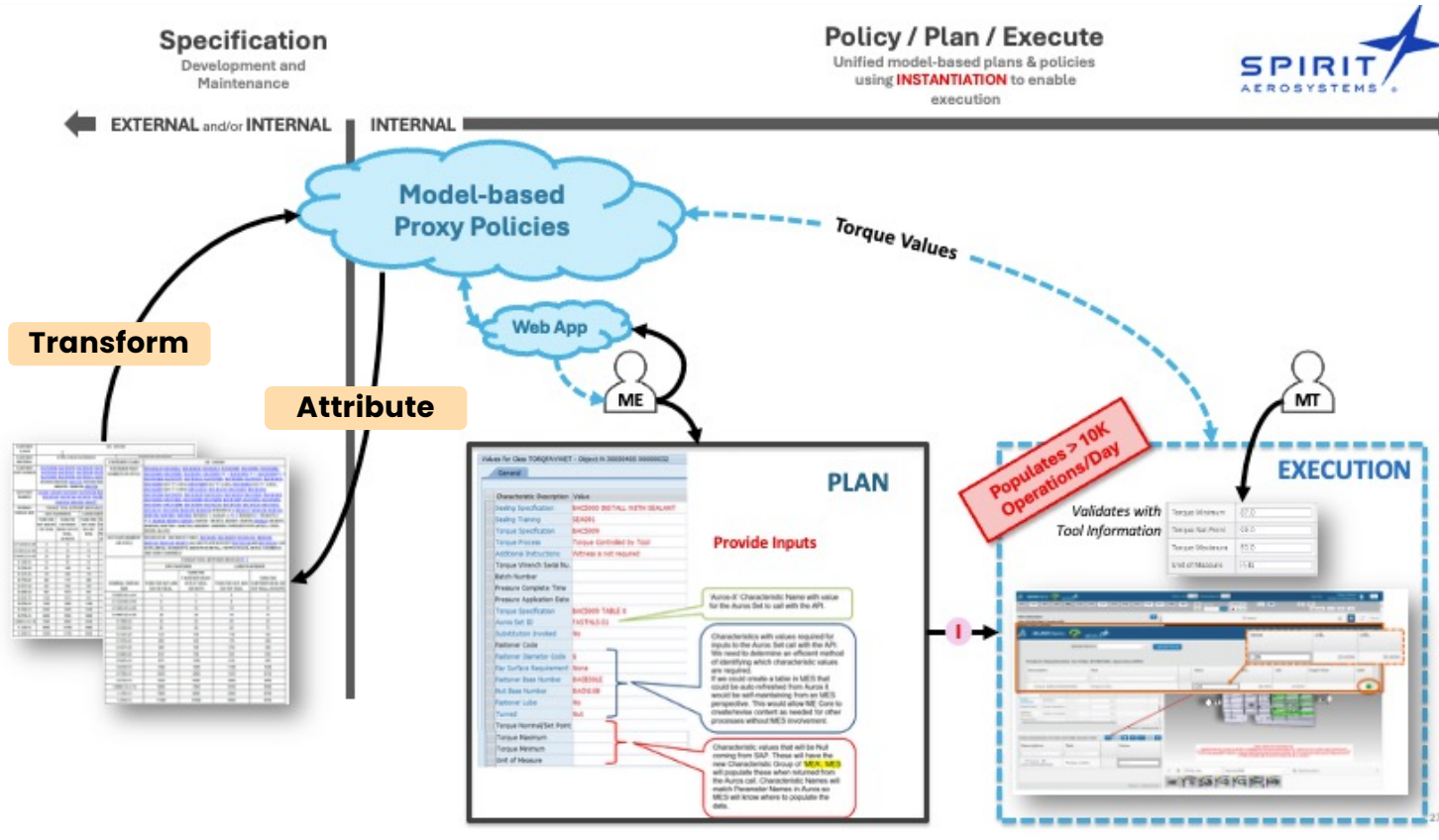
Analog, Document-based Specification Compliance



Hybrid: Document-Attributed Model-Based Compliance



Hybrid Example: Boeing / Spirit Aerosystems



Transformation Activity:

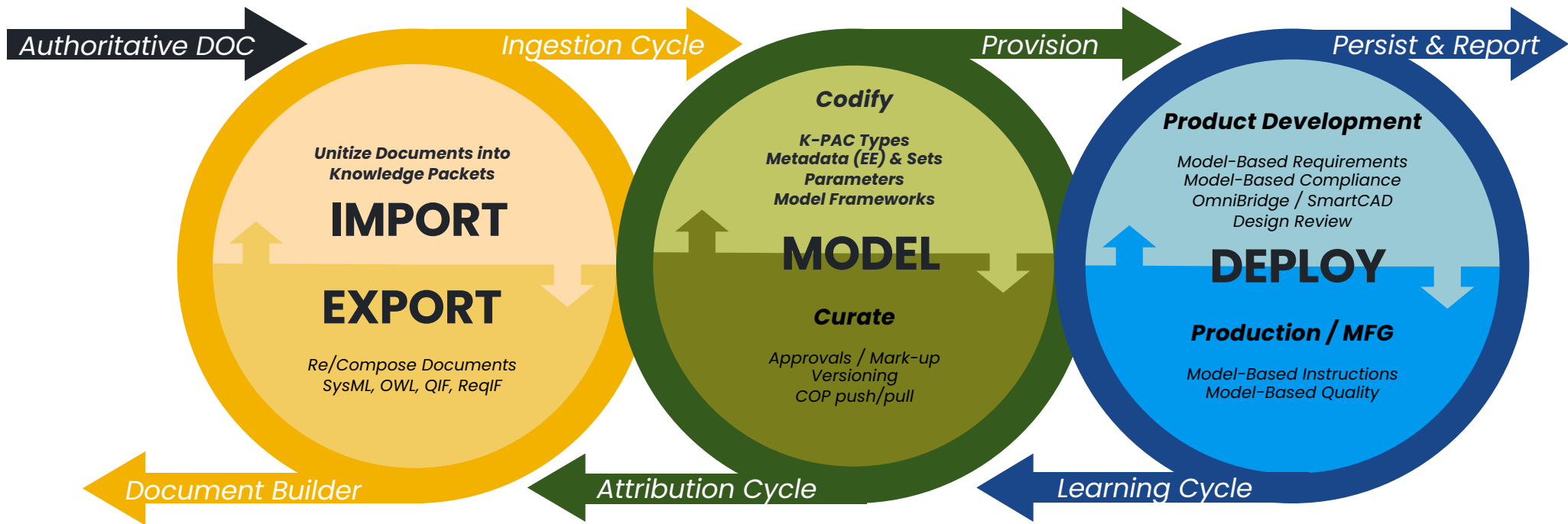
- Model Content
 - Requirements
 - Parameters
 - Operators / Qualifiers
- Model Context
 - Applicability
 - Logical / Conditional

Benefits:

- Content Related / Reuseable
- Transparent / Explainable
- Executable / Traceable during instantiation



Transform Analog Documents → Digital Models



General AI Classifications → Context

Class	Differentiators	Usage / Data
Symbolic	<ul style="list-style-type: none">• Rule-based reasoning using explicit symbols• Models' logic and knowledge declaratively• Human / Machine Readable / Explainable	<ul style="list-style-type: none">• Execute, Rationalize• Symbolic
Generative	<ul style="list-style-type: none">• Learns patterns from data to produce new content• Lacks explicit rules for reasoning	<ul style="list-style-type: none">• Transform, Synthesize, Summarize• Text, Image, Audio, Code
Agentic	<ul style="list-style-type: none">• Combines reasoning, learning and action to achieve a goal• May use symbolic and or generative	<ul style="list-style-type: none">• Automate, Govern• Text, Image, Audio, Code
Computational	<ul style="list-style-type: none">• Implicit discovery by mathematical convergence• Supported / adapted with learning	<ul style="list-style-type: none">• Classify, Recognize• Numeric



General AI Classifications → Context

Class	Differentiators	As Presented
Symbolic	<ul style="list-style-type: none">• Rule-based reasoning using explicit symbols• Models' logic and knowledge declaratively• Human / Machine Readable / Explainable	<ul style="list-style-type: none">• Parameters & Model Tables• Process Models• Collection Models• Orchestration Models• Processing Engine• Provisioning
Generative	<ul style="list-style-type: none">• Learns patterns from data to produce new content• Lacks explicit rules for reasoning	<ul style="list-style-type: none">• Write Assist• Search, Find & "X"
Agentic	<ul style="list-style-type: none">• Combines reasoning, learning and action to achieve a goal• May use symbolic and or generative	<ul style="list-style-type: none">• Propose Ingestion• Propose Attribution• Propose Iteration• Propose Parameters• Propose Models
Computational	<ul style="list-style-type: none">• Implicit discovery by mathematical convergence• Supported / adapted with learning	<ul style="list-style-type: none">• Not currently used



Quantification – what effort was involved?

Global Product Data Interoperability Summit | 2025

Deliverables	AVG Effort (Manual)	EST AVG Effort (LLM Assisted)
Modular K-PAC + Classification (175)	5 min / K-PAC (14.5 HRS)	0.5 min / K-PAC (1.5 HRS)
Parameters (54)	5 min / Parameter (4.5 HRS)	0.5 min / Parameter (0.5 HRS)
Modular K-PAC + Classification + Model (34)	30 min / K-PAC (17 HRS)	15 min / K-PAC (8.5 HRS)
Orchestration Model (1)	60 min / Orchestration (1 HRS)	60 min / Orchestration (1 HRS)
Validation & Rationalization (206)	1 min / K-PAC (3.4 HRS)	0.5 min / K-PAC (1.7 HRS)
TOTAL:	40.4 HRS	13.2 HRS

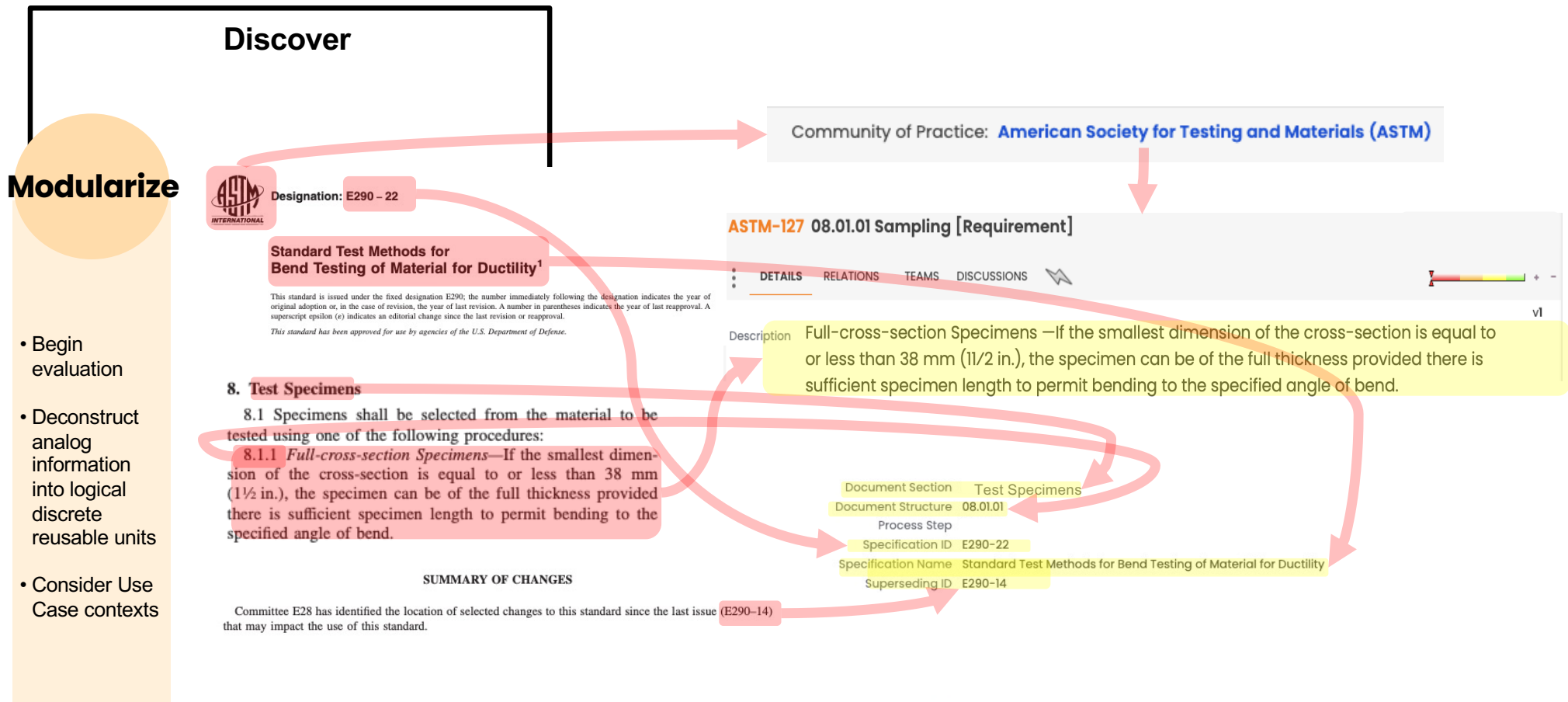
This is the effort and complexity of modelling 1 paragraph of an SAE specification and 12 pages of an ASTM specification



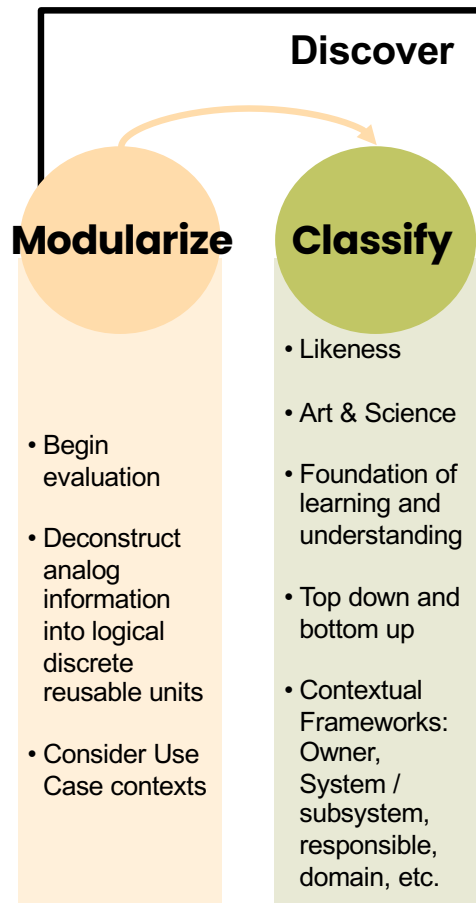
Bending Spec Pilot



Transform Analog Documents → Digital Models



Transform Analog Documents → Digital Models



ASTM-127 08.01.01 Sampling [Requirement]

DETAILS RELATIONS TEAMS DISCUSSIONS

Description Full-cross-section Specimens —If the smallest dimension of the cross-section is equal to or less than 38 mm (1 1/2 in.), the specimen can be of the full thickness provided there is sufficient specimen length to permit bending to the specified angle of bend.

Document Section Sampling

Document Structure 08.01.01

Process Step **Sample**

Specification ID E290-22

Specification Name Standard Test Methods for Bend Testing of Material for Ductility

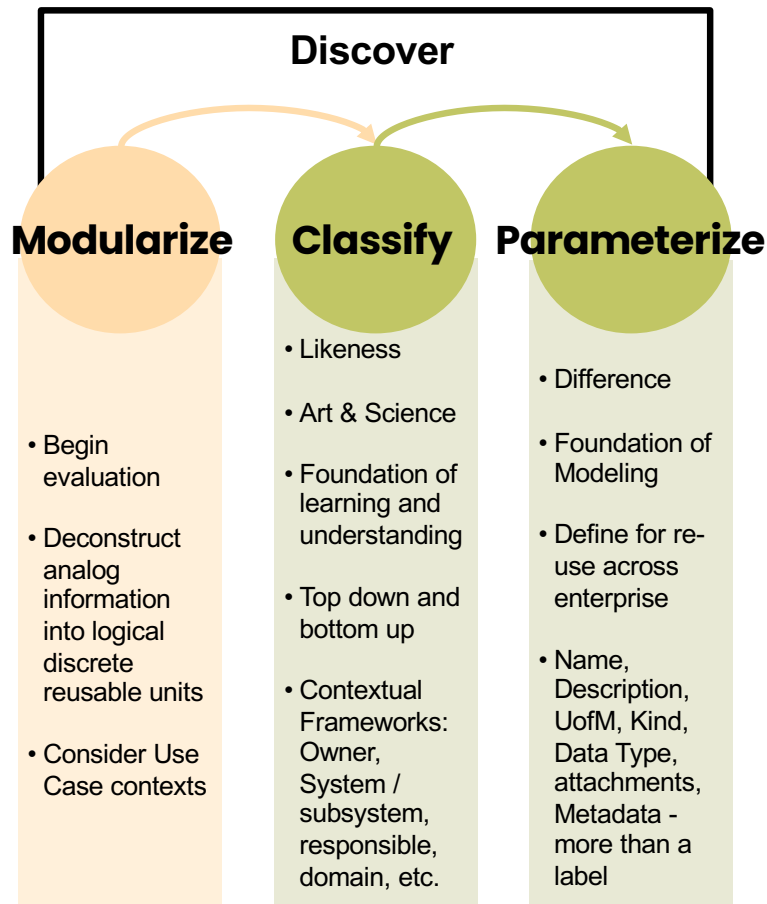
Superseding ID E290-14

Test Method Bend-and-flatten Test, Free-bend Tests: Type 1, Free-bend Tests: Type 2, Guided-bend, Guided-Bend, No-Die, Semi-guided Bend Tests: Arrangement A, Semi-guided Bend Tests: Arrangement B, Semi-guided Bend Tests: Arrangement C, U-bend Test, V-bend Test, V-bend test for cold-rolled sheet

Requirement ✓



Transform Analog Documents → Digital Models



ASTM-127 08.01.01 Sampling [Requirement]

Requirement ✓

DETAILS RELATIONS TEAMS DISCUSSIONS

Description: Full-cross-section Specimens (BT_Specimen_Selection_Procedure_CHOICE) —If the smallest dimension (BT_Material_Thickness_DIST) of the cross-section is equal to or less than 38 mm (1 1/2 in.), the specimen can be of the full thickness (BT_Specimen_Thickness_DIST) provided there is sufficient specimen length (BT_Specimen_Length_DIST) to permit bending to the specified angle of bend.

Additional Information

Parameters

- BT_Specimen_Selection_Procedure_CHOICE
- BT_Material_Thickness_DIST
- BT_Specimen_Thickness_DIST
- BT_Specimen_Length_DIST

ASTM-247 BT_Specimen_Selection_Procedure_CHOICE

DETAILS RELATIONS TEAMS DISCUSSIONS

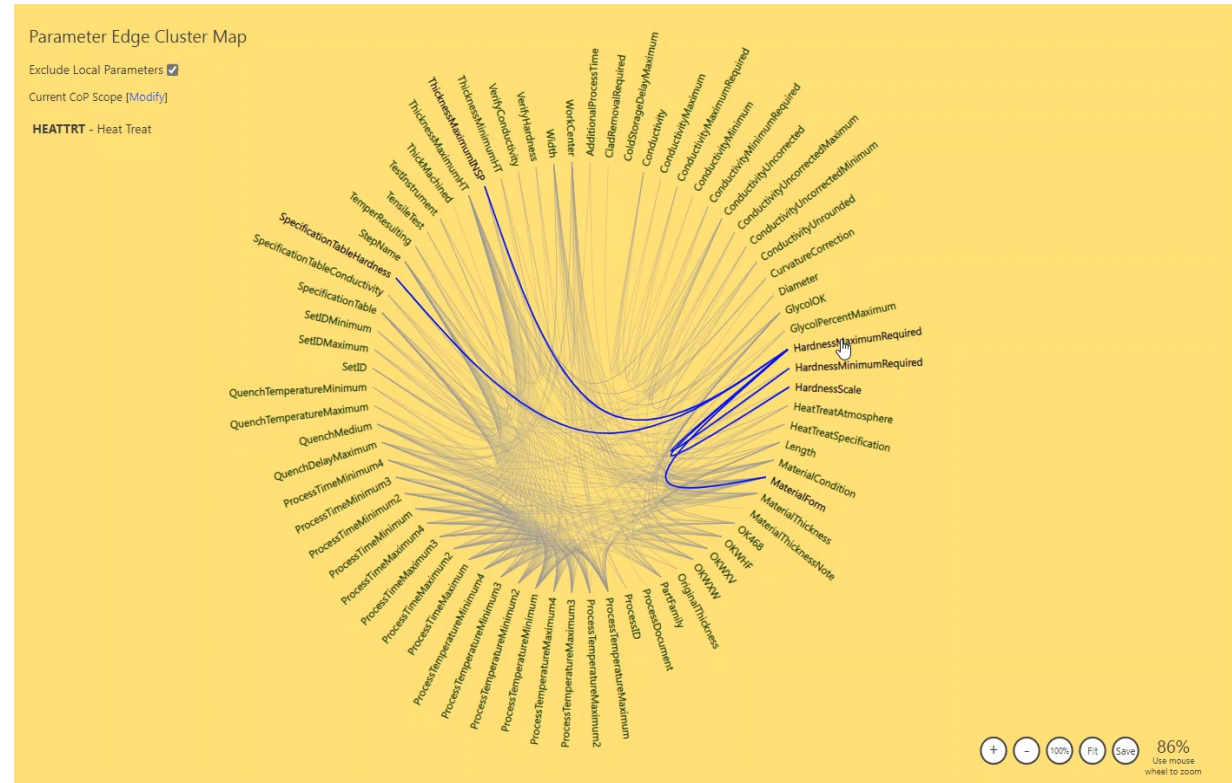
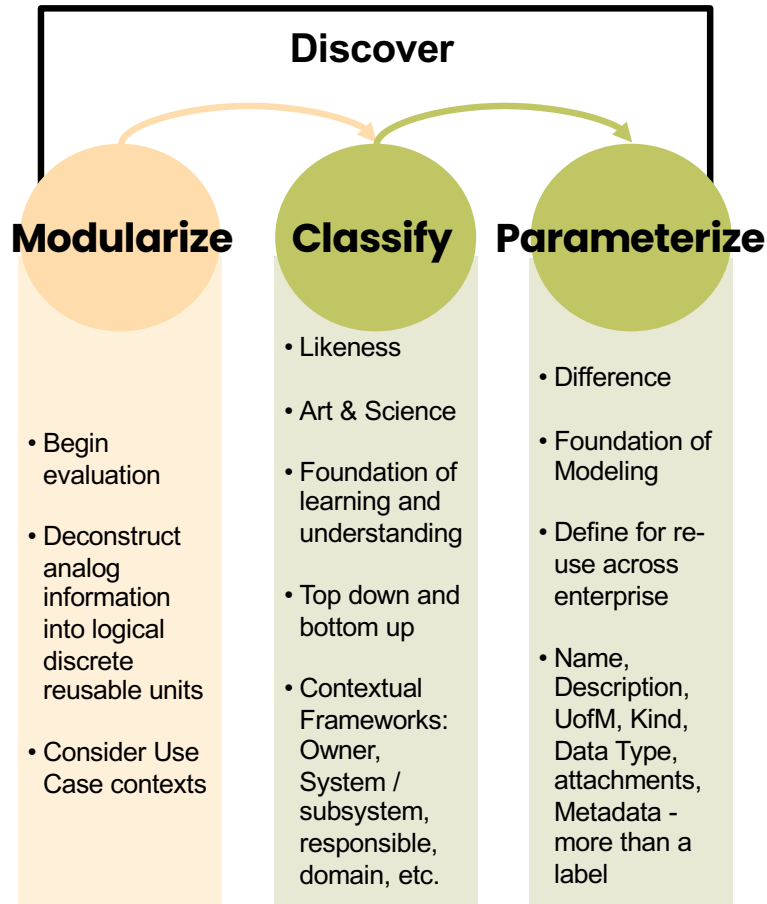
Description: The procedure (Choice: Full-Cross-Section, Full-Thickness) used to select the specimen to on which any bend test is conducted

Value Table ⊙

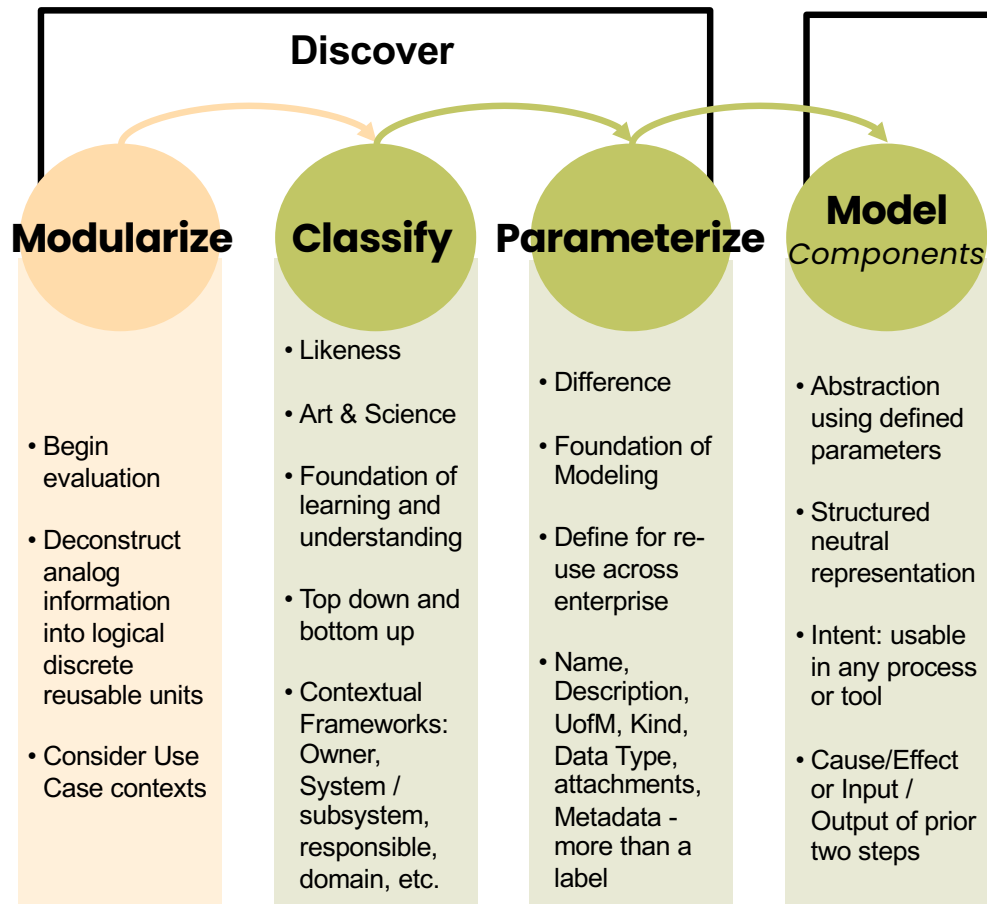
"Full-cross-section"
"Full-Thickness"
Reference
BT_Specimen_Selection_Procedure_CHOICE



Transform Analog Documents → Digital Models



Transform Analog Documents → Digital Models



Build

ASTM-127 08.01.01 Sampling [Requirement]

Requirement

DETAILS RELATIONS TEAMS DISCUSSIONS

Description Full-cross-section Specimens—If the smallest dimension `BT_Specimen_Width_DIST` `BT_Specimen_Thickness_DIST` of the cross-section is equal to or less than 38 mm (1 1/2 in.), the specimen can be of the full thickness provided there is sufficient specimen length `BT_Specimen_Length_DIST` to permit bending to the specified angle of bend.

Assumptions
Based on Figure 10 the Specimen length must be 5x the specimen width since the spec makes no other mention of length requirements applying this to all bend tests (not just free-bend)

Value Table

(0 - 38)	"Full-cross-section"	38	38	<code>BT_Specimen_Width_DIST</code> *5
(38 - ANY)	"Full-Thickness"	38	38	<code>BT_Specimen_Width_DIST</code> *5
Reference: Range	Default Value	Maximum	Maximum	Minimum
mm	mm	mm	mm	mm
<code>BT_Material_Thickness_DIST</code>	<code>BT_Specimen_Selection_Procedure_CHOICE</code>	<code>BT_Specimen_Thickness_DIST</code>	<code>BT_Specimen_Width_DIST</code>	<code>BT_Specimen_Length_DIST</code>

Parameter Traceability Map

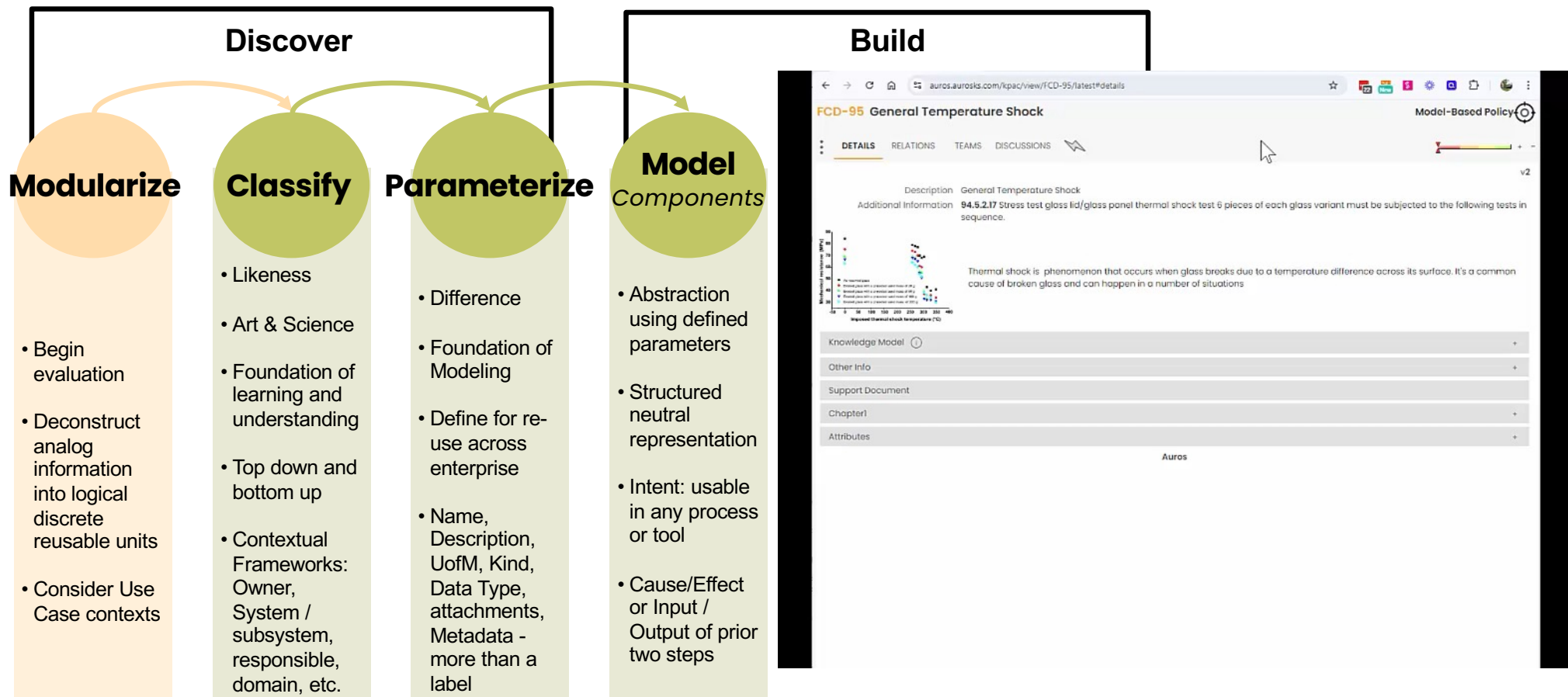
Parameter	Defined in (E-PAC)	Evaluated in (E-PAC)	Input to (E-PACs)
<code>BT_Spec</code>			
<code>BT_Specimen_Stamping_Location_CHK</code>	ASTM 235		
<code>BT_Specimen_Cross_Location_CHK2</code>	ASTM 262		
<code>BT_Specimen_Width_DIST</code>	E-ASTM 38		E-ASTM 38 E-ASTM 38
<code>BT_Specimen_Leng_Position_CHK2</code>	ASTM 226		
<code>BT_Specimen_Bend_Tha</code>	ASTM 232	ASTM 34	
<code>BT_Specimen_Length_DIST</code>	ASTM 248	ASTM 32 ASTM 32	
<code>BT_Specimen_Fracture_Yk</code>	ASTM 286		ASTM 3
<code>BT_Specimen_Width_DIST</code>	ASTM 265	ASTM 27 ASTM 265 SAE 2	ASTM 48 ASTM 45 ASTM 45 ASTM 45 ASTM 42 ASTM 27 ASTM 32
<code>BT_Specimen_Selection_Procedure_CHK</code>	ASTM 247	ASTM 37	



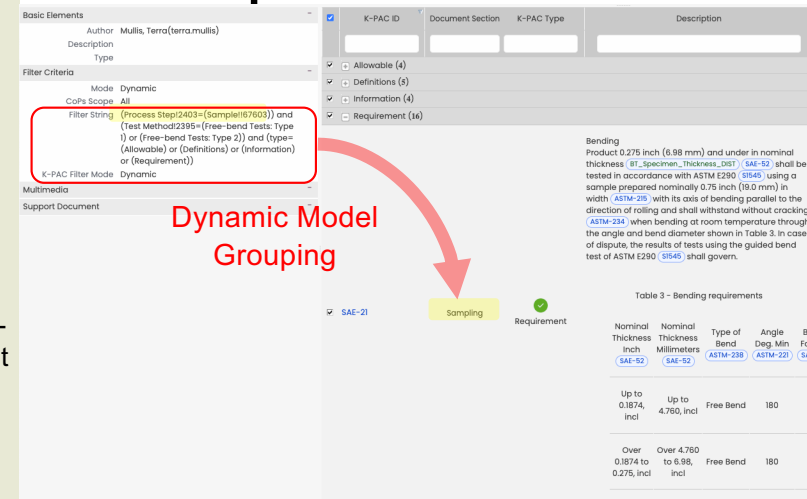
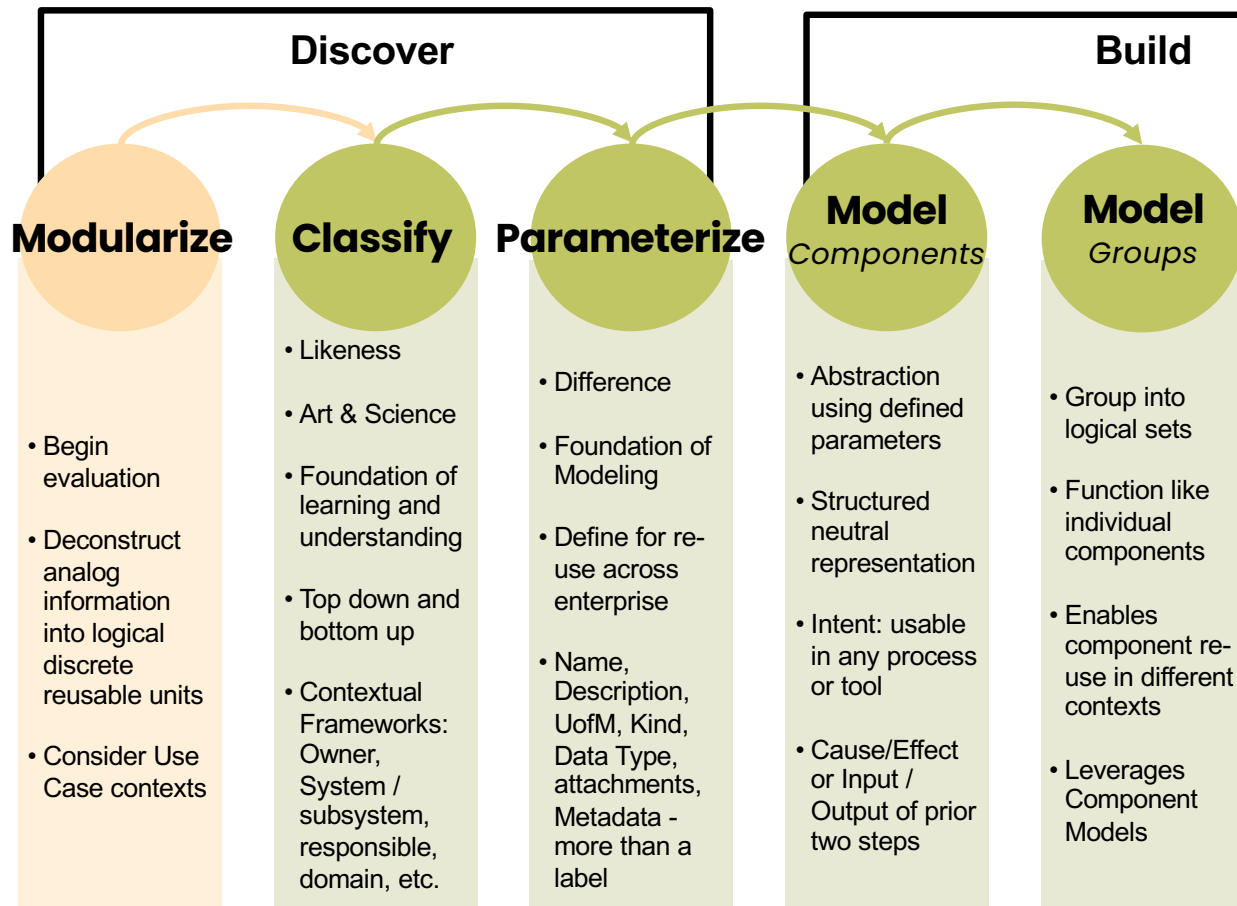
Bending Spec Pilot



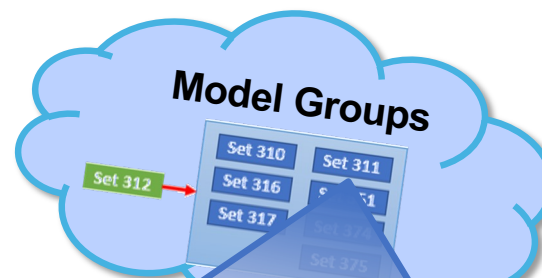
Transform Analog Documents → Digital Models



Transform Analog Documents → Digital Models



Transform Analog Documents → Digital Models



K-PAC 42 - BAC5602 Table IV
 Input
 • Alloy
 • MaterialForm
 Return
 • ProcessTemperatureMinimum
 • ProcessTemperatureMaximum

K-PAC 108
 Input
 • Alloy
 Return
 • ColdStorageDelayMaximum

K-PAC 150
 Input
 • MaterialThickness
 Return
 • ThicknessMinimumHT
 • ThicknessMaximumHT
 • ThicknessMaximumINSP

K-PAC 88
 Input
 • HeatTreatSpecification
 Return
 • ProcessDocument

K-PAC 40 BAC5602 Table IX
 Input
 • MaterialForm
 • Alloy
 • TemperFinal
 • ThicknessMaximumHT
 Return
 • GlycolPercentMaximum
 • GlycolOK

K-PACs 110 - 113 – Work Centers
 Input
 • GlycolOK
 • PartFamily
 • QuenchDelayMaximum
 • ProcessTemperatureMinimum
 • ProcessTemperatureMaximum
 • Length
 • Width
 Return
 • OK468, OKWHF, OKWXW, OKWXV

K-PAC 49 – Work Center
 Input
 • GlycolOK
 • OK468
 • OKWHF
 • OKWXW
 • OKWXV
 Return
 • WorkCenter
 • QuenchMedium

K-PAC 51
 Input
 • WorkCenter
 Return
 • HeatTreatAtmosphere

K-PAC 43 – BAC5602 Table V
 Input
 • ThicknessMaximumHT
 • HeatTreatAtmosphere
 • MaterialCondition
 Return
 • ProcessTimeMinimum
 • ProcessTimeMaximum

K-PAC 46 - BAC5602 Table VIII
 Input
 • Alloy
 • ThicknessMinimumHT
 Return
 • QuenchDelayMaximum

K-PAC 52
 Input
 • QuenchMedium
 Return
 • StepName



Transform Analog Documents → Digital Models

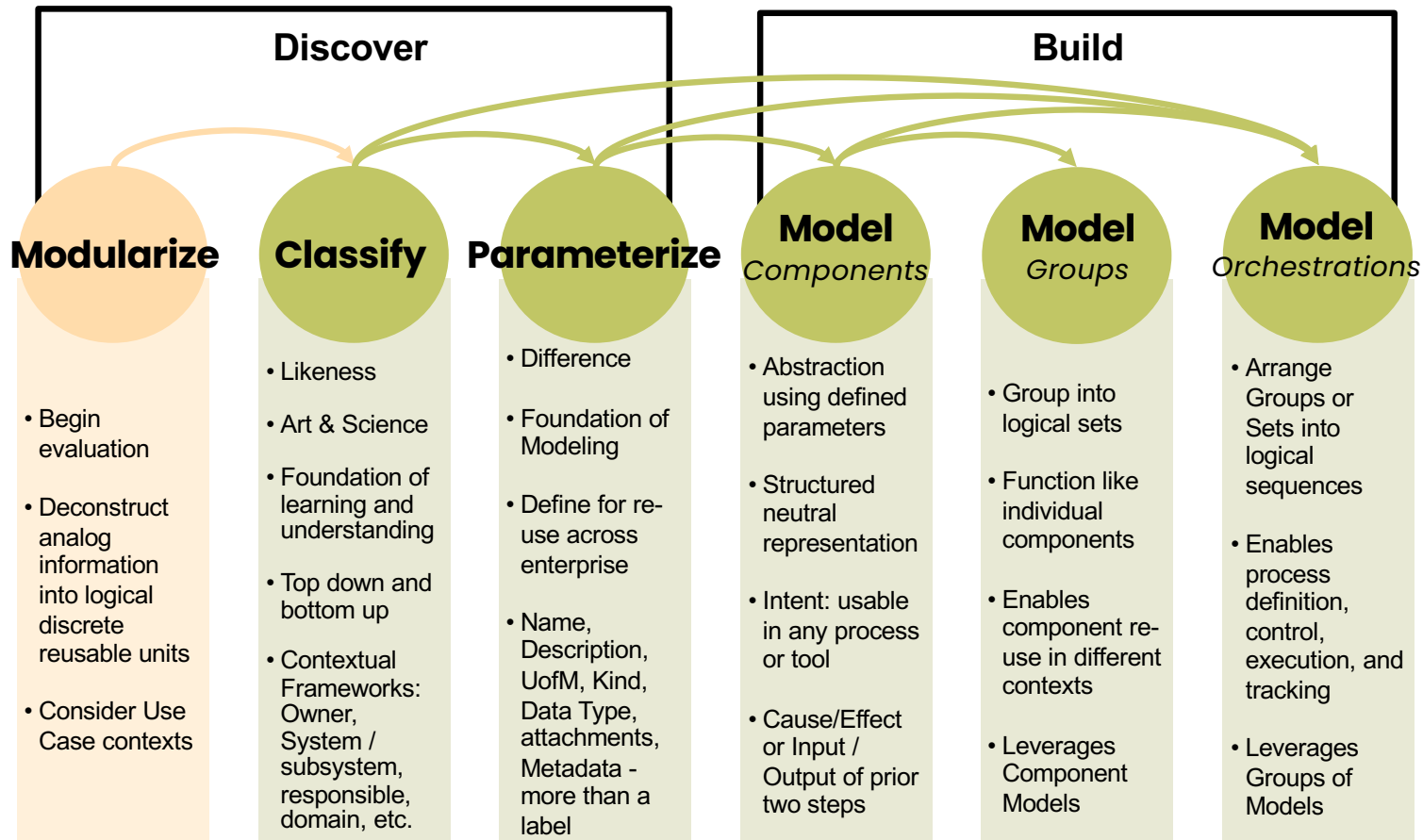
HEATTRT S311 Heat Treat Operation - BAC5602 Not Extrusion, Block, Forging, Casting or Weld Assembly

Options Build Reports Filter Views No Grouping K-PACs Found: 14

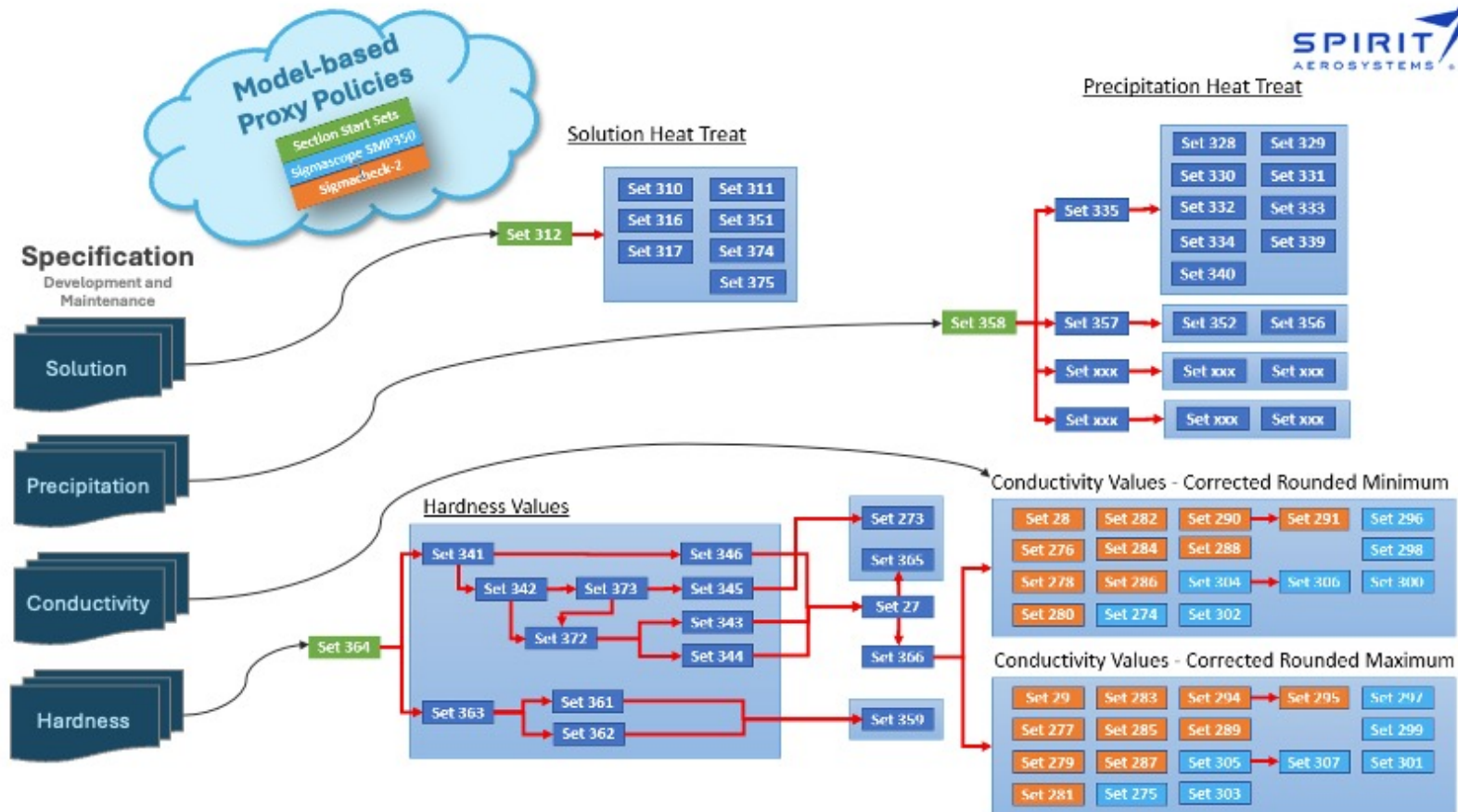
Basic Elements		<input checked="" type="checkbox"/>	K-PAC ID	Vit	K-PAC Status	K-PAC Type	K-PAC Title	Description
Author	Petersen, Darwin(darwin.w.petersen)	<input checked="" type="checkbox"/>	HEATTRT 150		Active		Convert Material Thickness to Thickness Minimum HT, Thickness Maximum HT and Thickness Maximum INSP	Convert Material Thickness to Thickness Minimum Thickness Maximum HT and Thickness Maximum I
Description	Heat Treat Operation - All Except Forgings, Castings and Weld Assemblies	<input checked="" type="checkbox"/>	HEATTRT 113		Active		OK WXV	OK WXV
Type		<input checked="" type="checkbox"/>	HEATTRT 112		Active		OK WXW	OK WXW
Filter Criteria		<input checked="" type="checkbox"/>	HEATTRT 111		Active		OK WHF	OK WHF
Mode	Static	<input checked="" type="checkbox"/>	HEATTRT 110		Active		OK 468	OK 468
CoPs Scope	local	<input checked="" type="checkbox"/>	HEATTRT 108		Active		Cold Storage Delay Maximum - BAC5602 Section 8.2.4.2.h	Cold Storage Delay Maximum - BAC5602 Section
Multimedia		<input checked="" type="checkbox"/>	HEATTRT 88		Active		Specification to Process Document	Specification to Process Document
Support Document		<input checked="" type="checkbox"/>	HEATTRT 52		Active		Step Name from Quench Medium	Step Name from Quench Medium
		<input checked="" type="checkbox"/>	HEATTRT 51		Active		Heat Treat Atmosphere from Work Center	Heat Treat Atmosphere from Work Center
		<input checked="" type="checkbox"/>	HEATTRT 49		Active		Work Center - Heat Treat Operation - Not Forging, Casting or Weld Assembly	Work Center - Heat Treat Operation - Not Forging Weld Assembly
		<input checked="" type="checkbox"/>	HEATTRT 46		Active		Quench Delay Maximum - BAC5602 Table VIII	Quench Delay Maximum - BAC5602 Table VIII
		<input checked="" type="checkbox"/>	HEATTRT 43		Active		Process Times - Not Forgings - BAC5602 Table V	Process Times - Not Forgings - BAC5602 Table V
		<input checked="" type="checkbox"/>	HEATTRT 42		Active		Process Temperatures - Not Forgings - BAC5602 Table IV	Process Temperatures - Not Forgings - BAC5602 T
		<input checked="" type="checkbox"/>	HEATTRT 40		Active		Quench Medium - BAC5602 Table IX - Glycol Quench OK	Quench Medium - BAC5602 Table IX - Glycol Quer



Transform Analog Documents → Digital Models

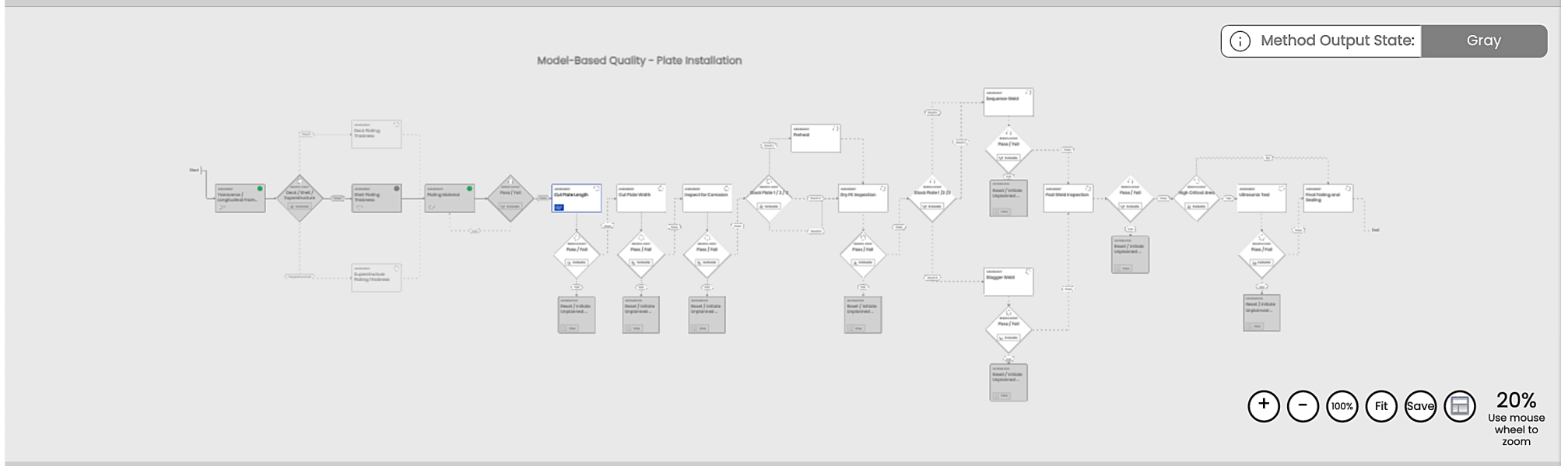


Model Orchestration



Model Orchestration

Measurement Plan

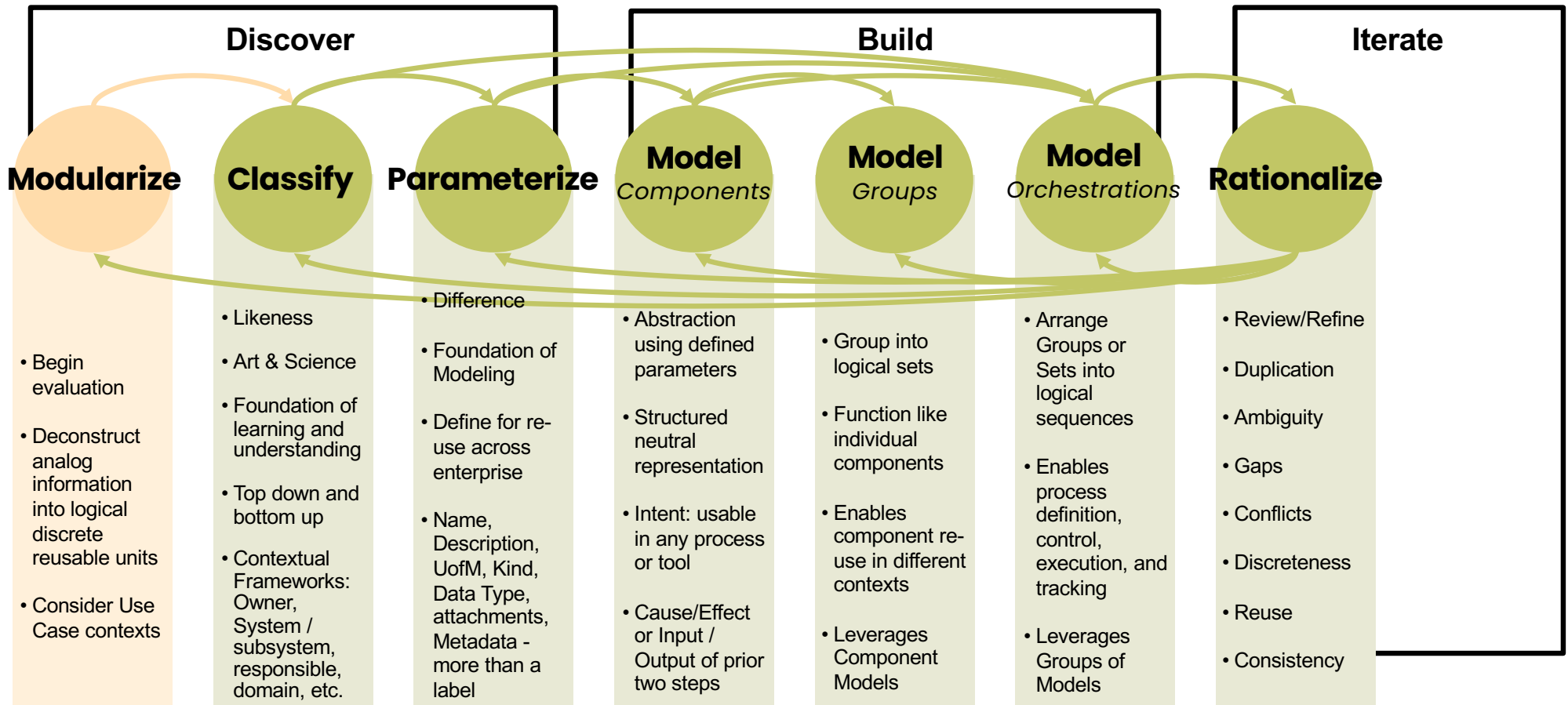


Parameter Sheet

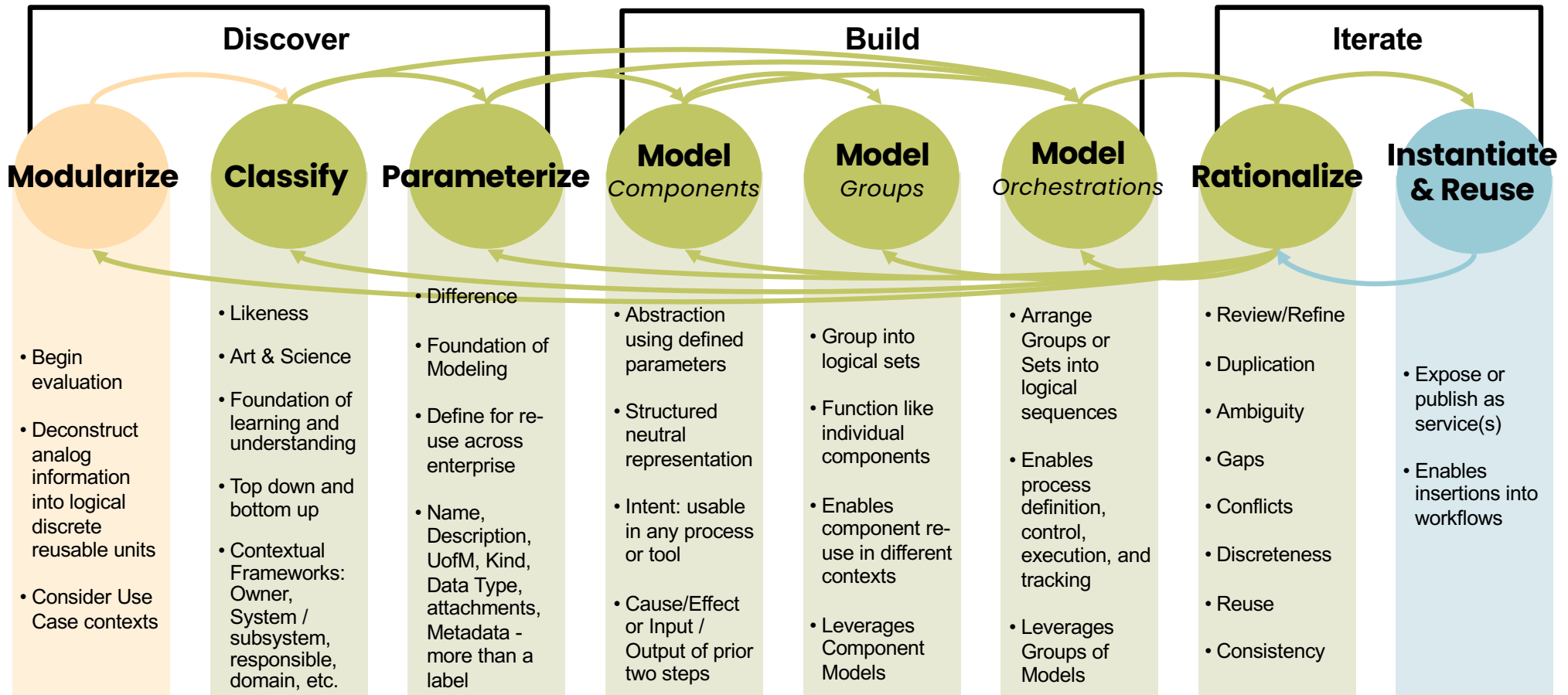
Measurement Type	Input Parameters	End User Message	Action
Plating Material	Material	"H30"	Reset
Plating Material	stock_thickness	7	Reset



Transform Analog Documents → Digital Models



Transform Analog Documents → Digital Models



Instantiate & Reuse

SPIRIT AEROSYSTEMS HEAT TREAT

Heat Treat View Records ME Launch Pad Maintenance

Solution Heat Treat

Solution Heat Treat Precipitation Heat Treat Inspection

Material Form Select an Option
Heat Treat Specification
Alloy Select an Option
Initial Temper

Next Reset

Debug
 Production

- Bar
- Block
- Casting
- Extrusion
- Forging
- Plate
- Ring
- Rod
- Section

Set ID	
Parameters	Values
1st Set ID	312



Questions

SCAN THE QR CODE!

Please give me feedback
on my presentation!

