AUTODESK. UNIVERSITY

Isn’t It Great When We Iterate: Rapid Innovation for Additive Manufacturing

Orrin Bourne

Manufacturing Technical Specialist

Justin Janelli

Manufacturing Technical Specialist

Orrin Bourne

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I have a background in mechanical engineering and software engineering and have been using Autodesk technologies for more than 20 years. Prior to joining Autodesk I built technologies used to improve workflows for engineering and manufacturing. Fusion Lifecycle is one or my areas of expertise having been a user/developer for nearly 8 years.

Justin Janelli

Manufacturing Technical Specialist

Justin has a background in Mechanical Engineering and Materials Science, and industry experience in Aerospace with General Atomics Aeronautical Systems. He's been with Autodesk for 4 years, streamlining workflows and delivering valuable automation and insight to customers' collaboration, design, and manufacturing processes.

SAFE HARBOR STATEMENT

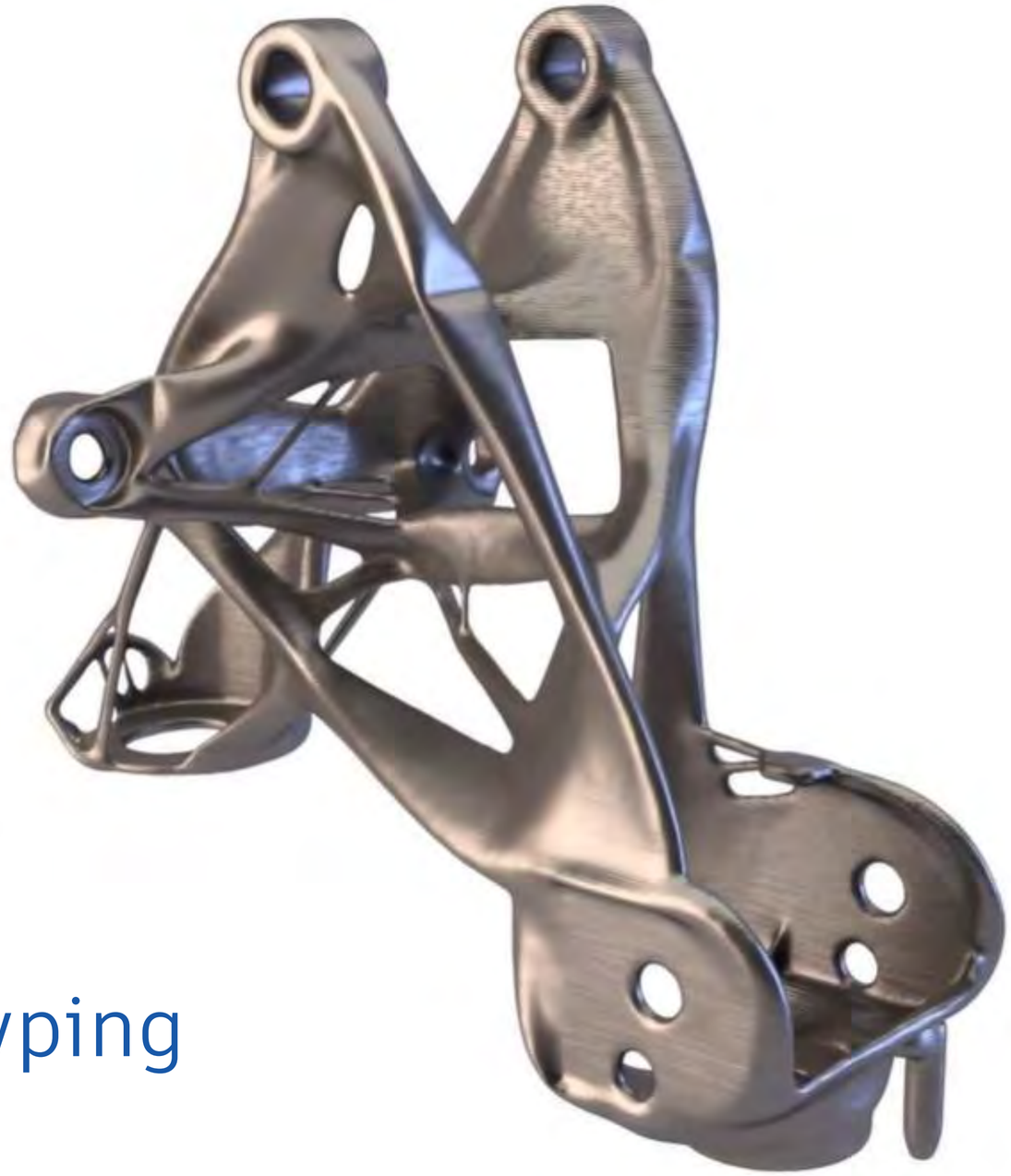
We may make statements regarding planned or future development efforts for our existing or new products and services. These statements are not intended to be a promise or guarantee of future availability of products, services or features but merely reflect our current plans and based on factors currently known to us. These planned and future development efforts may change without notice. Purchasing decisions should not be made based upon reliance on these statements. These statements are being made as of 10/27/2020 and we assume no obligation to update these forward-looking statements to reflect events that occur or circumstances that exist or change after the date on which they were made. If this presentation is reviewed after 10/27/2020, these statements may no longer contain current or accurate information.

Industrialization of Additive Manufacturing

Growing Confidence

Demonstrated Value

Transitioning from Prototyping to Production



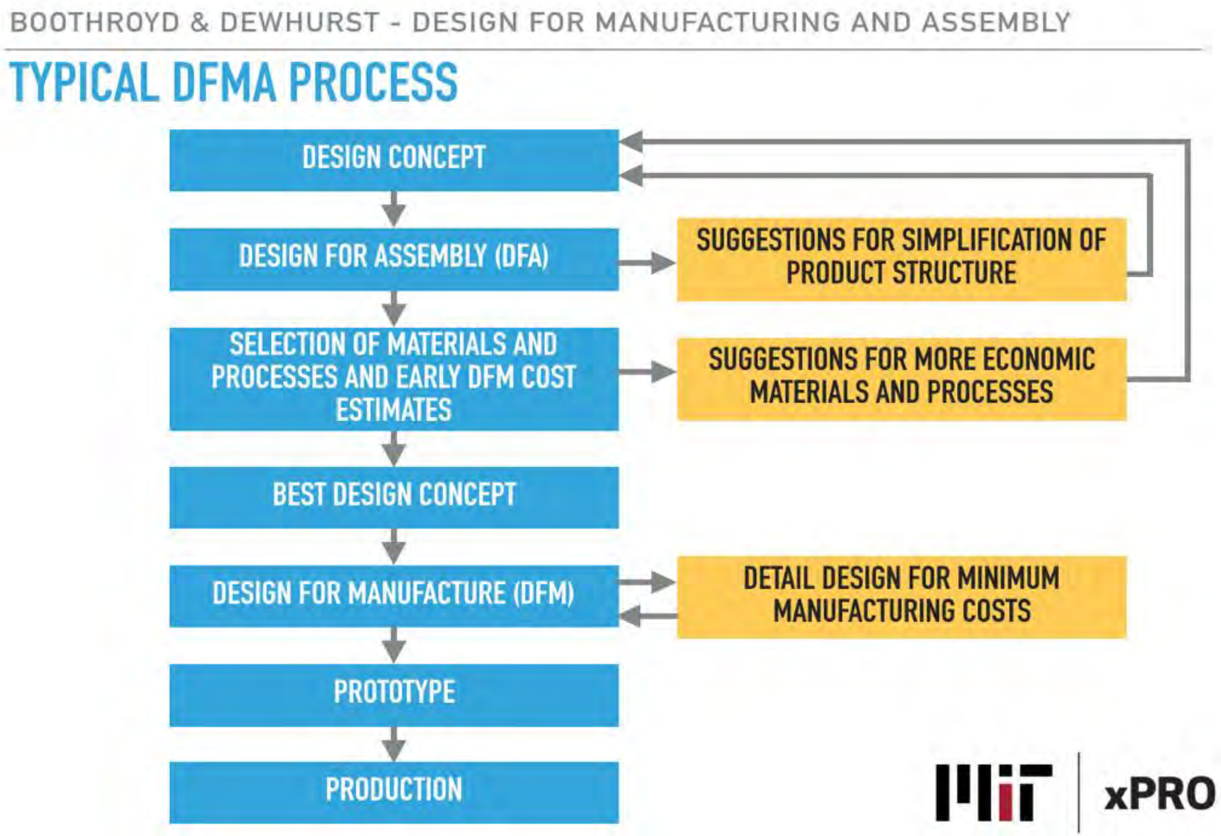
Source: Prof. H John Hart, MIT

Can Conventional DFMA Be Applied?

LINEAR PROCESS FOCUSED ON DESIGN SELECTION

COST STRONGLY CORRELATED TO ASSEMBLY TIMES

MANUFACTURABILITY RELEGATED TO LATER IN THE PROCESS



Source: MIT

“While past knowledge and expertise has often been the value we add in our work, it may … become one of the biggest inhibitors to generating new AM innovations.”

– Professor John Hart, MIT

Additive Manufacturing Is Just Different

HIGHLY COMPLEX DESIGN PROCESS

- **Consider materials, design constraints, AM machines, process parameters, part properties, and quality**
- **There are few hard and fast rules**

AM CAN HAPPEN ANYWHERE IN THE PRODUCT LIFECYCLE

- **Conceptualization, Prototyping, Ramp Up, Maturity, Decline, End-of-Life**

UNIQUE VALUE PROPOSITION AND CHALLENGES

- **Must fully explore AM space to find that “break out” design or product**
- **Balance between very high design freedom and stringent manufacturing constraints**

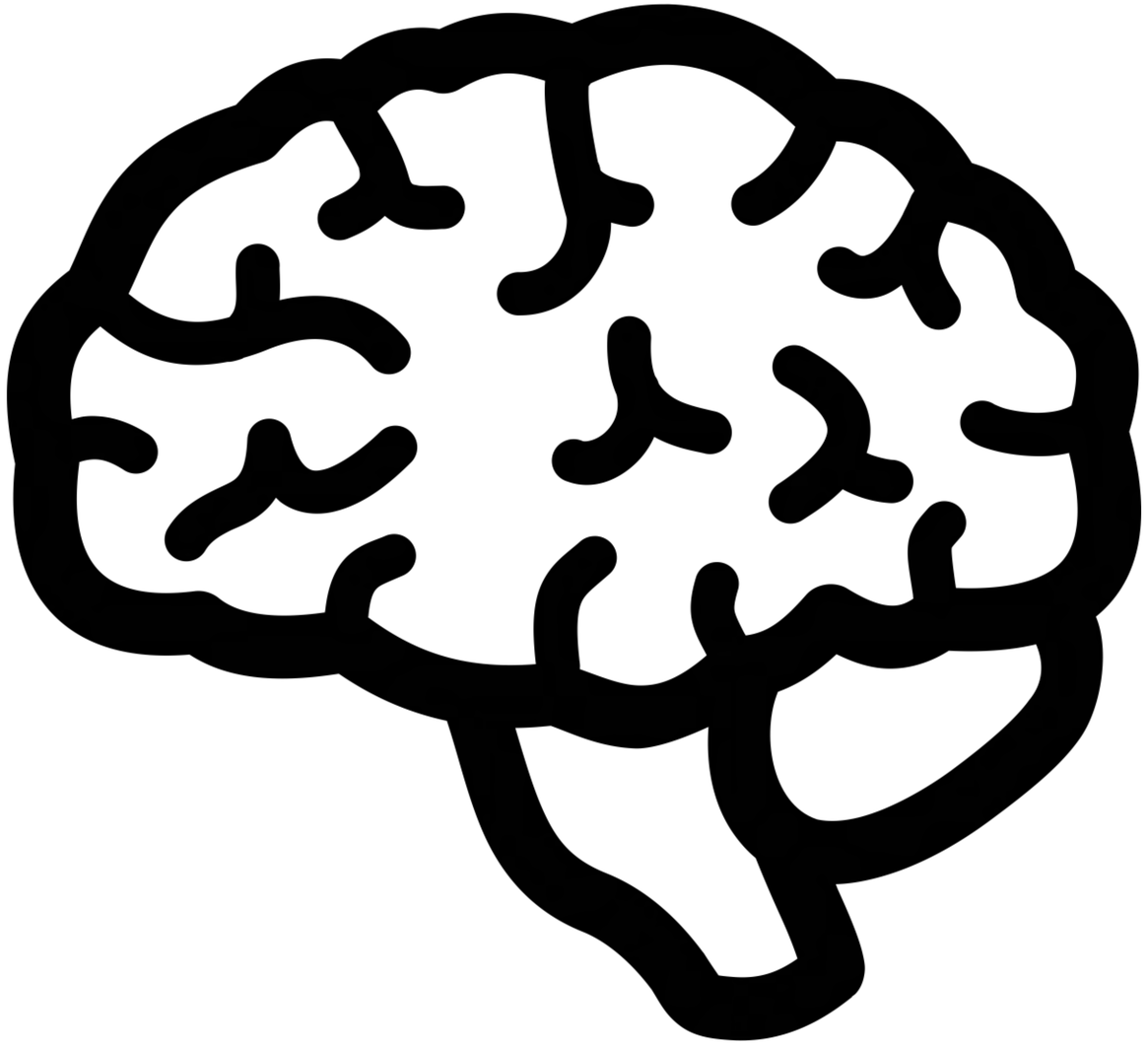
RETHINK

Designing

Production

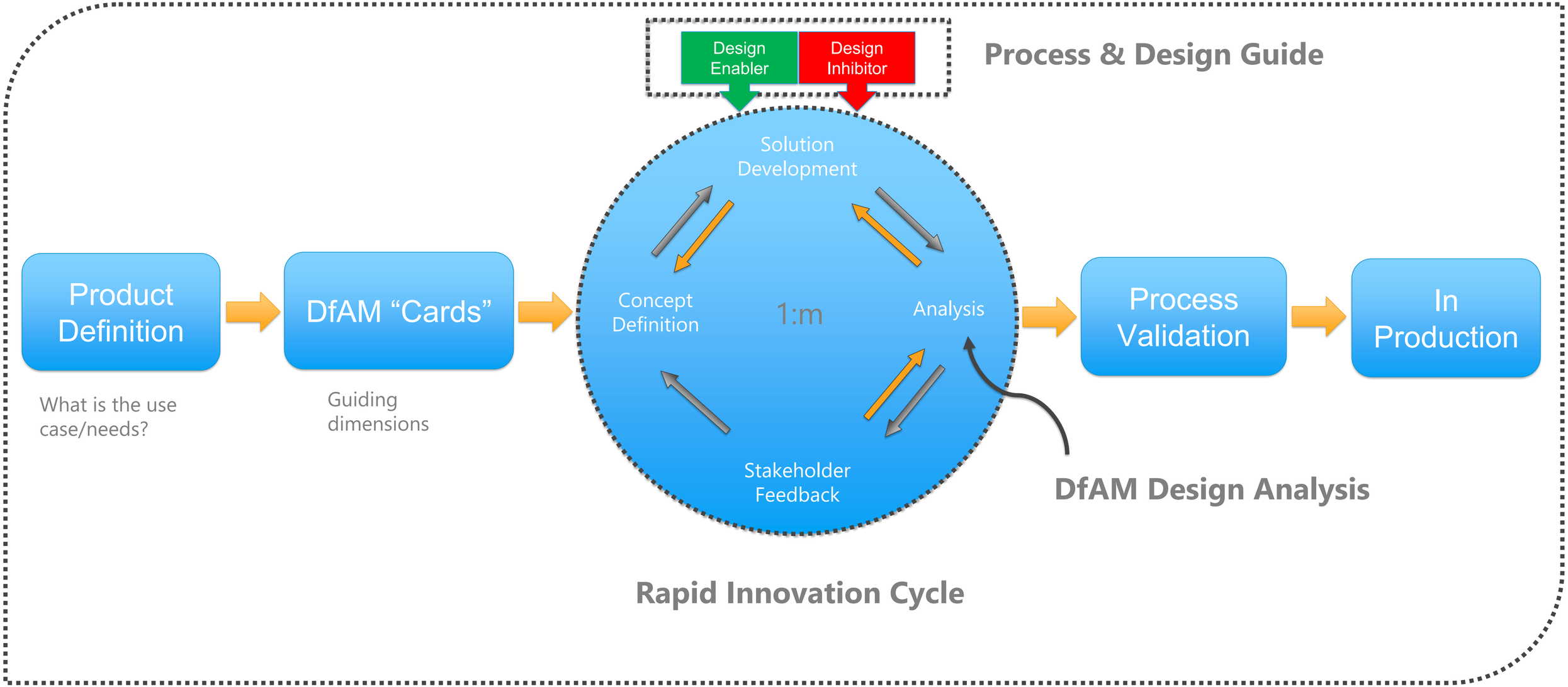
Delivery

Servicing



How Do We Pursue Innovation Across the AM Product Lifecycle?

Agile Product Development



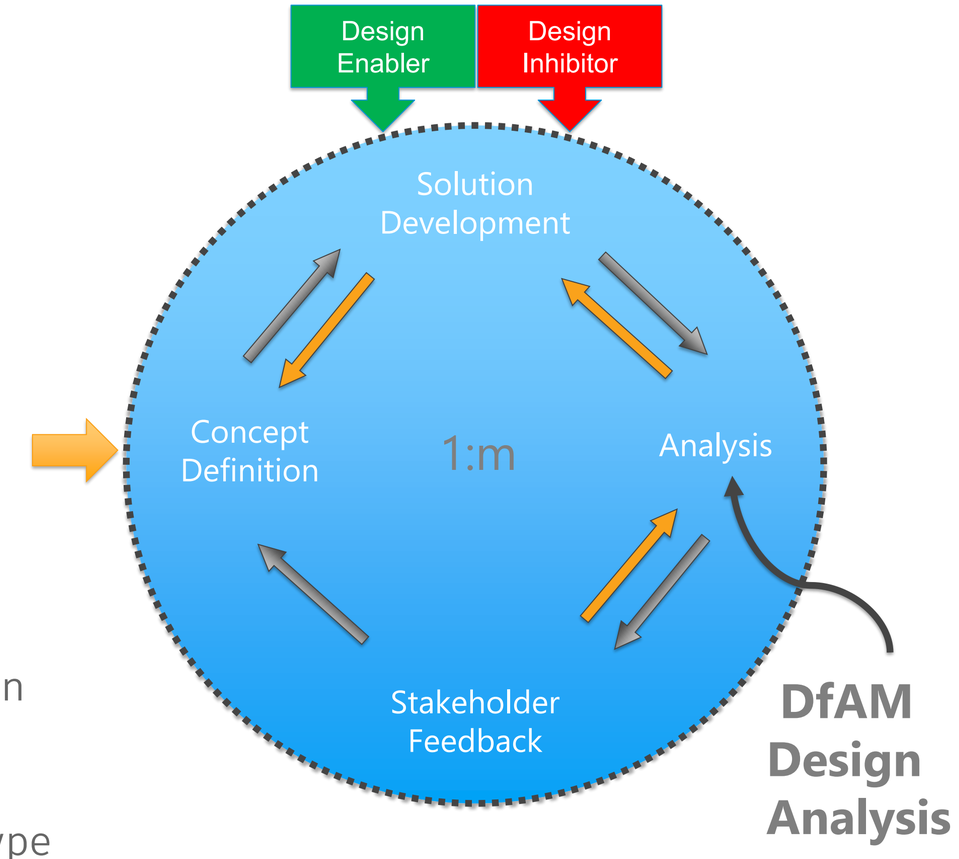
Inspired by the MIT course "Additive Manufacturing for Innovative Design and Production"

Rapid Innovation Cycle

Agile product development as applied to manufacturing

Has four main steps:

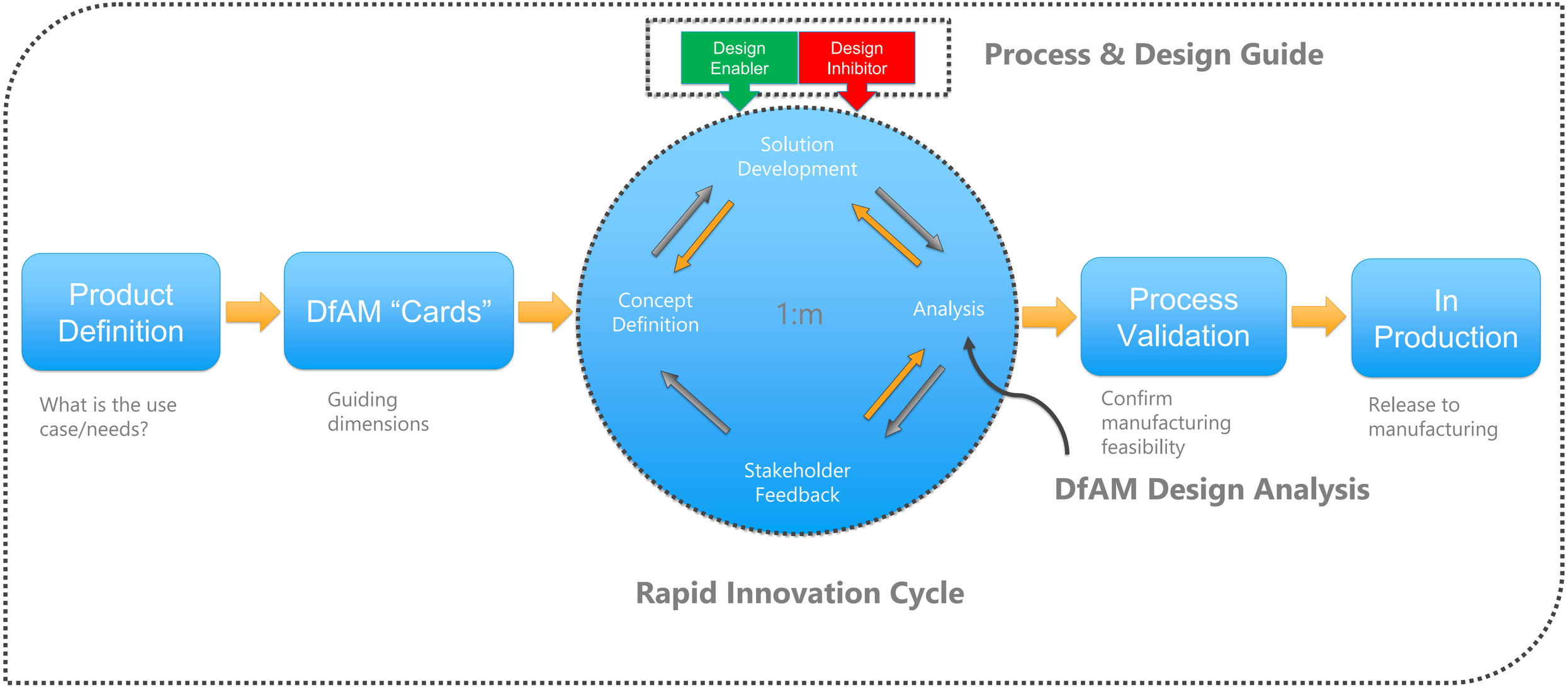
- **Concept Definition**
  - Refine the “solution” concept that satisfies the use case
- **Solution Development**
  - Consider process that will likely bring the concept to fruition
  - Evaluate design inhibitors and enablers – incorporate into design
- **Analysis**
  - Short first order analysis, thought experiments, physical prototype
  - Maximize insights while minimizing costs
- **Stakeholder Feedback**
  - Gather feedback from target group (internal and external)
  - Re-iterate as needed



Rapid Innovation Cycle

Characterized By Collaboration and Feedback At All Steps Along The Way

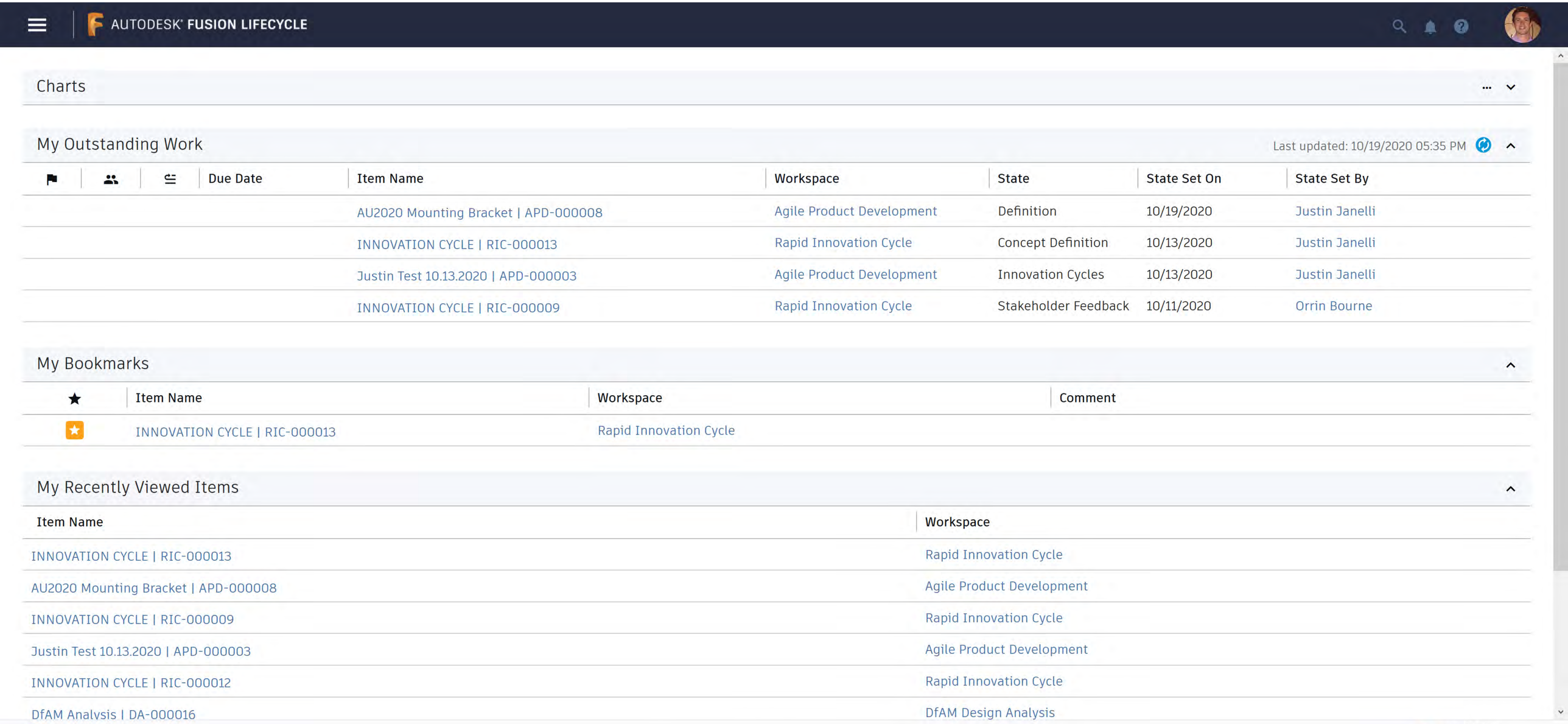
Agile Product Development



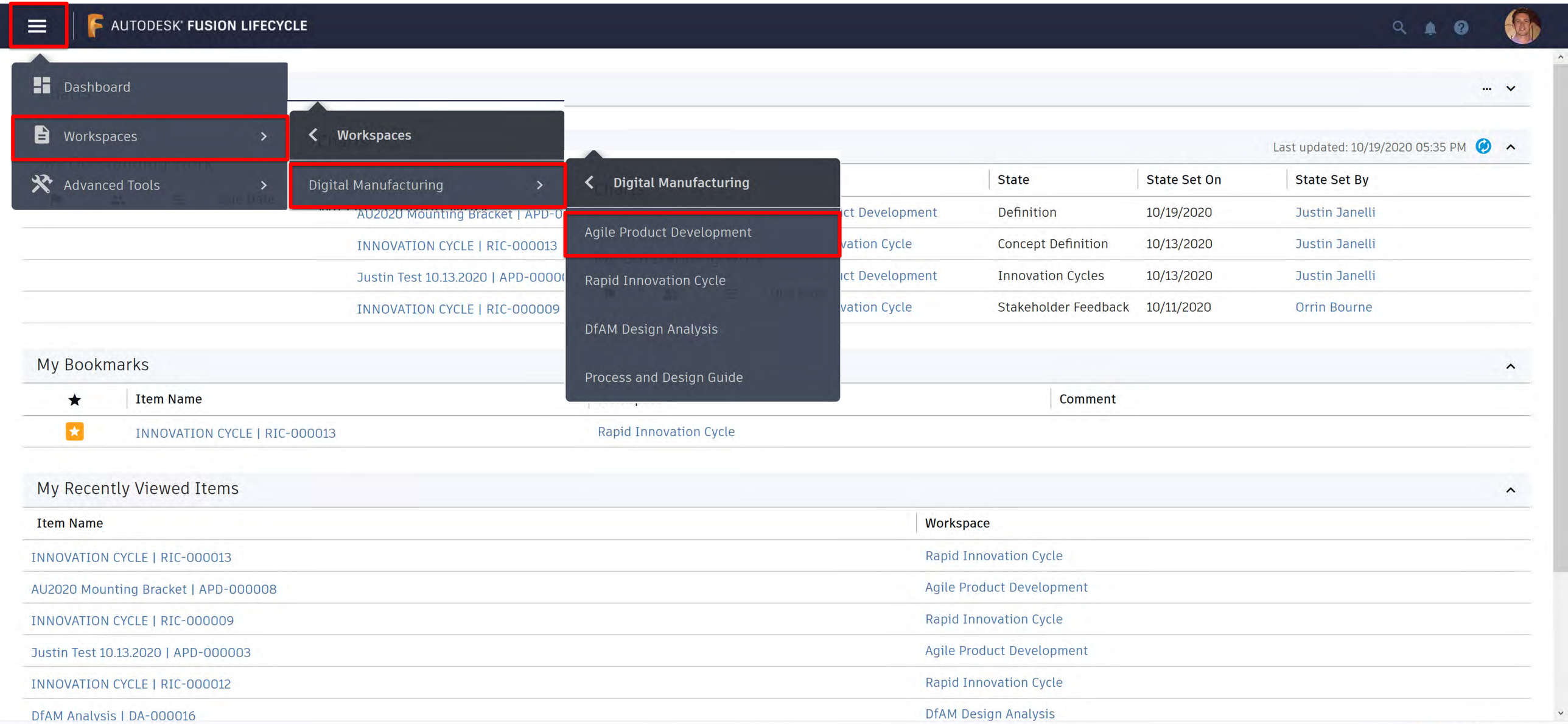
Inspired by the MIT course "Additive Manufacturing for Innovative Design and Production"


DEMO

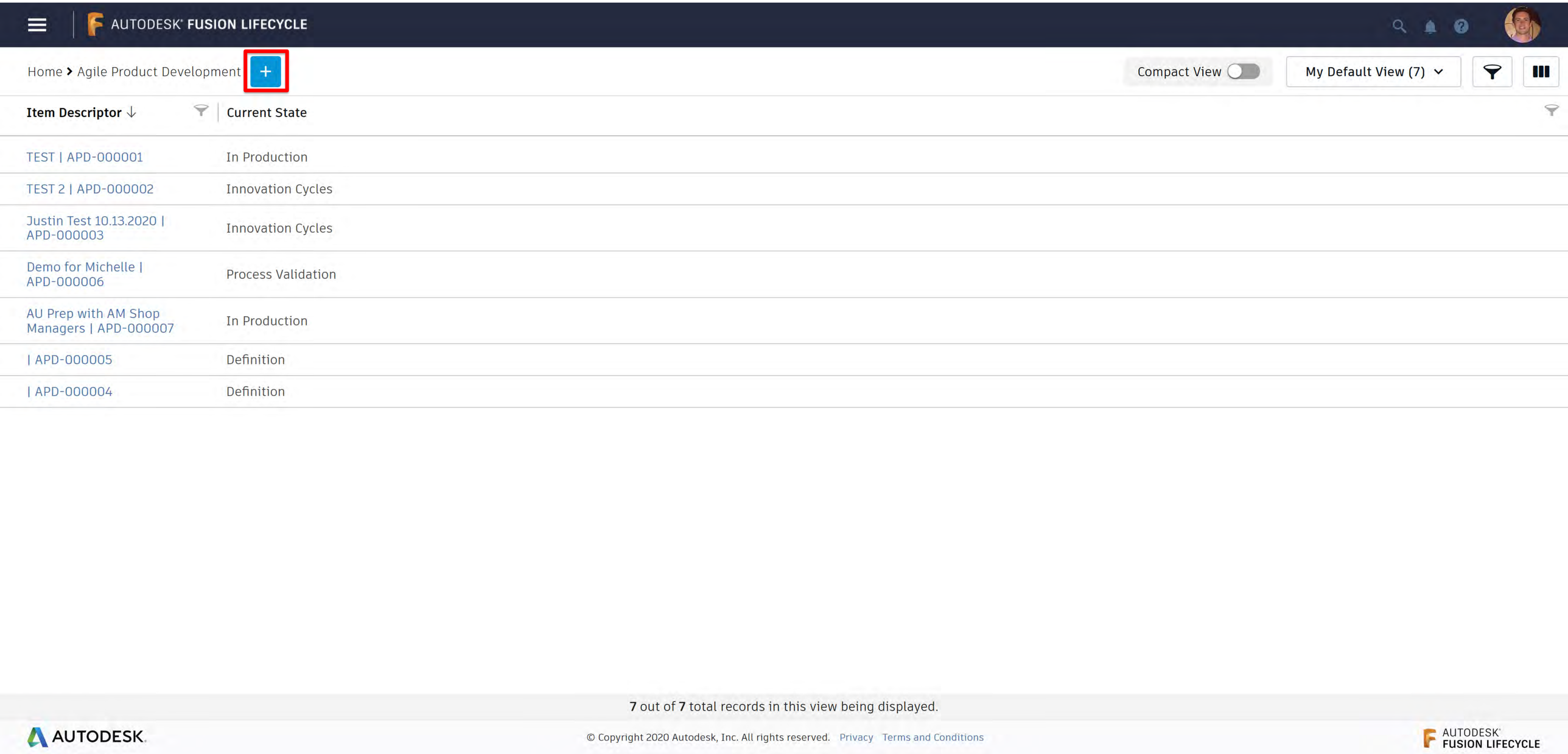
Home Dashboard



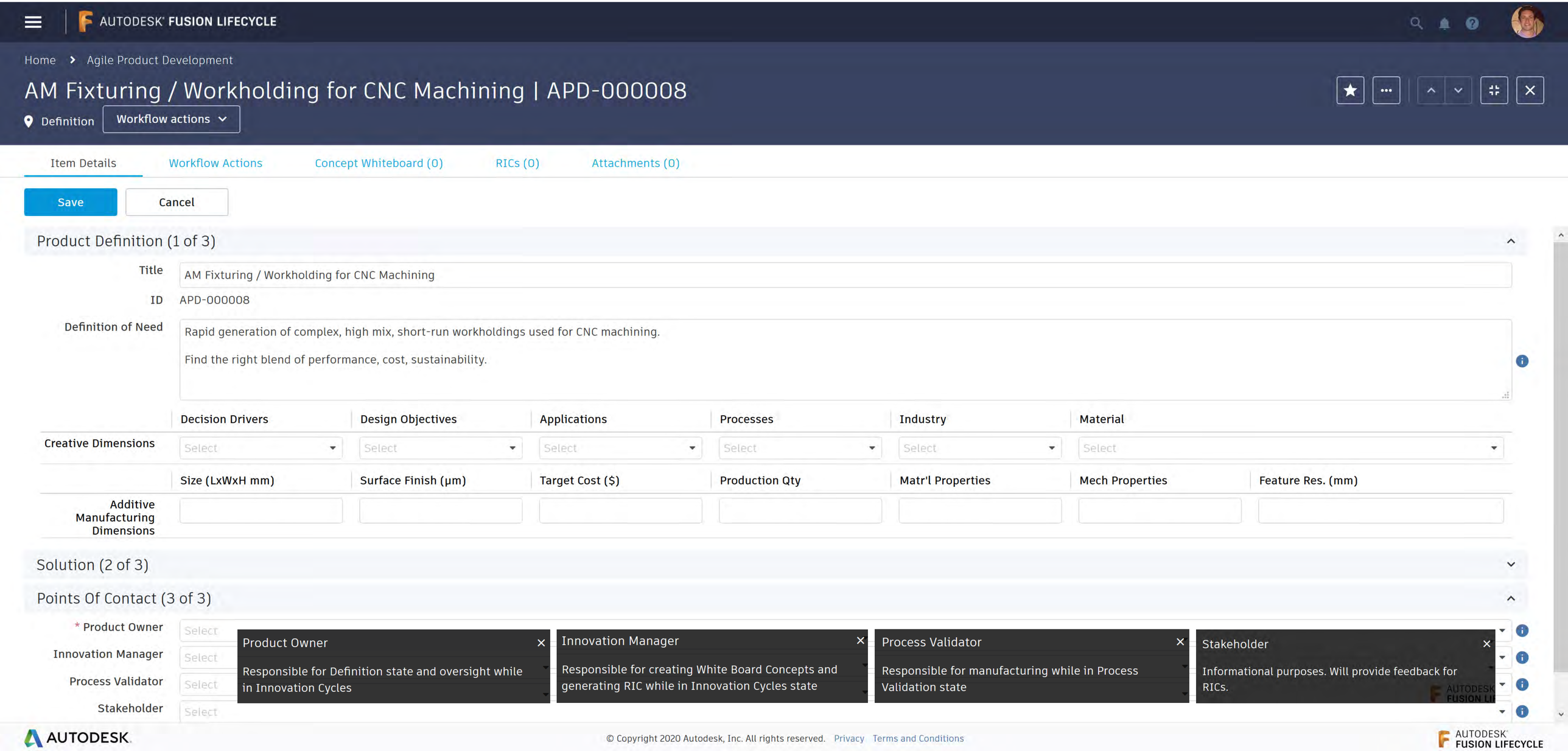
Home Dashboard



Create New Agile Product Development (APD)



APD | Populate Item Details



DfAM Cards

DECISION DRIVERS	COST	TIME TO MARKET	FLEXIBILITY	PERFORMANCE	QUALITY	INDUSTRY	APPLICATION	PROCESS	DESIGN	
DESIGN OBJECTIVES	HIGH-STRENGTH	LOW/HIGH VOLUME	LIGHTWEIGHT	MODULARIZED	INDUSTRIALLY DESIGNED	GENERATIVELY DESIGNED	PARAMETRICALLY DESIGNED	COMPLIANT DESIGN	REVERSE ENGINEERED	
AM APPLICATIONS	PROTOTYPING / PRODUCT DEVELOPMENT	TOOLING & MANUFACTURING PRODUCTIVITY	CUSTOMIZATION & PERSONALIZATION	PRODUCTION	ART, DESIGN, ARCHITECTURE	PERFORMANCE OPTIMIZATION	SPARE PARTS / MRO	PROCESS	SUSTAINABILITY	
AM PROCESSES	FFF / FDM	SLA	SLS	SLM	BINDER JETTING	MATERIAL JETTING	DED	LOM	HYBRID	
INDUSTRY	AEROSPACE	AUTOMOTIVE	INDUSTRIAL	CONSUMER ELECTRONICS	CONSUMER	TEXTILES	MANUFACTURING	MEDICAL	ARCHITECTURE	
MATERIAL	POLYMERS	METALS	COMPOSITES	ORGANICS	MULTIMATERIALS	FOODS	CERAMICS	GLASS		

Source: MIT

APD | Review Item Details

AUTODESK FUSION LIFECYCLE

Home > Agile Product Development

AM Fixturing / Workholding for CNC Machining | APD-000008

Definition | Workflow actions

Item Details | Workflow Actions | Concept Whiteboard (0) | RICs (0) | Attachments (0)

Edit

Product Definition (1 of 3)

Title AM Fixturing / Workholding for CNC Machining

ID APD-000008

Definition of Need Rapid generation of complex, high mix, short-run workholdings used for CNC machining.

Find the right blend of performance, cost, sustainability.

	Decision Drivers	Design Objectives	Applications	Processes	Industry	Material
Creative Dimensions	Application Design Performance Time to Market	Gernatively Designed High-Strength Industrially Designed Low/High Volume	Performance Optimization Process Sustainability Tooling & Manufacturing	Binder Jetting Hybrid SLA SLM SLS	Industrial	Metals Polymer

	Size (LxWxH mm)	Surface Finish (µm)	Target Cost ($)	Production Qty	Matr'l Properties	Mech Properties	Feature Res. (mm)
Additive Manufacturing Dimensions	300x300x300	400.00	100.00	100	Corrosion-resistant	Thermoplastic	1.00

Solution (2 of 3)

Points Of Contact (3 of 3)

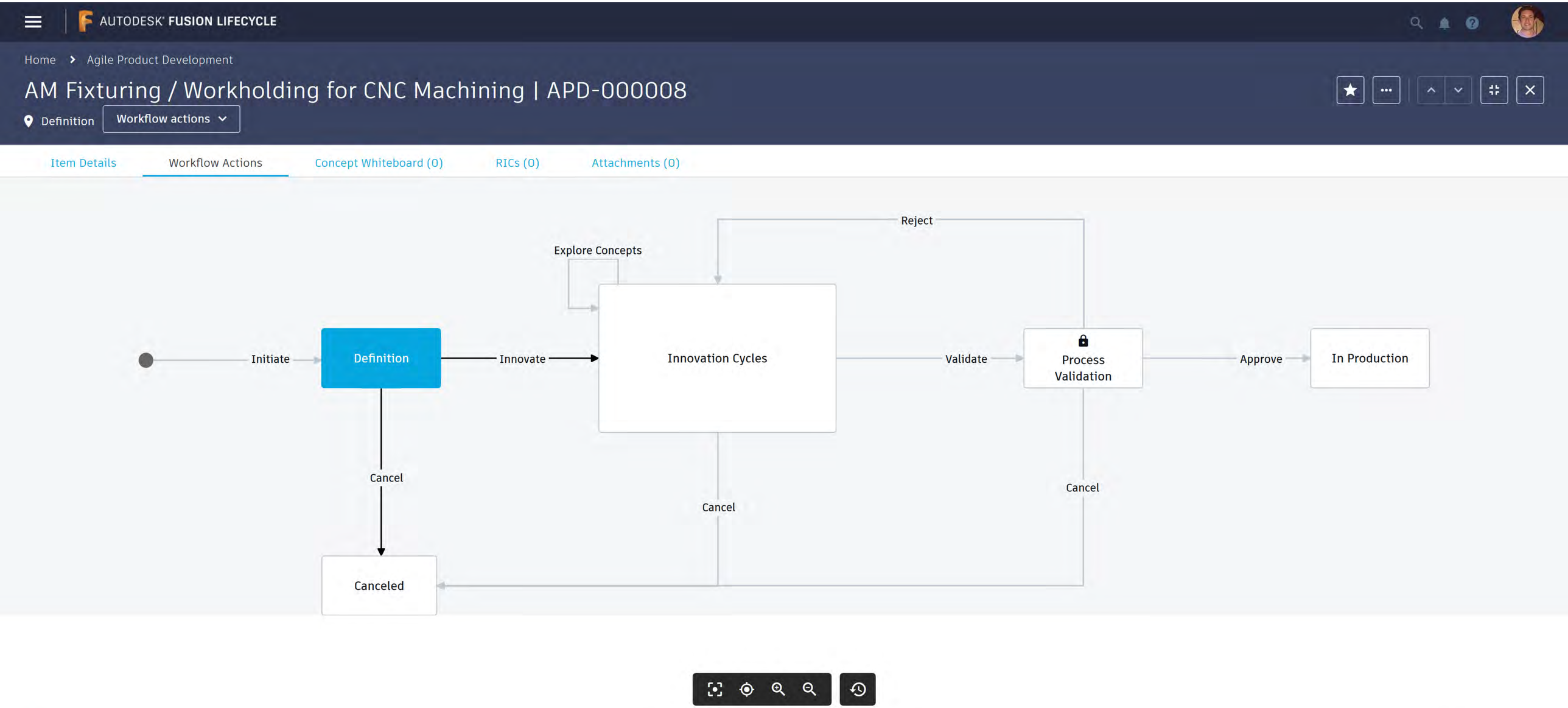
Product Owner Janelli, Justin

Innovation Manager Janelli, Justin

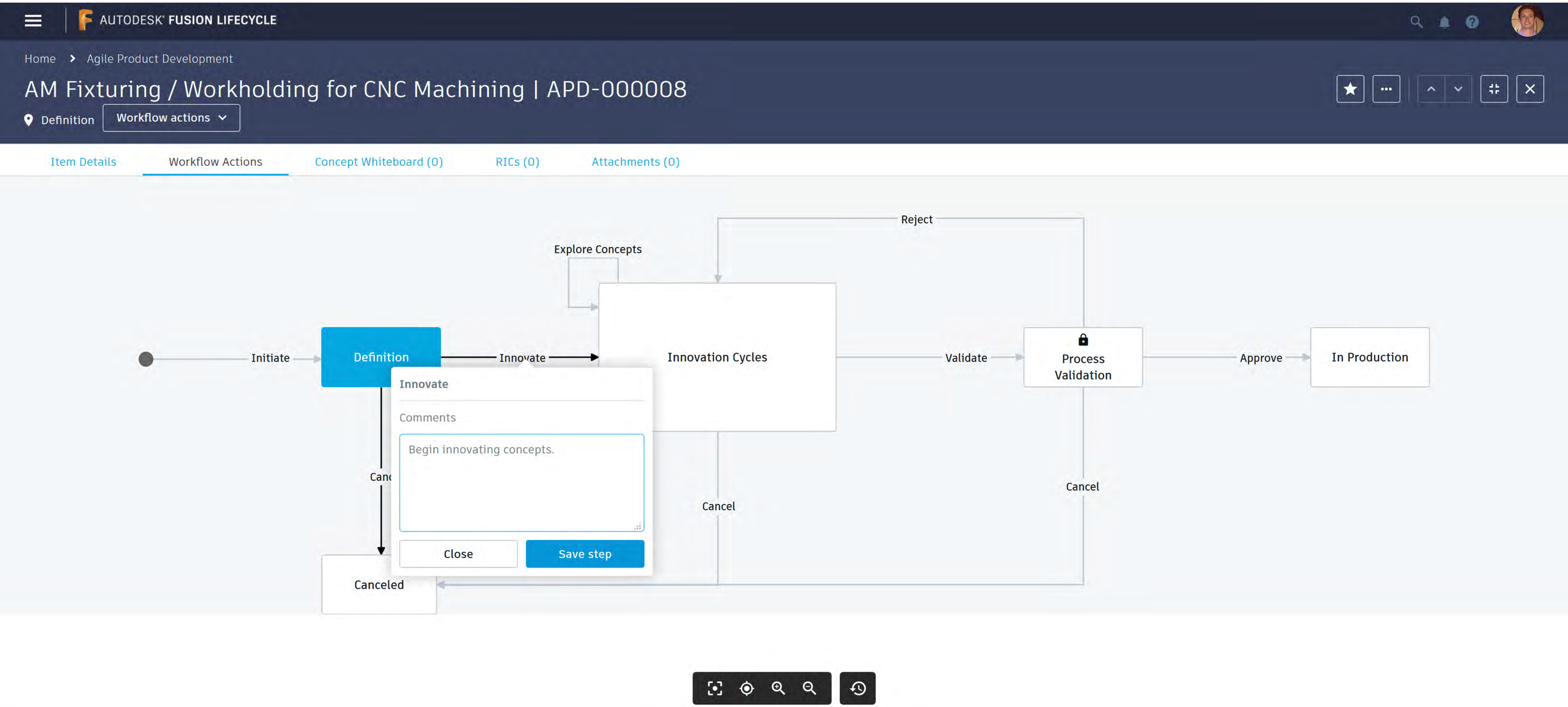
Process Validator Janelli, Justin

Stakeholder Janelli, Justin

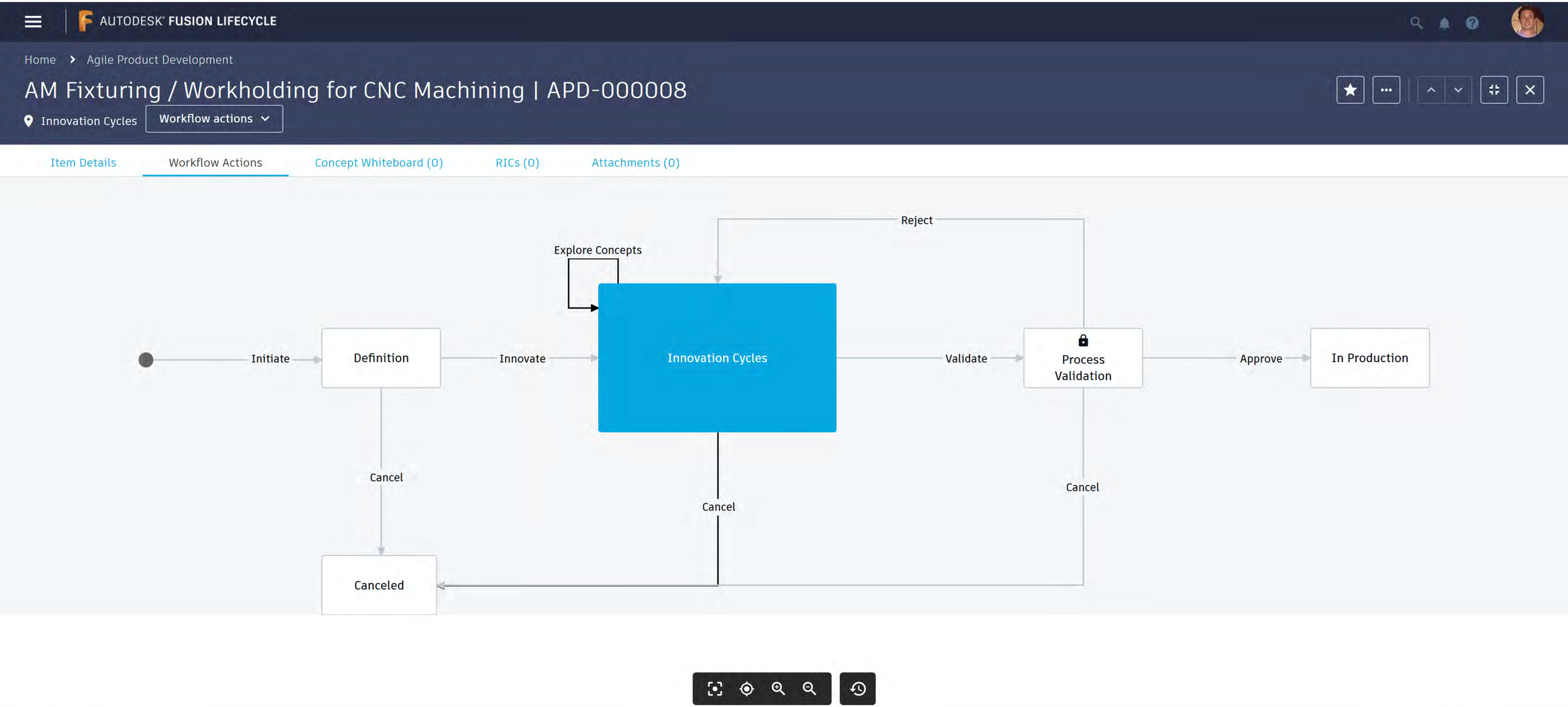
APD | Product Owner Hand-Off to Innovation Manager



APD | Product Owner Hand-Off to Innovation Manager



APD | Ready to Innovate



APD | Innovate Concepts to Explore

AUTODESK® FUSION LIFECYCLE

Home › Agile Product Development

AM Fixturing / Workholding for CNC Machining | APD-000008

Innovation Cycles | Workflow actions

Item Details | Workflow Actions | Concept Whiteboard (3) | RICs (0) | Attachments (0)

Edit | Add | Remove

Explore	Concept ↑	Notes	Supporting Data Link (URL)
	Enable reuse / recycling for sustainability.	Concept whiteboard sketch with material ideas in supporting link.	https://a360.co/31pxiza
	Generatively designed.	Inspired by Matsuura. See supporting AU Class link.	https://www.autodesk.com/autodesk-university/class/Automated-Fixture-Creation-CNC-Milling-Using-Generative-Design-Approach-2019#video
	Parts are user-configurable via web, cloud-based interface.	Inspired by internal project around AM jigs and drilling templates.	https://a360.co/34f4fjB

APD | Innovation Manager Must Choose Which to Explore

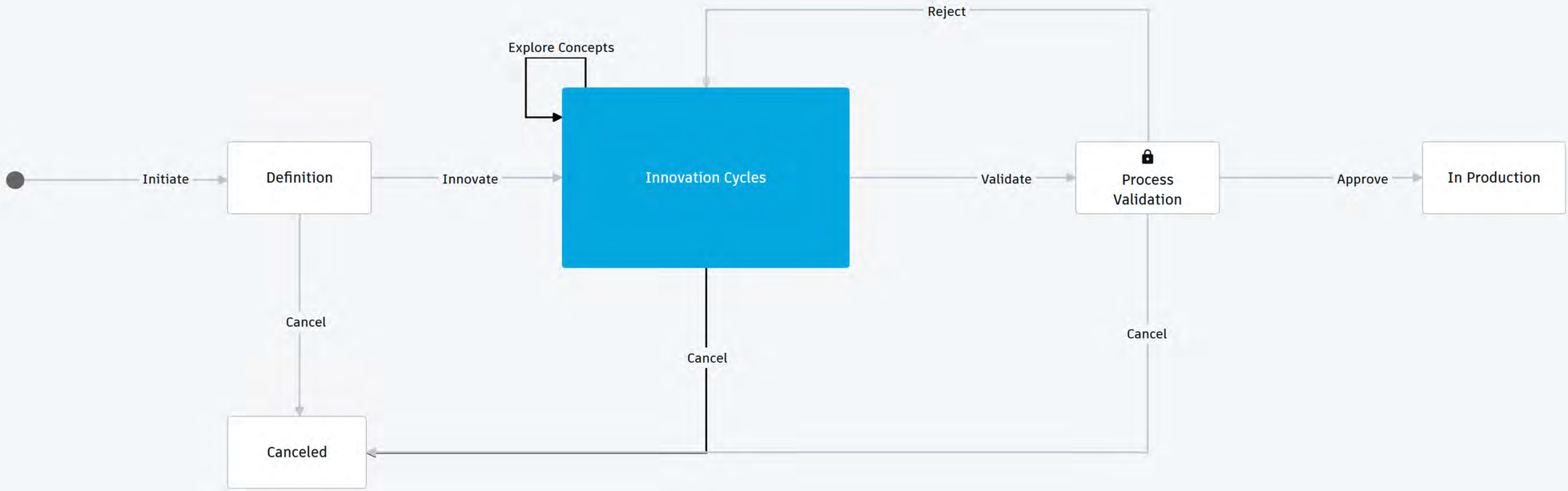
AUTODESK FUSION LIFECYCLE

Home > Agile Product Development

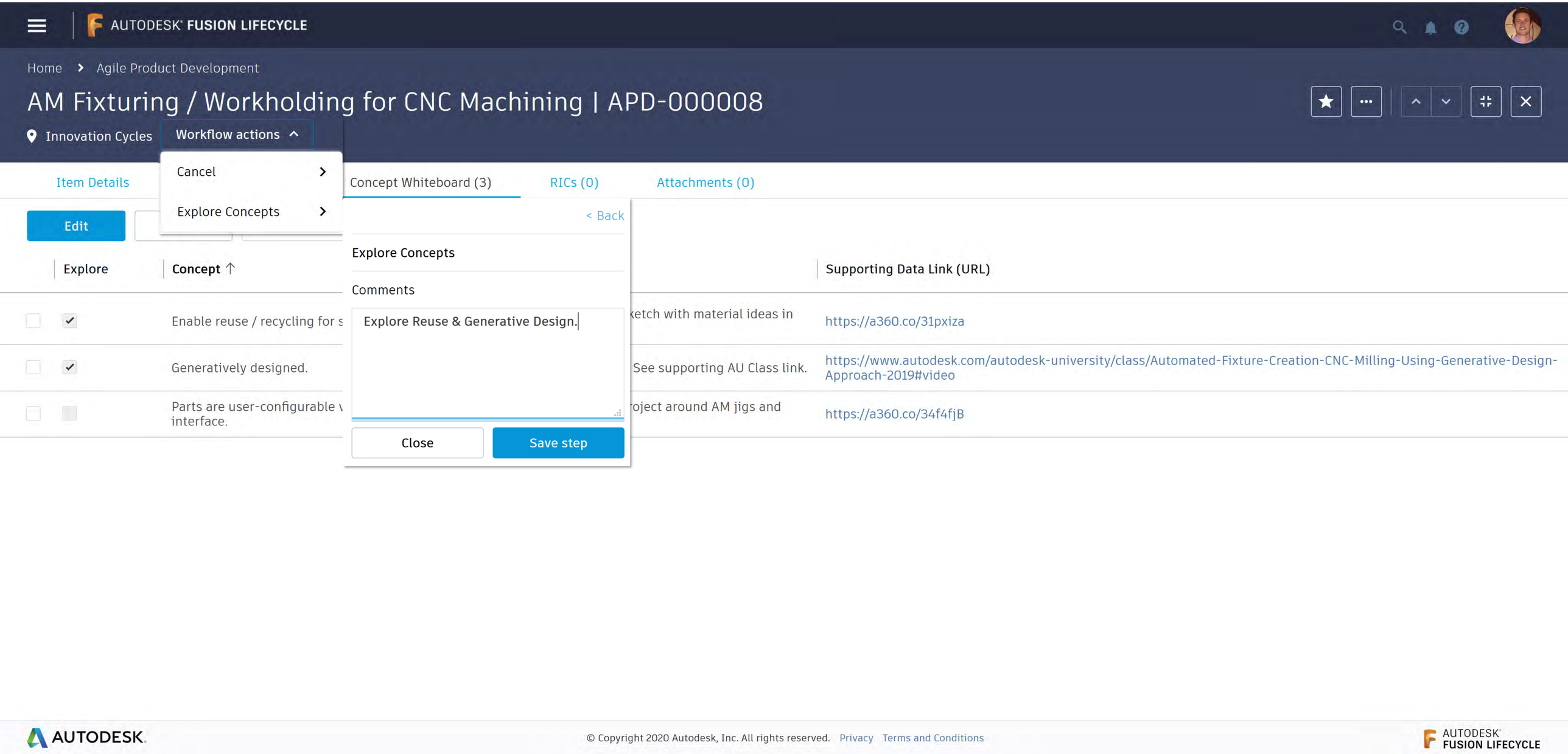
AM Fixturing / Workholding for CNC Machining | APD-000008

Innovation Cycles | Workflow actions

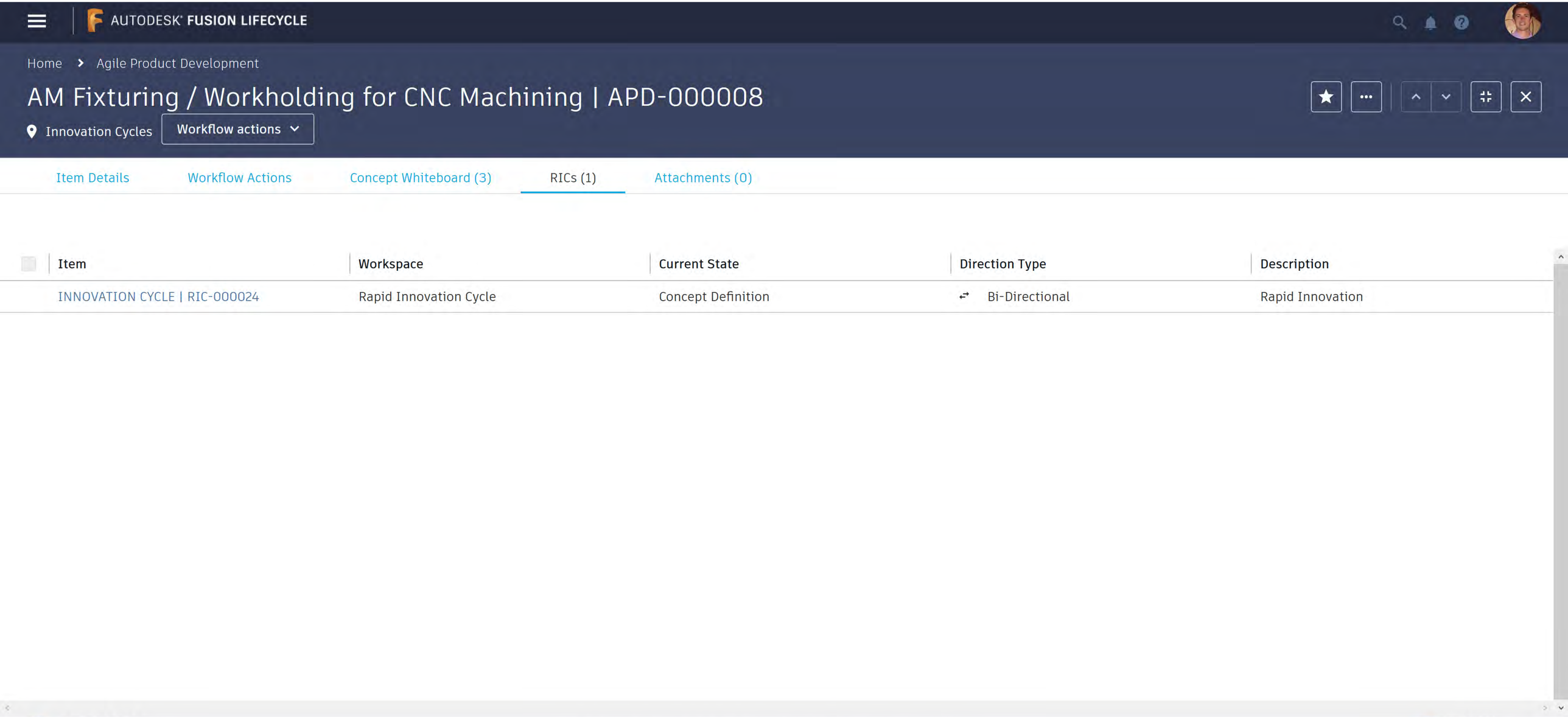
Item Details | Workflow Actions | Concept Whiteboard (3) | RICs (0) | Attachments (0)



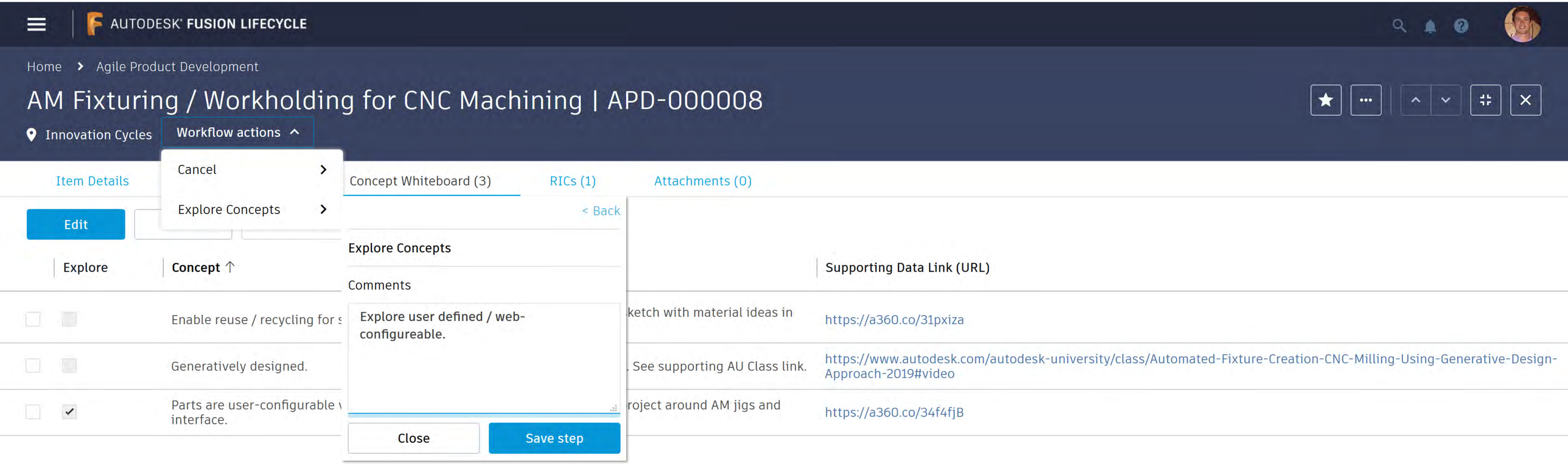
APD | Group & Explore Concepts



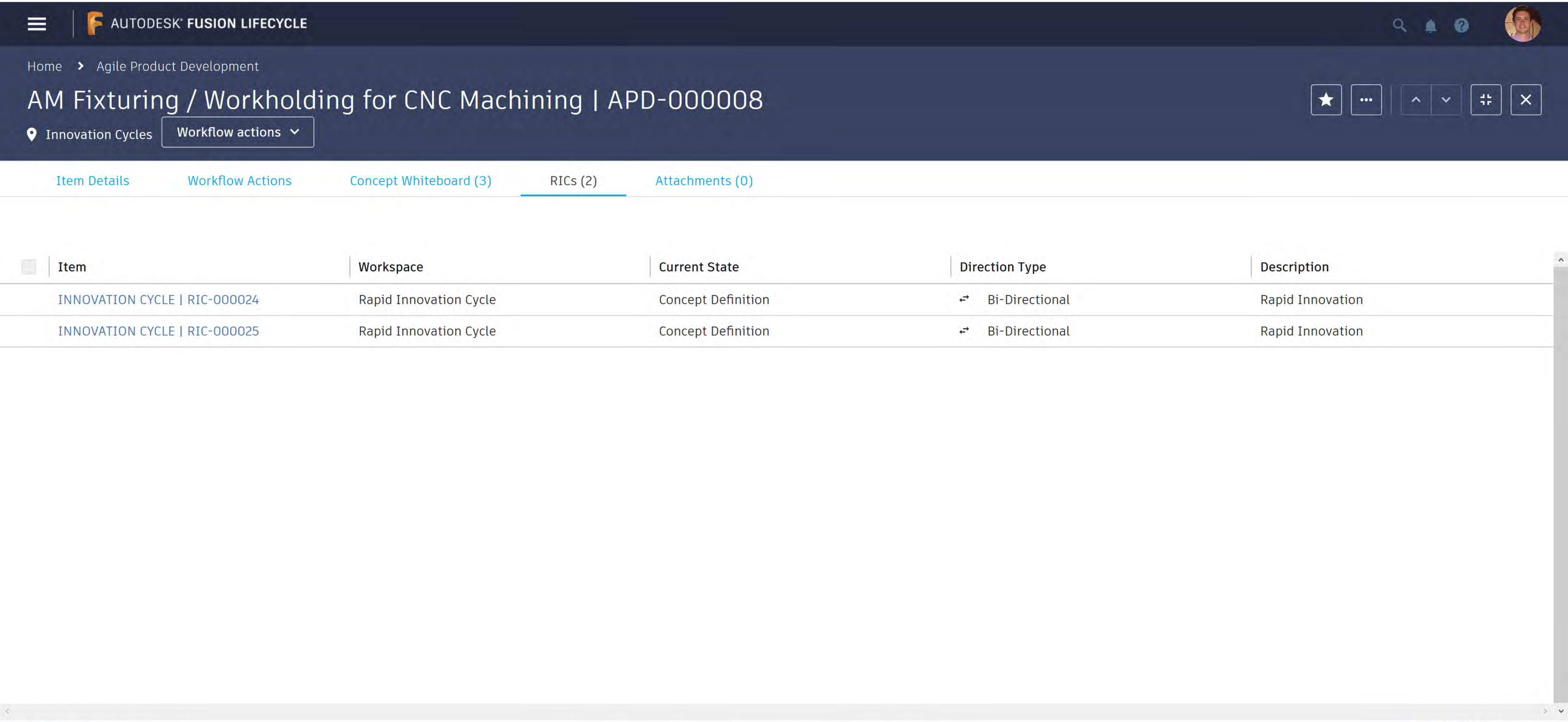
ADP | Creates New Rapid Innovation Cycle (RIC)

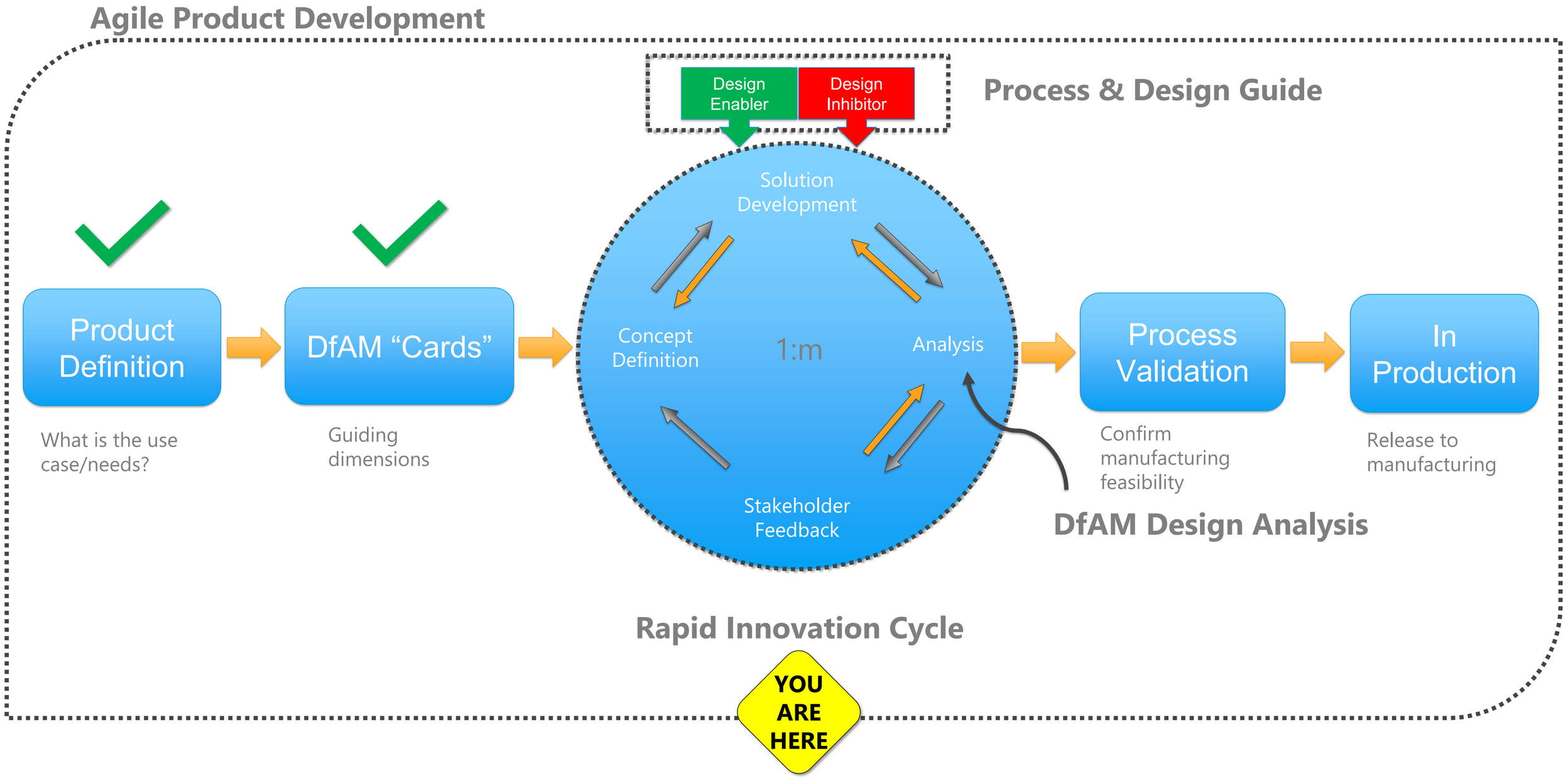


APD | Group & Explore Remaining Concepts



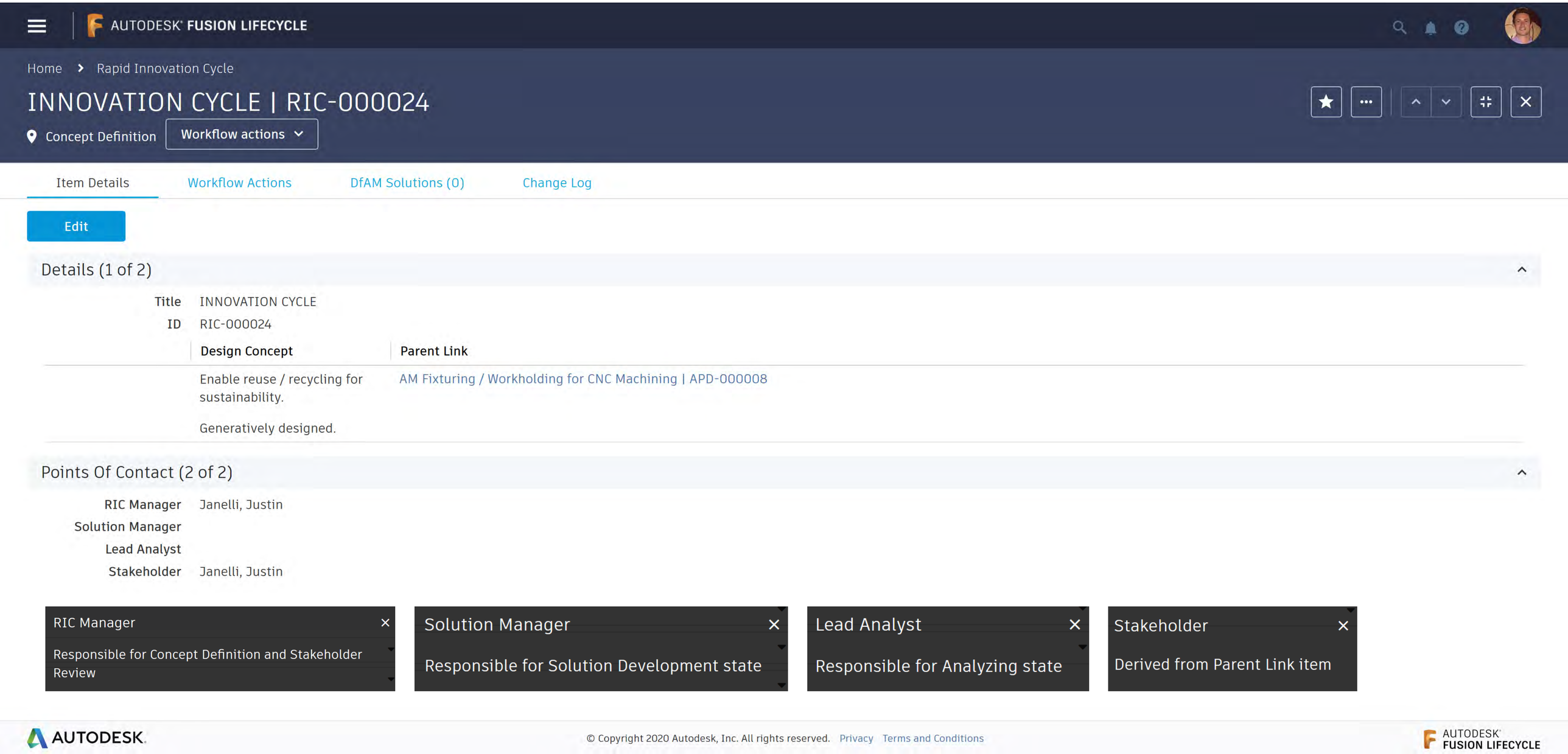
APD | Creates New Rapid Innovation Cycle (RIC)



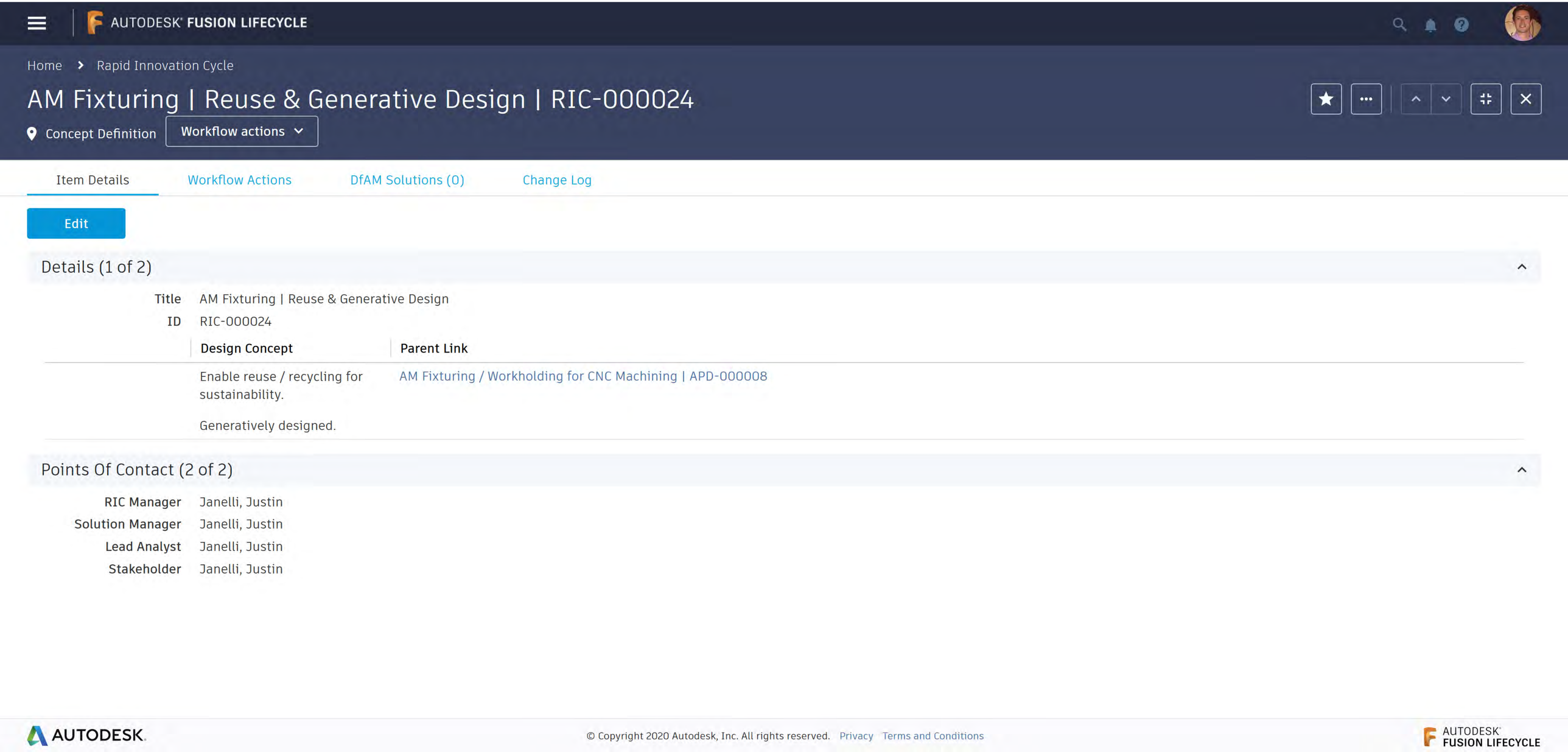


Inspired by the MIT course "Additive Manufacturing for Innovative Design and Production"

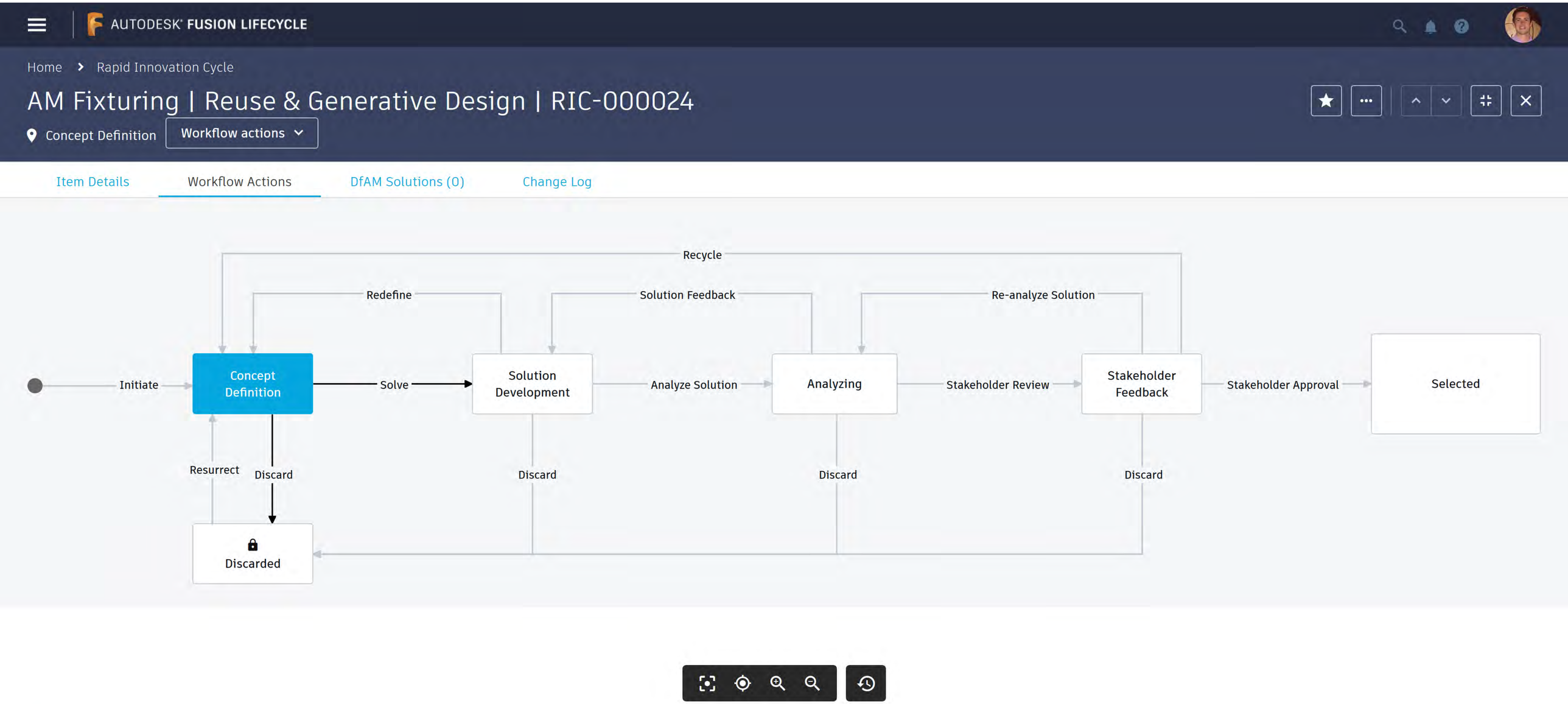
RIC | Review Rapid Innovation Cycle (RIC)



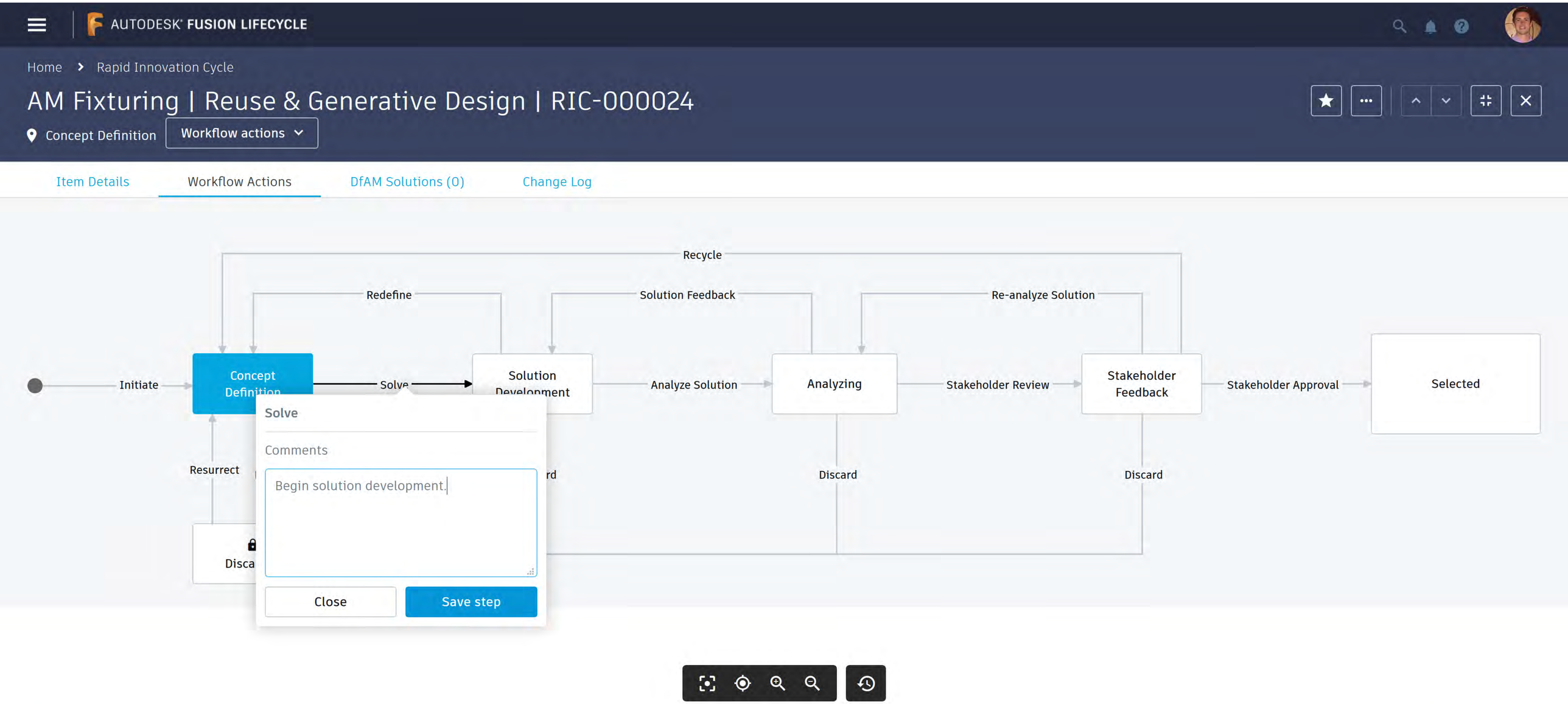
RIC | Update Rapid Innovation Cycle (RIC)



RIC | RIC Manager



RIC | Hand-off to Solution Manager



RIC | Ready for Solution Development

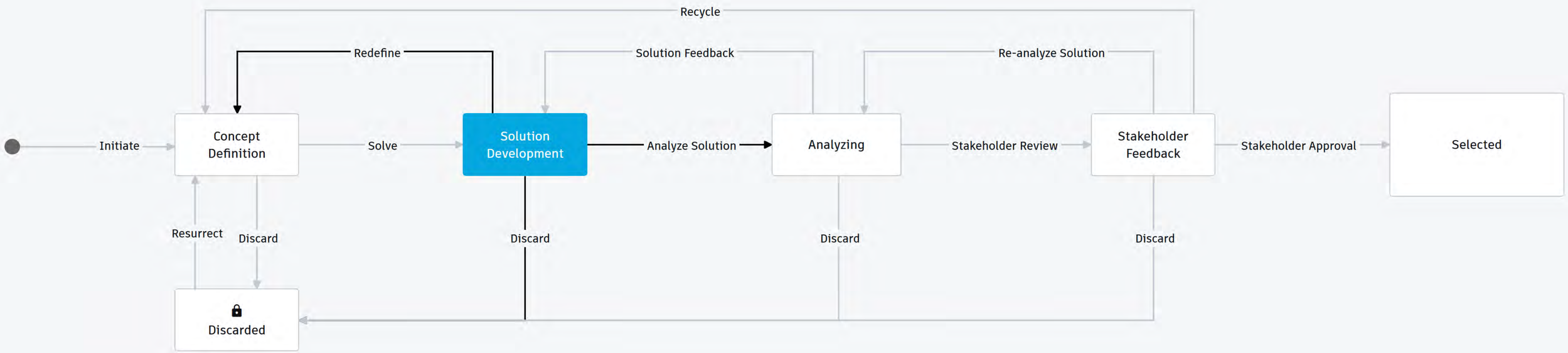
AUTODESK FUSION LIFECYCLE

Home > Rapid Innovation Cycle

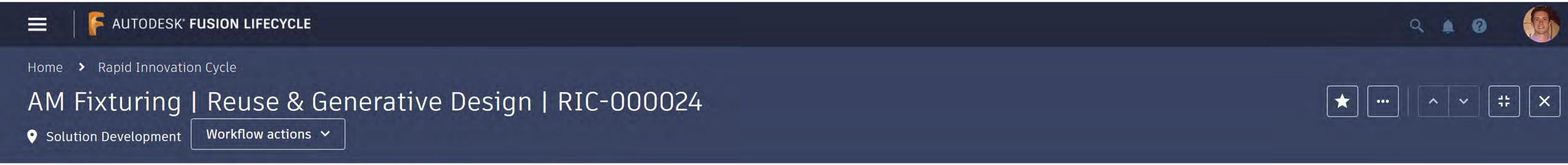
AM Fixturing | Reuse & Generative Design | RIC-000024

Solution Development | Workflow actions

Item Details | Workflow Actions | DfAM Solutions (0) | Change Log



RIC | Add Designs and MFG Processes to Explore



Item Details | Workflow Actions | DfAM Solutions (4) | Change Log

Edit | Add | Remove

Additional Actions	Design Data (URL)	Mfg. Process	Status ↓	Design Analysis	Stakeholder Feedback
	https://a360.co/2TezPYn	SLM | EOSm400-4	Under Consideration		
	https://a360.co/3dOgas0	Binder Jetting | HP Metal Jet	Under Consideration		
	https://a360.co/34g6aEG	SLA | 3D Systems ProX 950	Under Consideration		
	https://a360.co/31pR5P1	Generative Design | Reference	Reference		

RIC | Build Out Your Available MFG Processes

Item Details | Attachments (0) | Change Log

Edit

Info. (1 of 1)

Process	SLA
Machine	3D Systems ProX 950
Build Volume	1500 x 750 x 550 mm
Design Enablers	Compliant Materials, Durable Materials, Easy to Use, Isotropic Materials, Large Scale Parts, Simple Post-Processing (No Machining), Smooth Surface, Soluble Material
Design Inhibitors	Requires Support Material & Post-Processing

Design Enablers & Inhibitors

Design Enablers *process attributes that expand the design space, and enable new solutions*	**Design Inhibitors** *process attributes that challenge the feasibility of new solutions*
• Compliant materials • Durable materials • Easy to use • Efficient build utilization • Electrically conductive • Full color • High build rate • High detail • Isotropic mechanics • Large-scale parts • Low feedstock cost • Simple post-processing • Smooth surface • Soluble material • Thermally conductive • Uses well-known materials • Other (your suggestions)	• Anisotropic mechanics • Complicated post-processing • Expensive equipment • Expensive materials • Low resolution • Poor material durability • Residual stress • Safety precautions • Other (your suggestions)

RIC | Attach Supporting Documentation

AUTODESK FUSION LIFECYCLE

Home > Process and Design Guide

SLA | 3D Systems ProX 950

Item Details | Attachments (1) | Change Log

Upload | Download (0) | Bulk Download | Display folders at the top

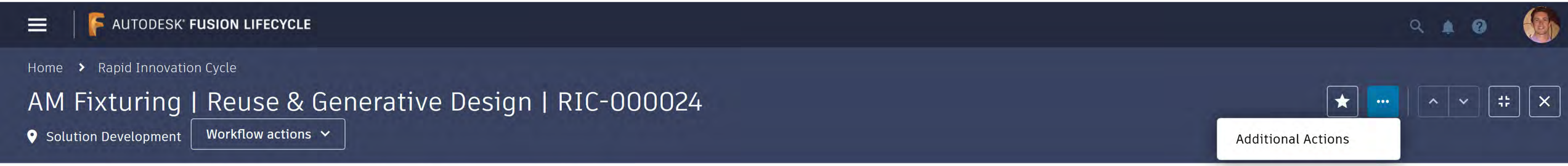
Direct Attachments

File Name	Title	Ver.	Type	Size	Last Updated	Description
3d-systems-3dsprint-sla-en-letter-flyer-web-2017-04-26.pdf	3d-systems-3dsprint-sla-en-letter-flyer-web-2017-04-26	1	Adobe PDF	295.6 KB	10/21/2020	3D Systems ProX 950 Spec Sheet

Related Attachments

No related attachments to this item.

RIC | Tag Solutions to Analyze

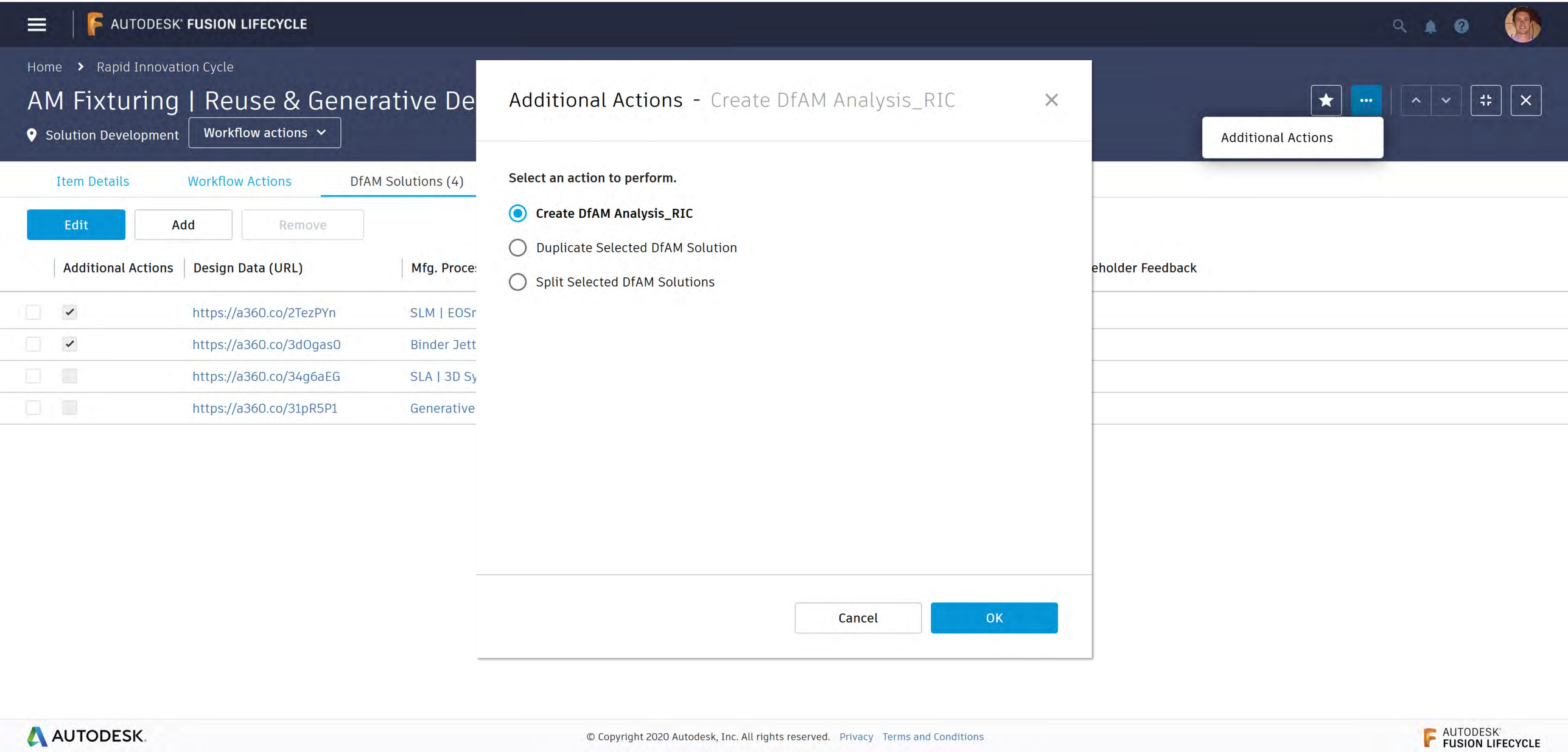


Item Details | Workflow Actions | DfAM Solutions (4) | Change Log

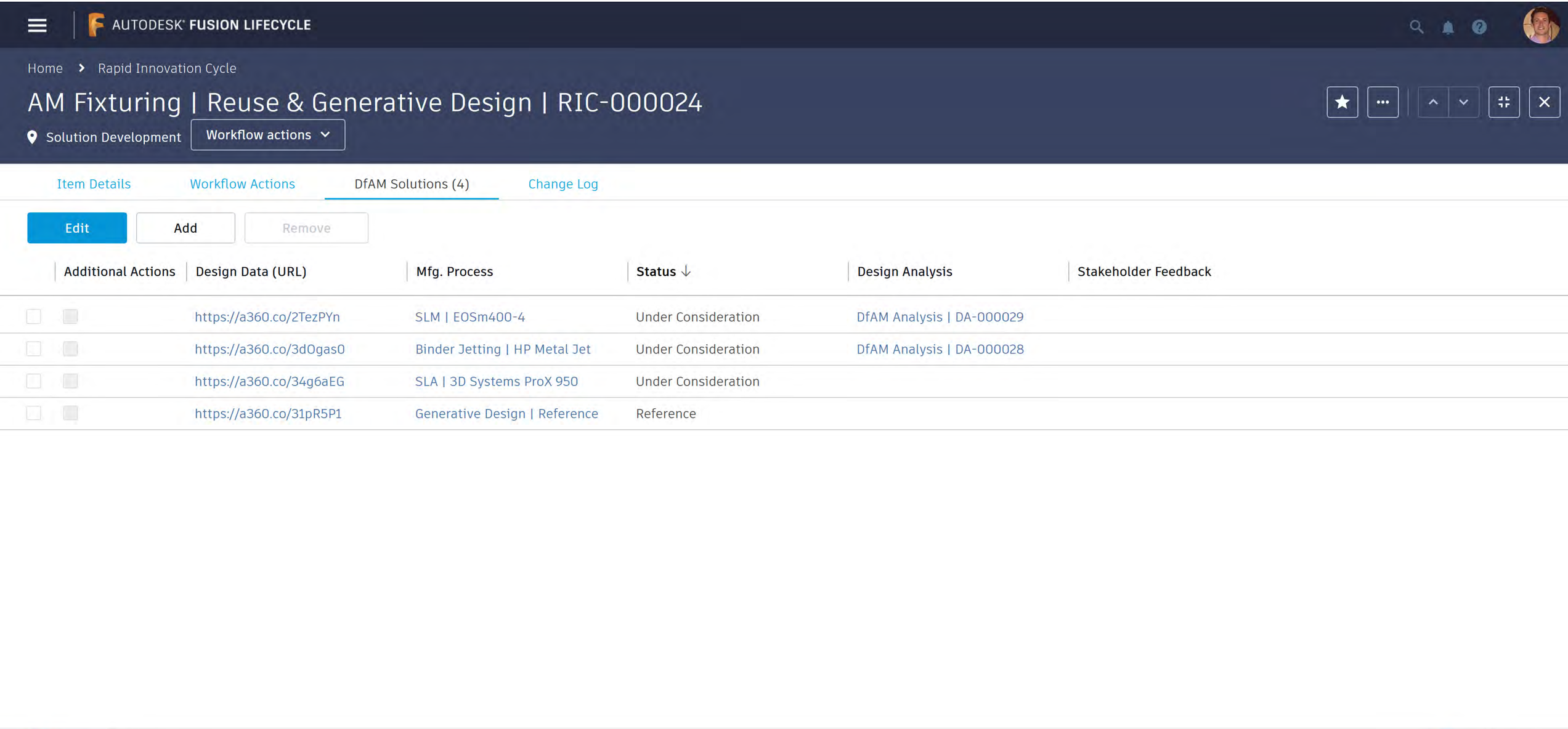
Edit | Add | Remove

Additional Actions	Design Data (URL)	Mfg. Process	Status ↓	Design Analysis	Stakeholder Feedback
☑	https://a360.co/2TezPYn	SLM | EOSm400-4	Under Consideration		
☑	https://a360.co/3dOgas0	Binder Jetting | HP Metal Jet	Under Consideration		
☐	https://a360.co/34g6aEG	SLA | 3D Systems ProX 950	Under Consideration		
☐	https://a360.co/31pR5P1	Generative Design | Reference	Reference		

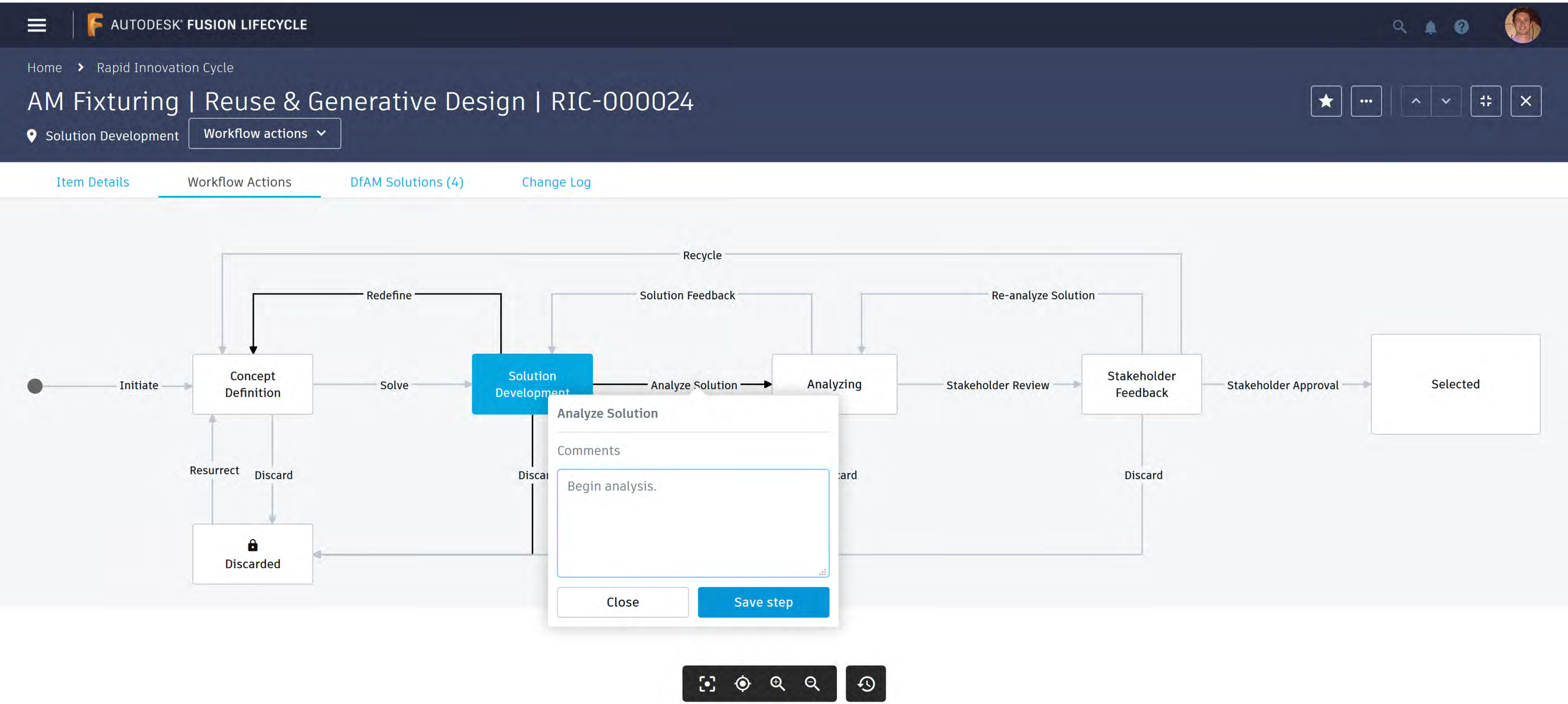
RIC | Create New DfAM Analysis



RIC | DfAM Analyses Created



RIC | Hand-off to Lead Analyst



RIC | Ready for Analysis

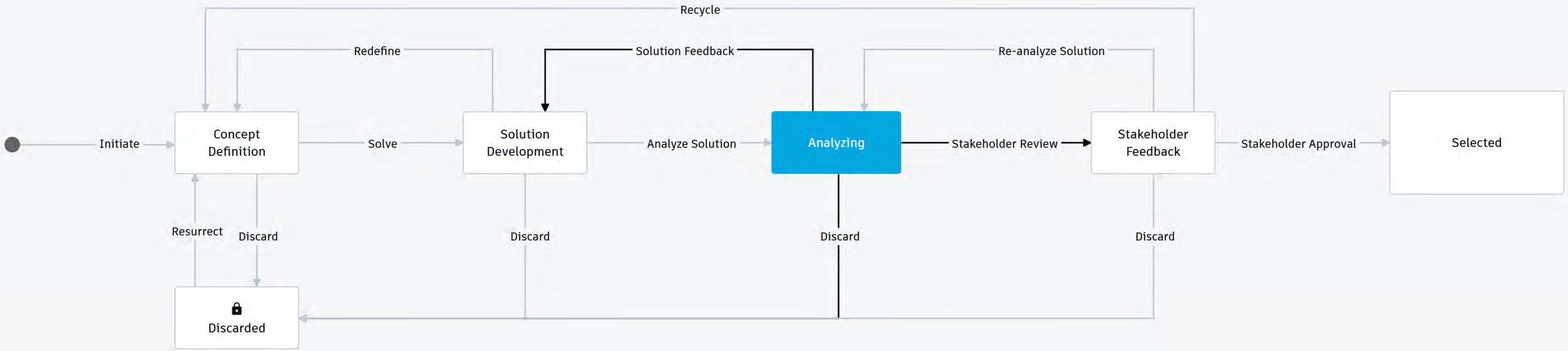
AUTODESK® FUSION LIFECYCLE

Home › Rapid Innovation Cycle

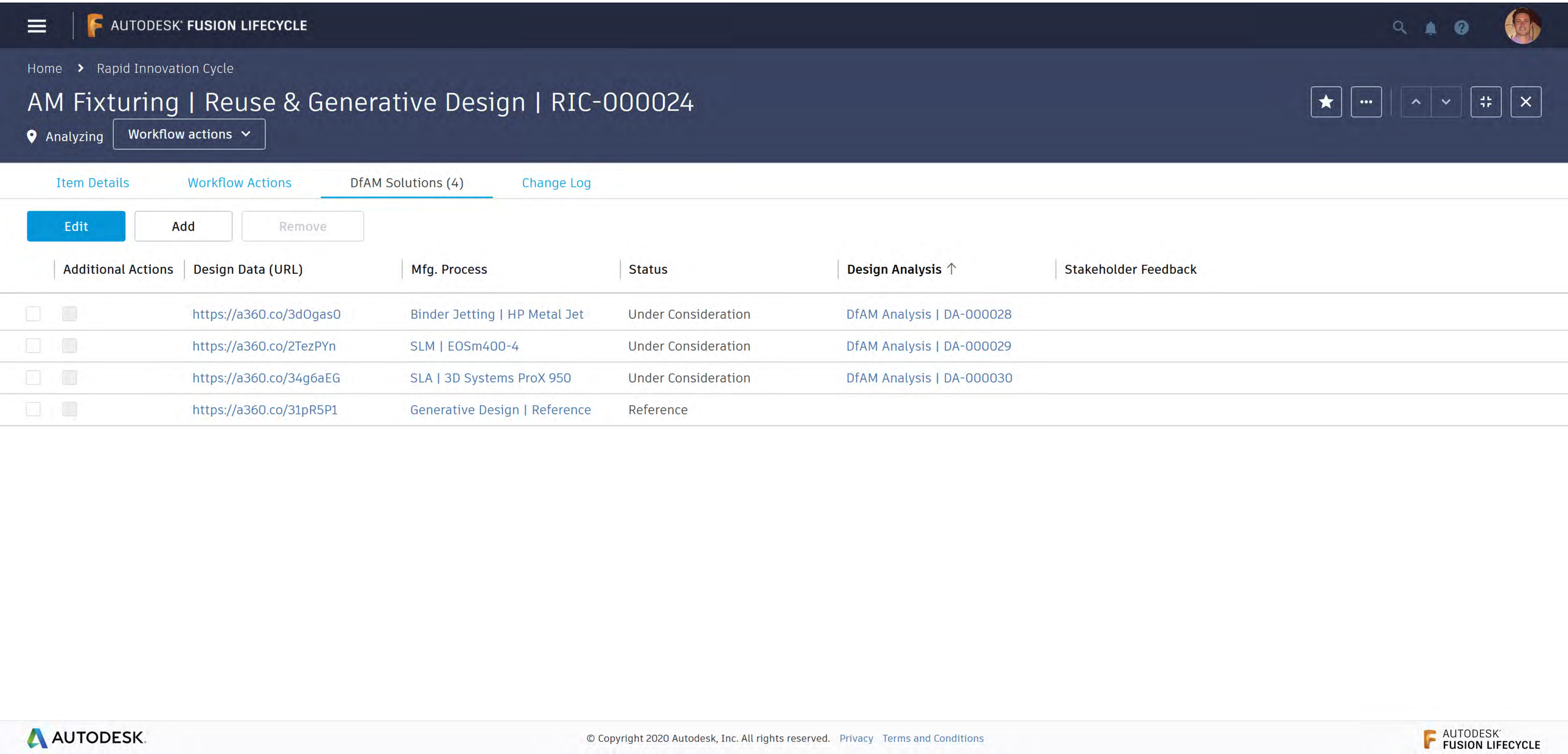
AM Fixturing | Reuse & Generative Design | RIC-000024

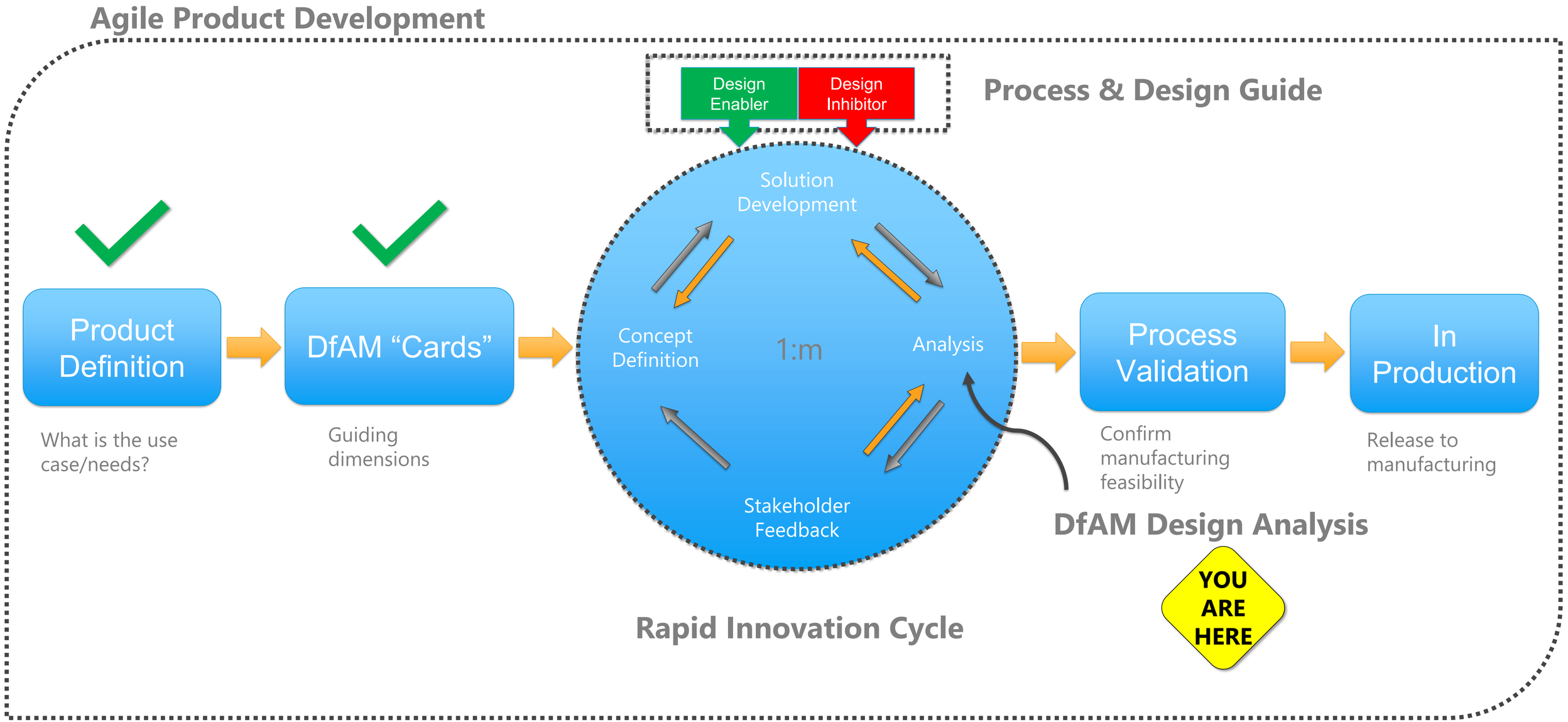
Analyzing | Workflow actions

Item Details | Workflow Actions | DfAM Solutions (4) | Change Log



RIC | Remaining DfAM Analyses Auto Created





Inspired by the MIT course "Additive Manufacturing for Innovative Design and Production"

Analysis | Populate with All Relevant Analysis Info

Analysis | Attach Supporting Documentation

AUTODESK® FUSION LIFECYCLE

Home > DfAM Design Analysis

DfAM Analysis | DA-000028

Item Details | Supporting Documents (3) | Change Log

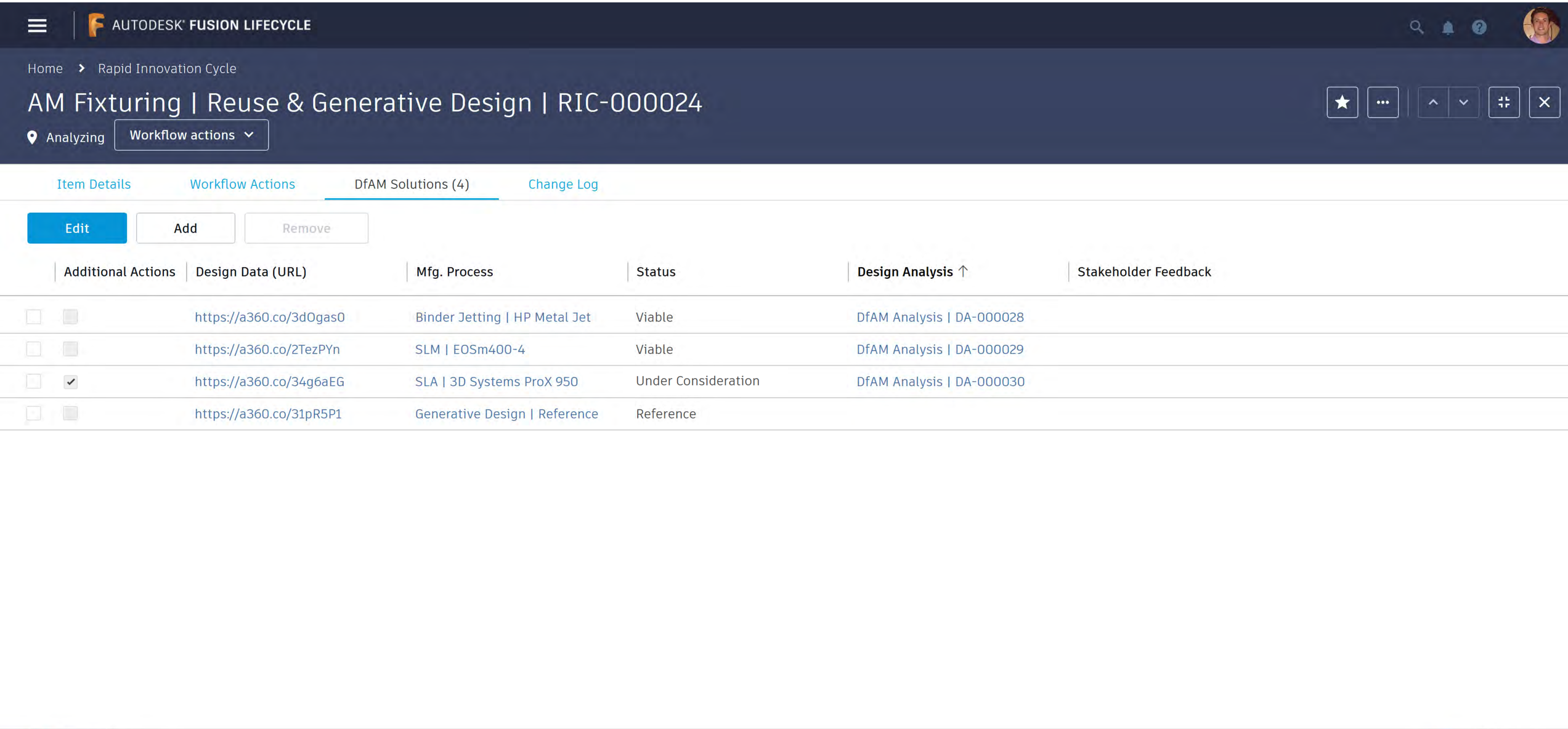
Upload | Download (0) | Bulk Download | Display folders at the top

Direct Attachments

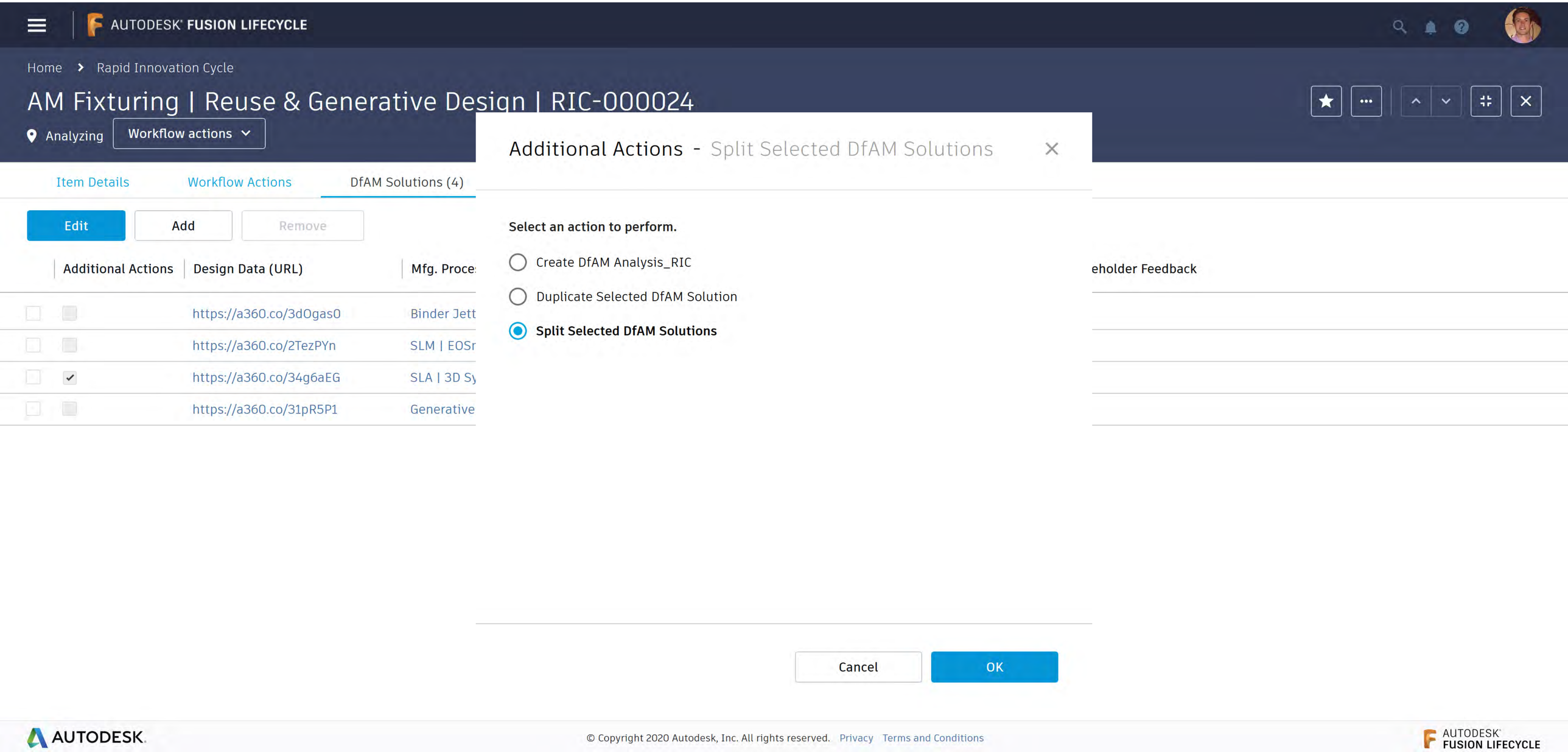
File Name	Title	Ver.	Type	Size	Last Updated	Description
Costing						
Cost Analysis.xlsx	Cost Analysis	1	Microsoft Excel	294.9 KB	10/21/2020	
FEA (Nastran)						
FEA Analysis - Nastran.pdf	FEA Analysis - Nastran	1	Adobe PDF	615.8 KB	10/21/2020	
Manufacturability (Netfabb)						
Manufacturability Analysis - Netfabb.pdf	Manufacturability Analysis - Netfabb	1	Adobe PDF	615.8 KB	10/21/2020	

Related Attachments

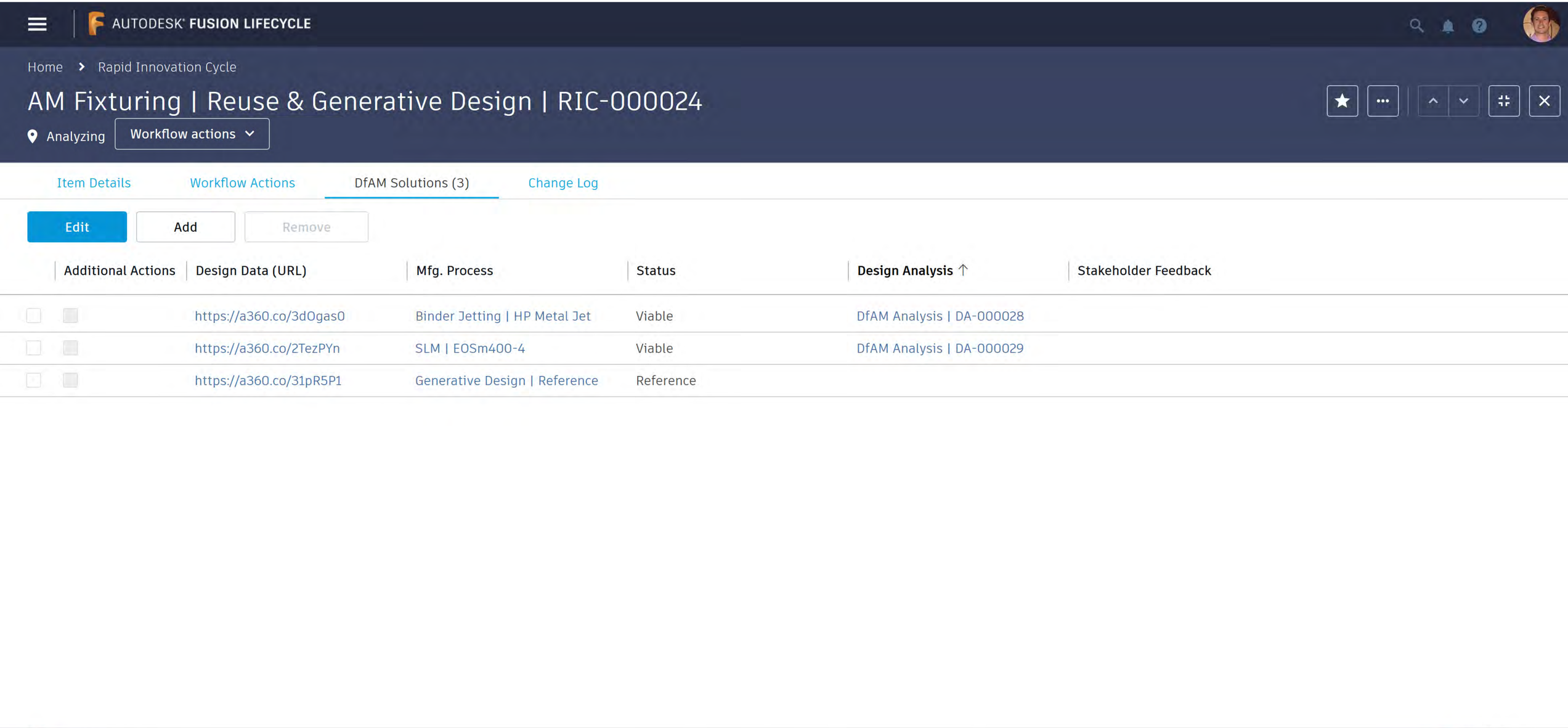
RIC | Option to Split Solution into Own RIC



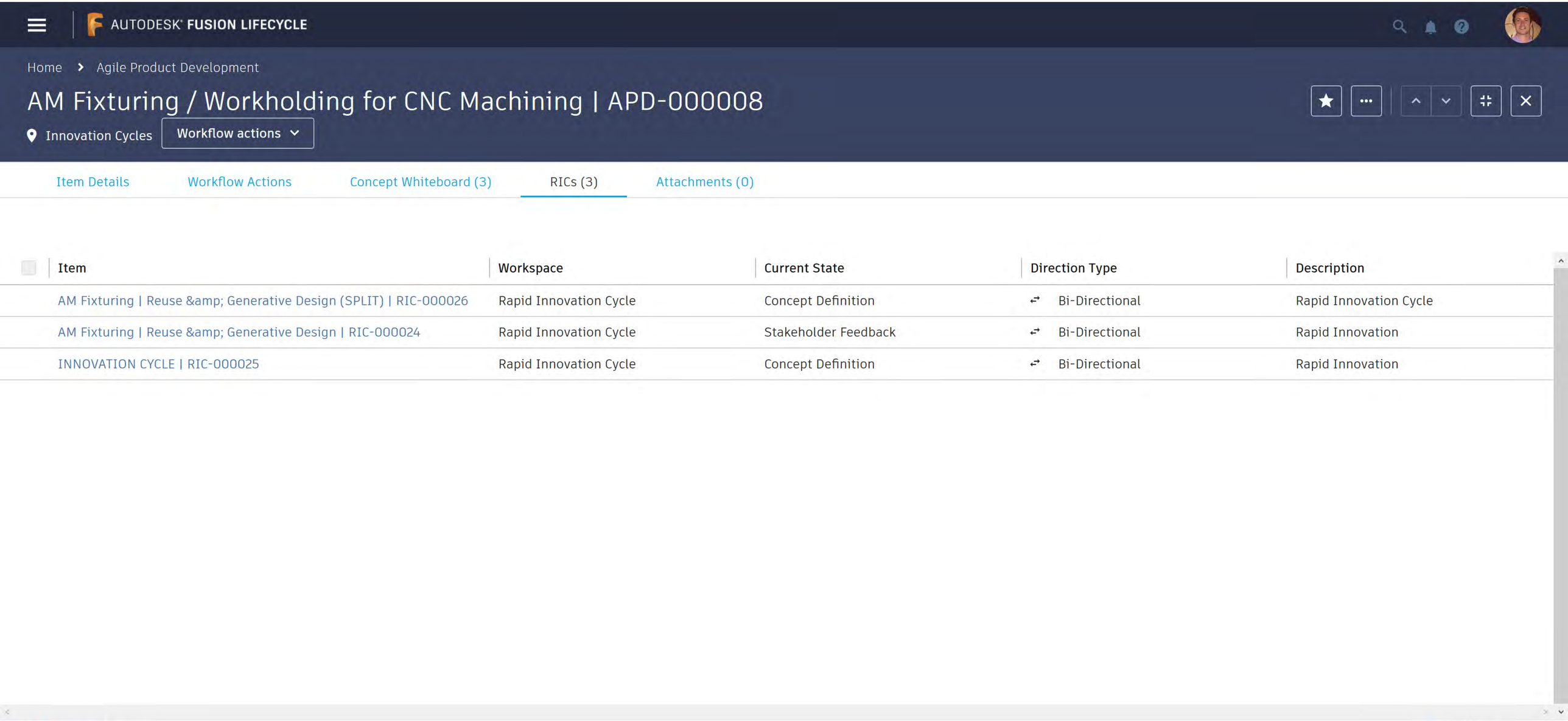
RIC | Tag Solution and Split into New RIC



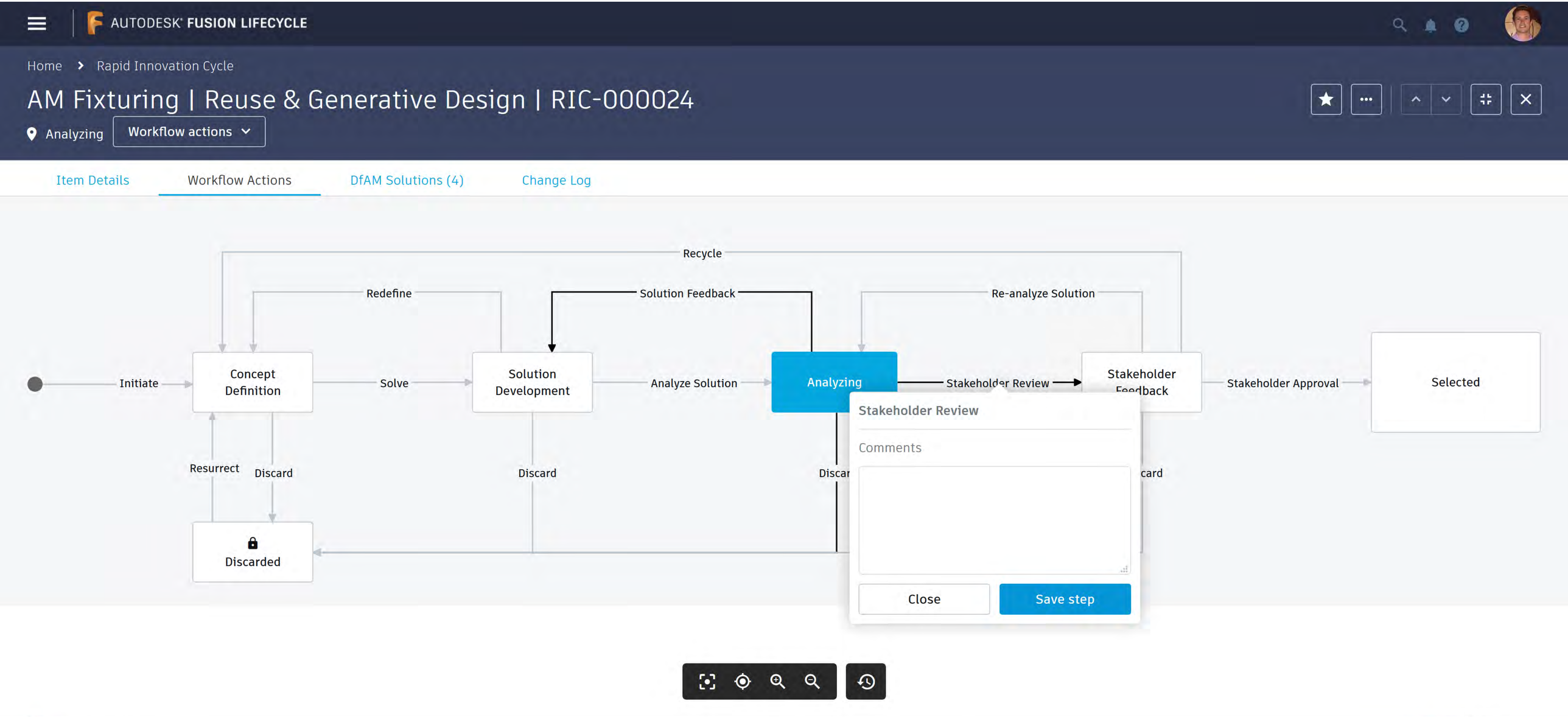
RIC | Review DfAM Solutions Post-Split



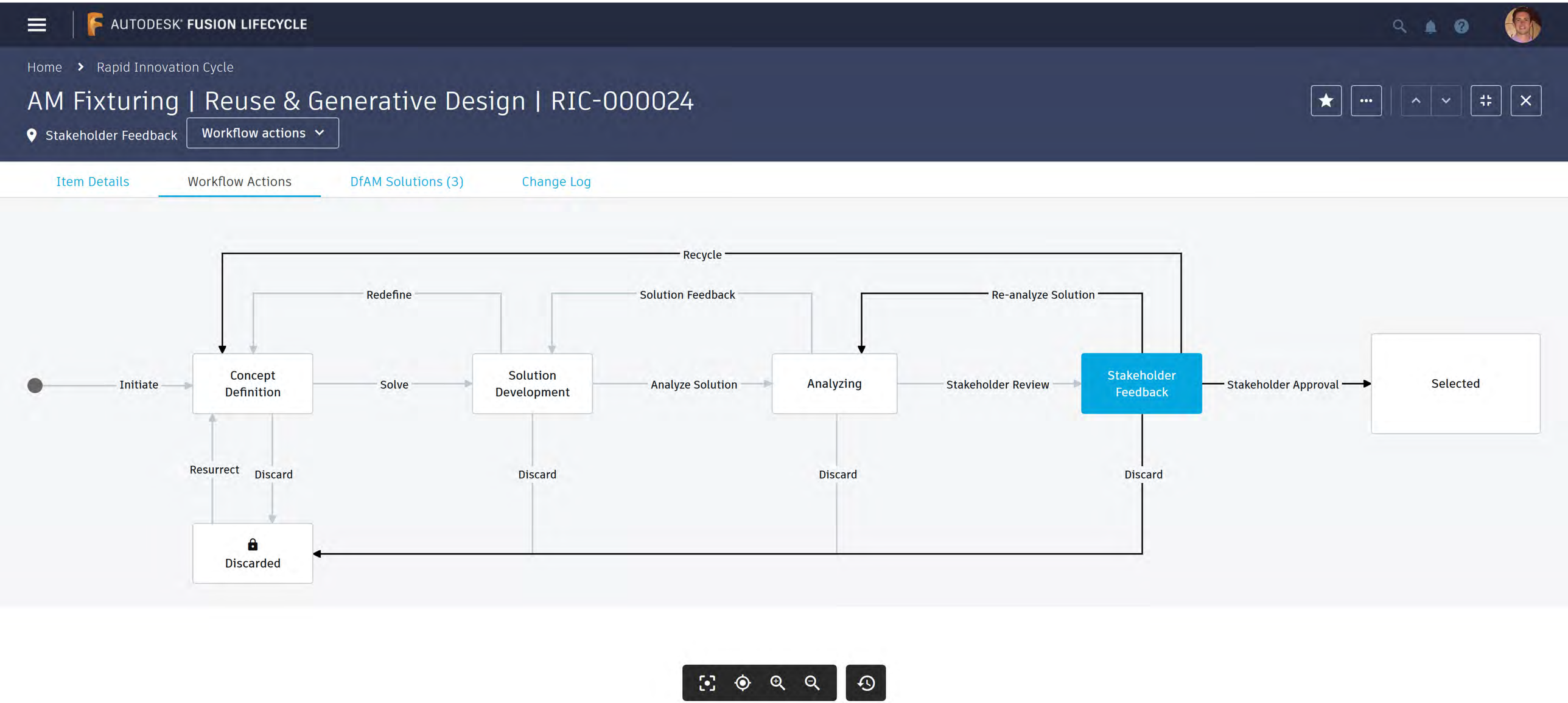
APD | Review, Track, Manage Newly Split RIC from APD



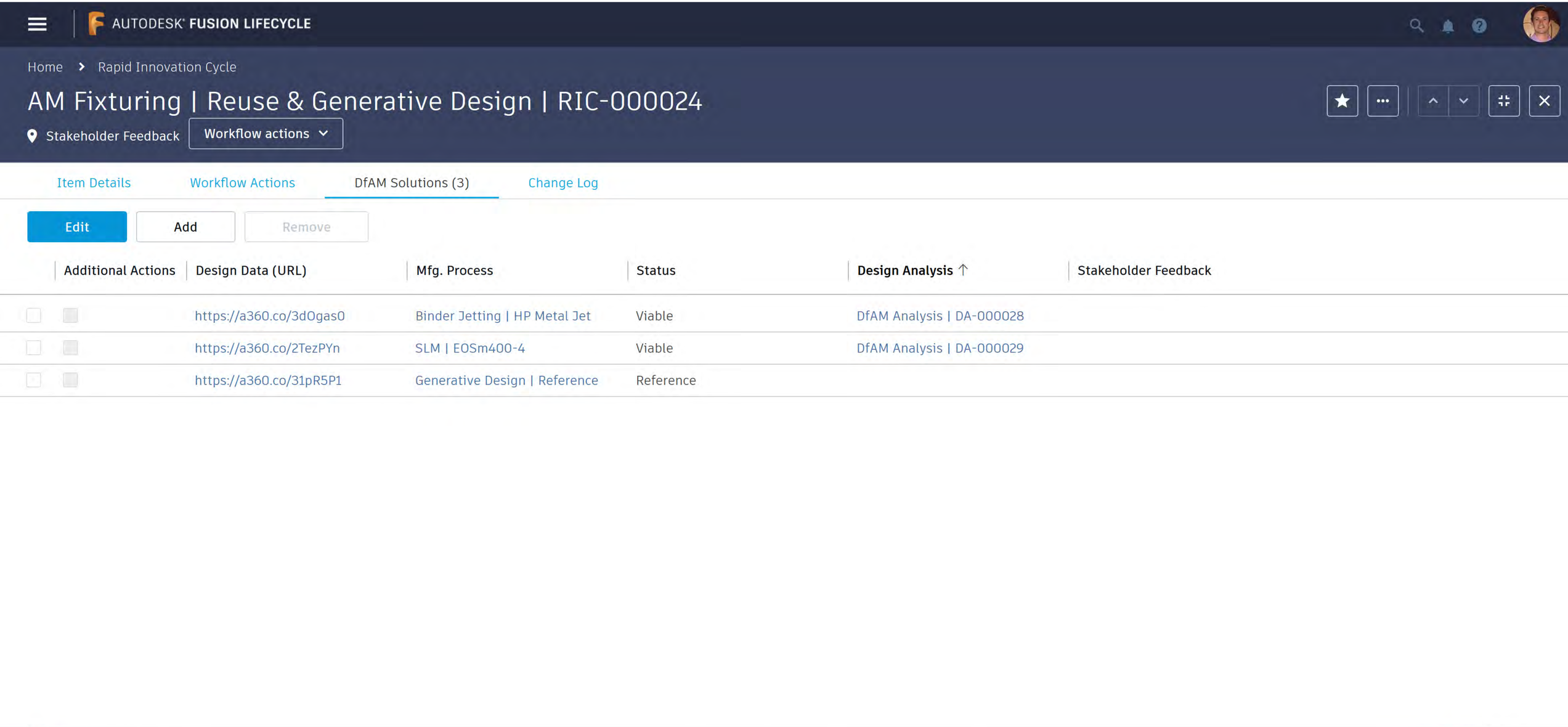
RIC | Hand-off to RIC Manager



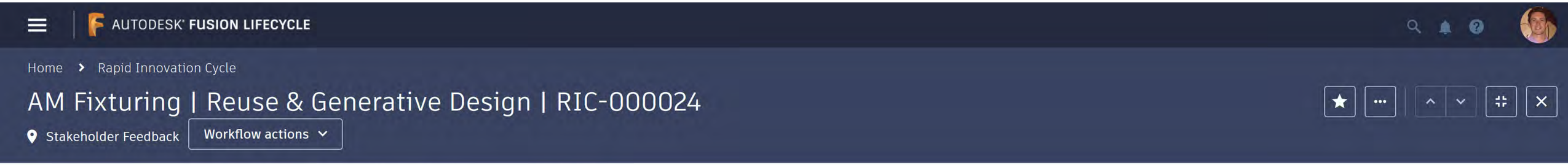
RIC | Ready to Gather Stakeholder Feedback



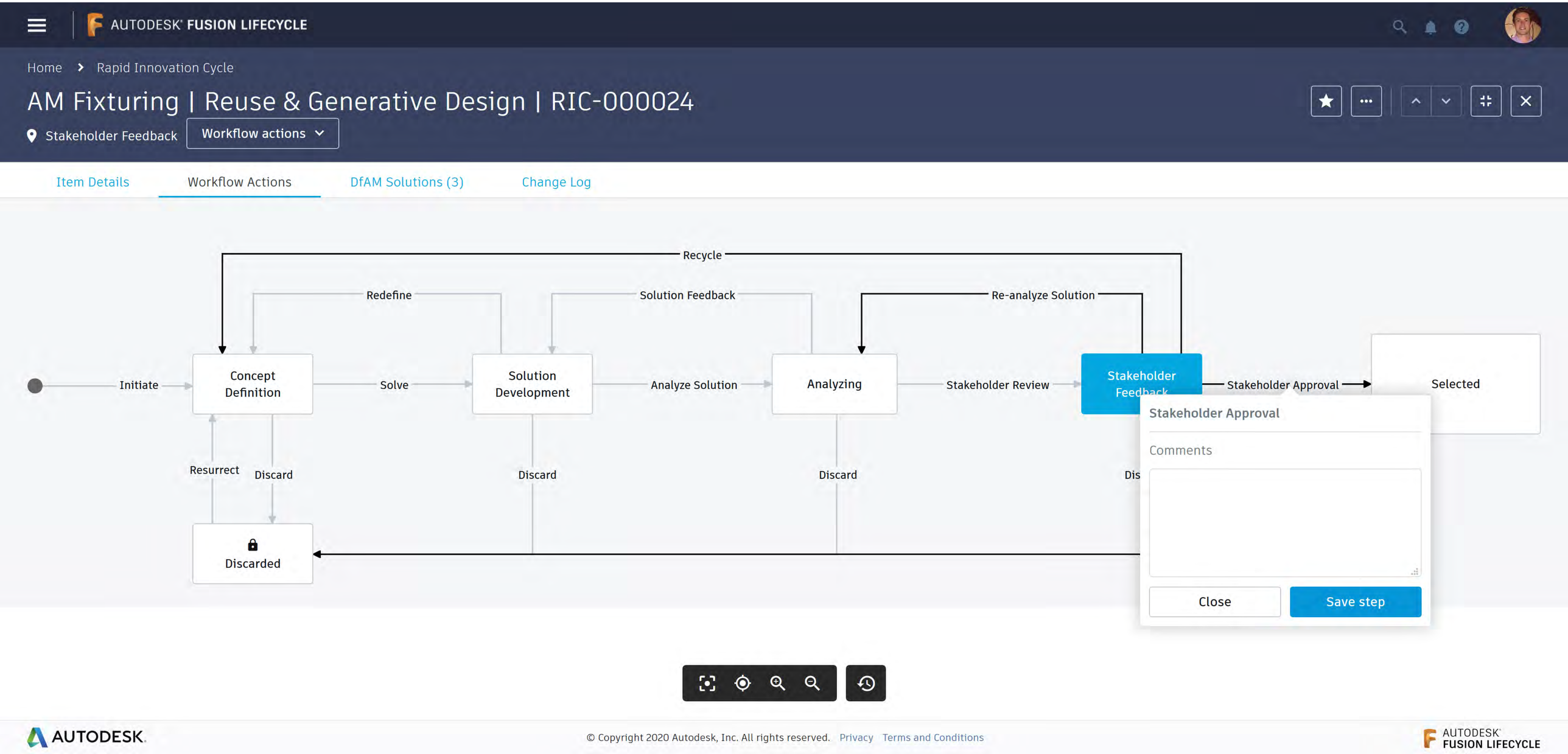
RIC | RIC Manager Reviews & Presents to Stakeholder



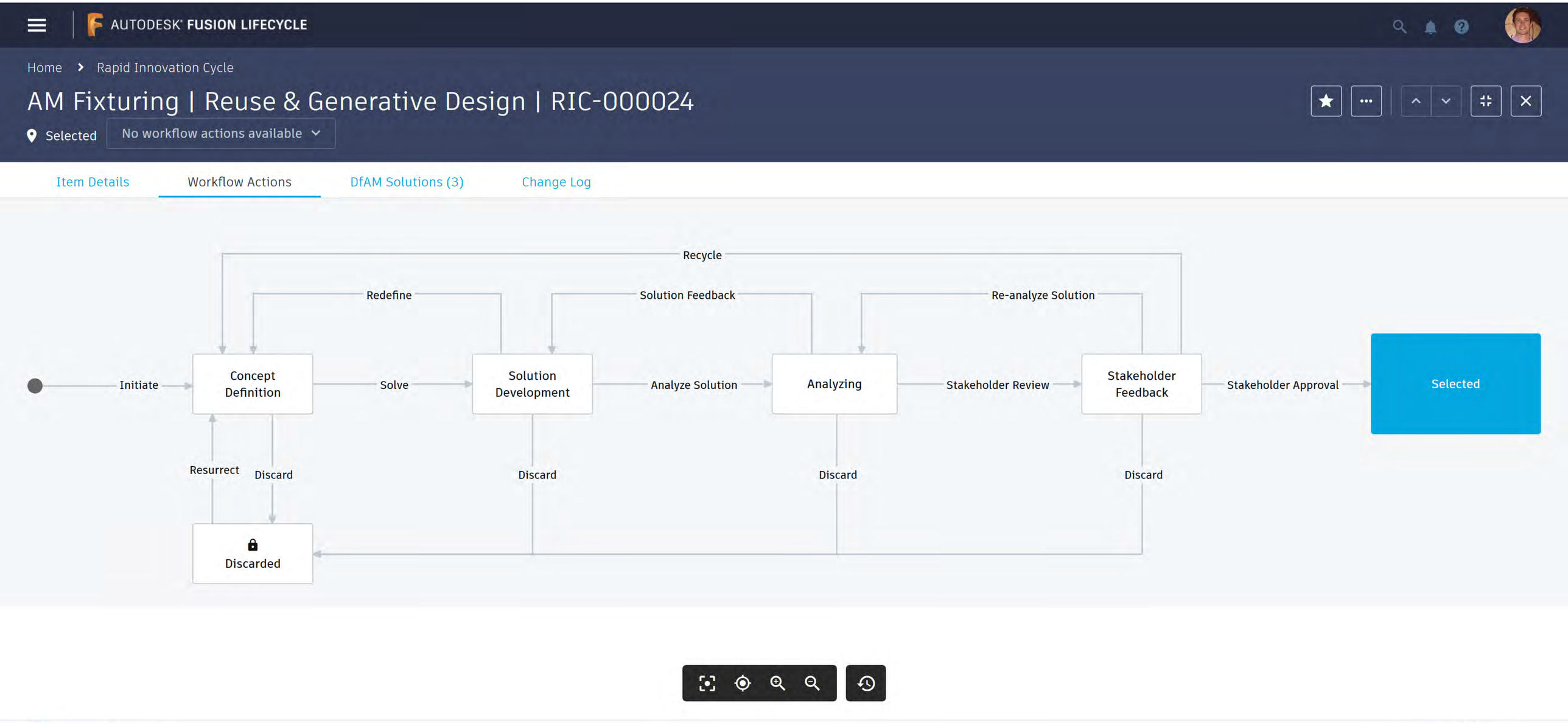
RIC | Stakeholder Selects Solution

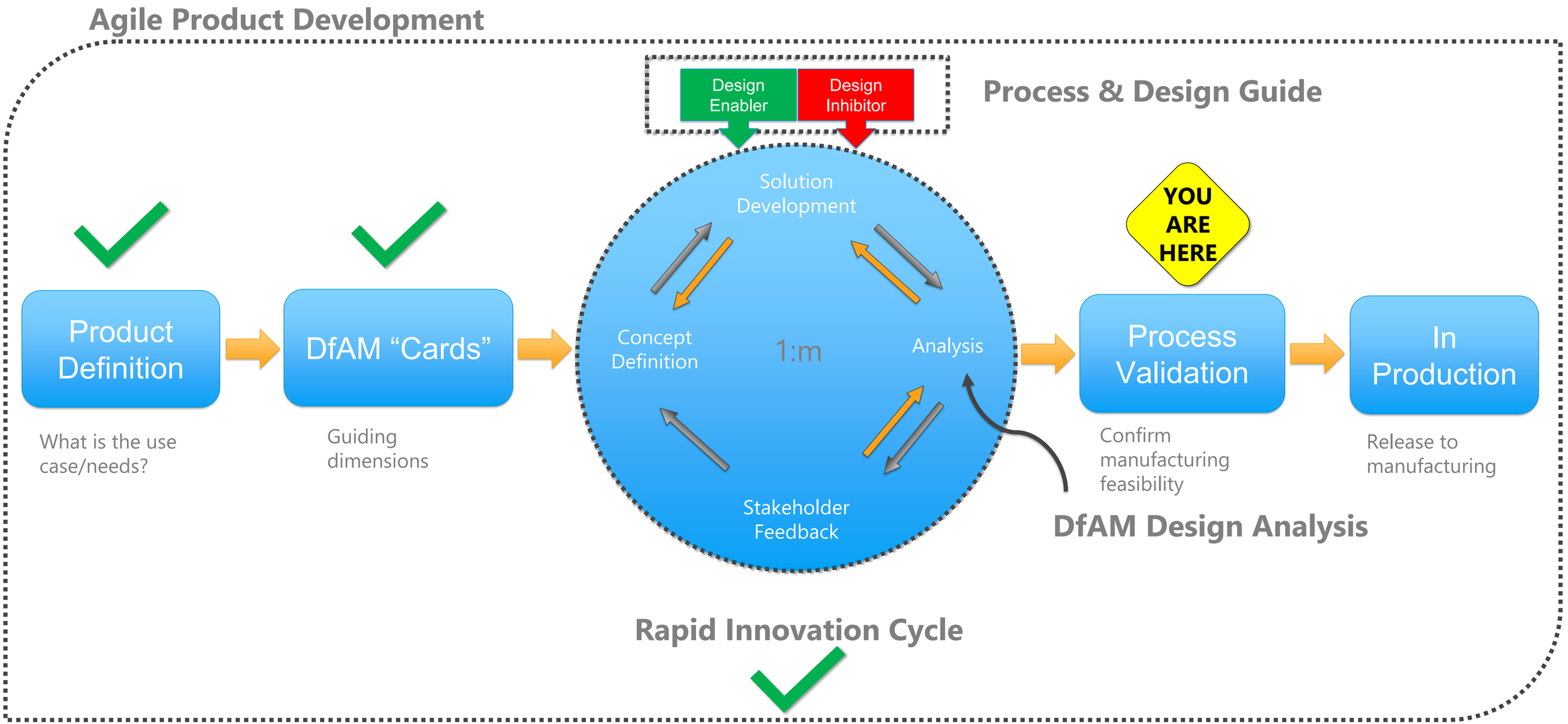


RIC | Hand-off to Process Validator



RIC | Ready for Process Validation





Inspired by the MIT course "Additive Manufacturing for Innovative Design and Production"

APD | Review Item Details with Solution Info

AUTODESK FUSION LIFECYCLE

Home > Agile Product Development

AM Fixturing / Workholding for CNC Machining | APD-000008

Locked | Process Validation | Workflow actions

Item Details | Workflow Actions | Concept Whiteboard (3) | RICs (3) | Attachments (0)

Edit

Product Definition (1 of 3)

Title	AM Fixturing / Workholding for CNC Machining
ID	APD-000008
Definition of Need	Rapid generation of complex, high mix, short-run workholdings used for CNC machining. Find the right blend of performance, cost, sustainability.

	Decision Drivers	Design Objectives	Applications	Processes	Industry	Material
Creative Dimensions	Application Design Performance Time to Market	Gernatively Designed High-Strength Industrially Designed Low/High Volume	Performance Optimization Process Sustainability Tooling & Manufacturing	Binder Jetting Hybrid SLA SLM SLS	Industrial	Metals Polymer

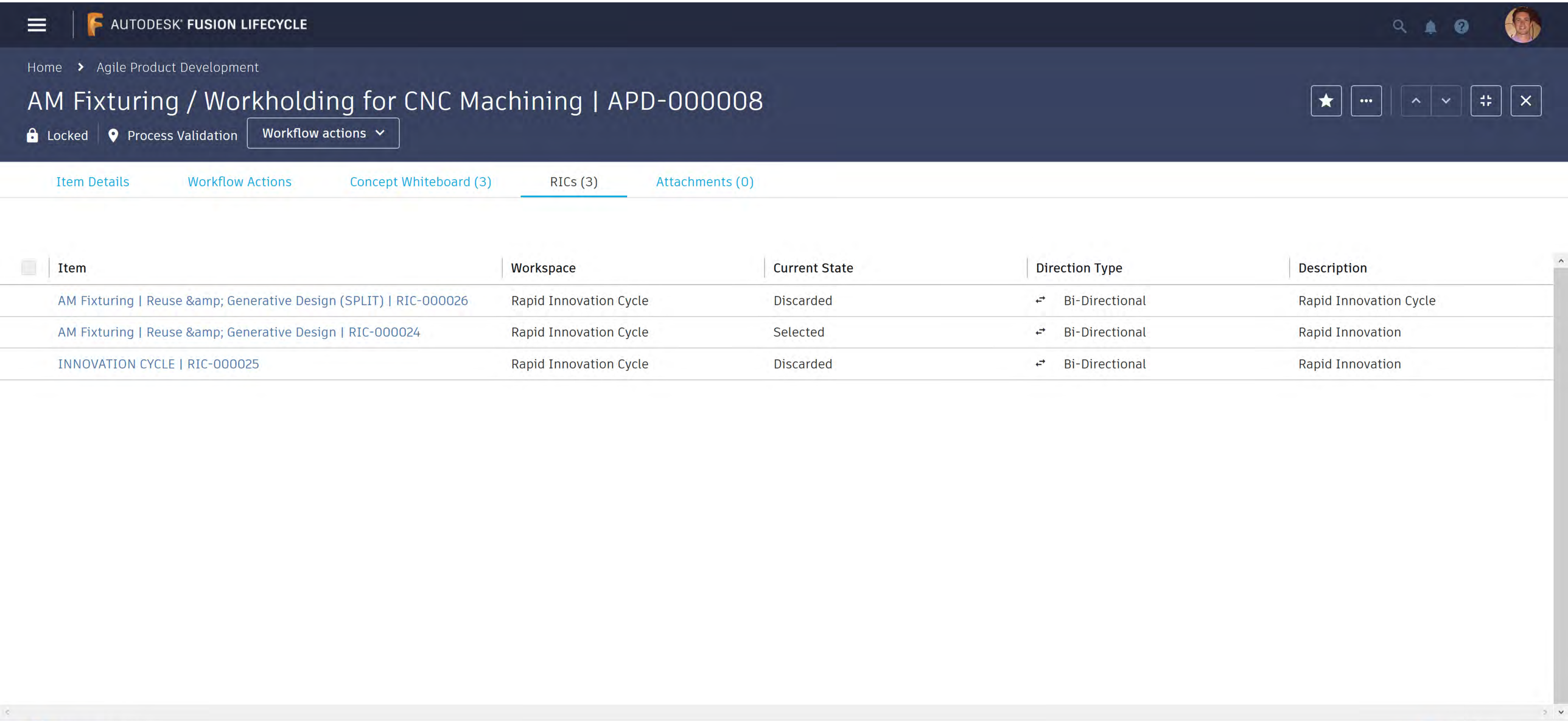
	Size (LxWxH mm)	Surface Finish (µm)	Target Cost ($)	Production Qty	Matr'l Properties	Mech Properties	Feature Res. (mm)
Additive Manufacturing Dimensions	300x300x300	400.00	100.00	100	Corrosion-resistant	Thermoplastic	1.00

Solution (2 of 3)

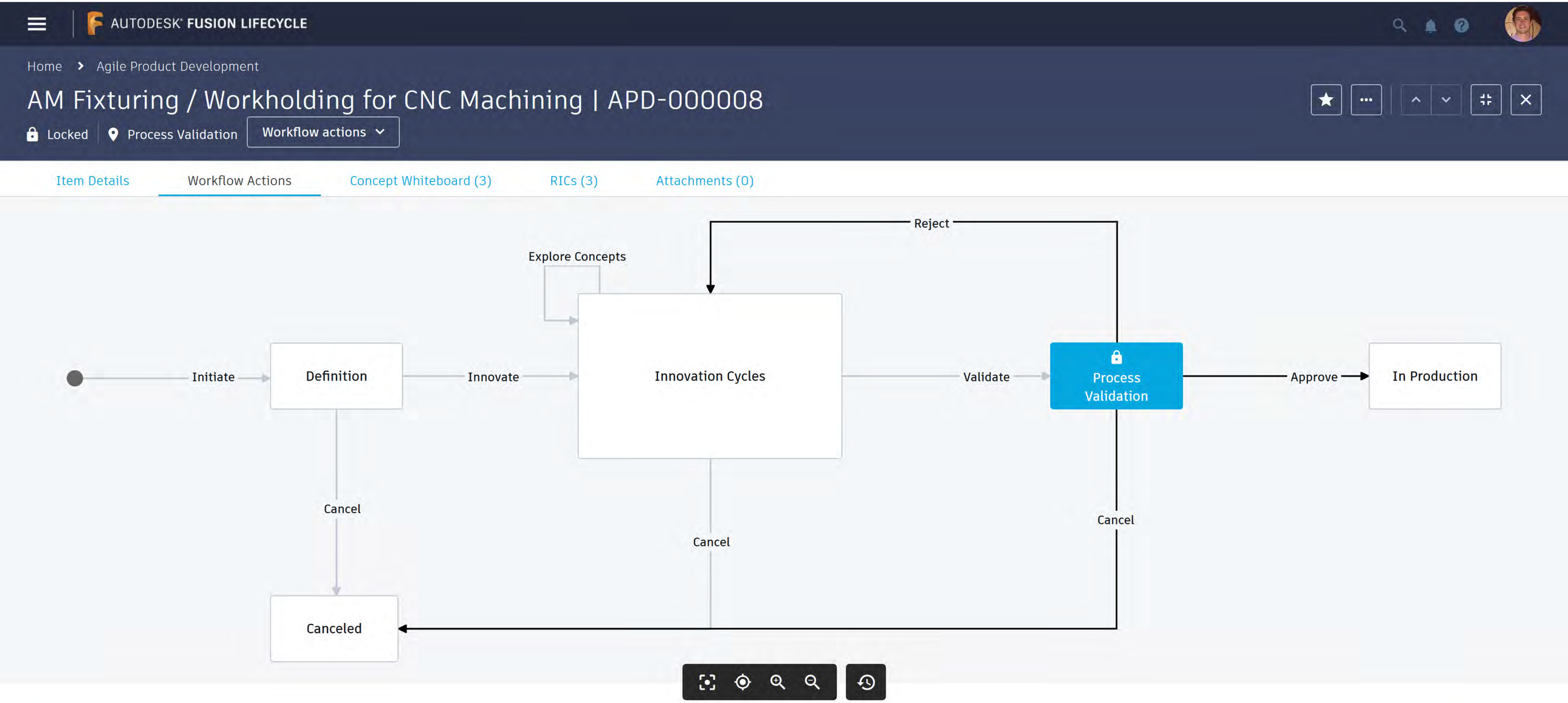
Solution Link	AM Fixturing | Reuse & Generative Design | RIC-000024
Design Data	https://a360.co/3dOgas0
Mfg. Process	Binder Jetting | HP Metal Jet
Design Analysis	DfAM Analysis | DA-000028

Points Of Contact (3 of 3)

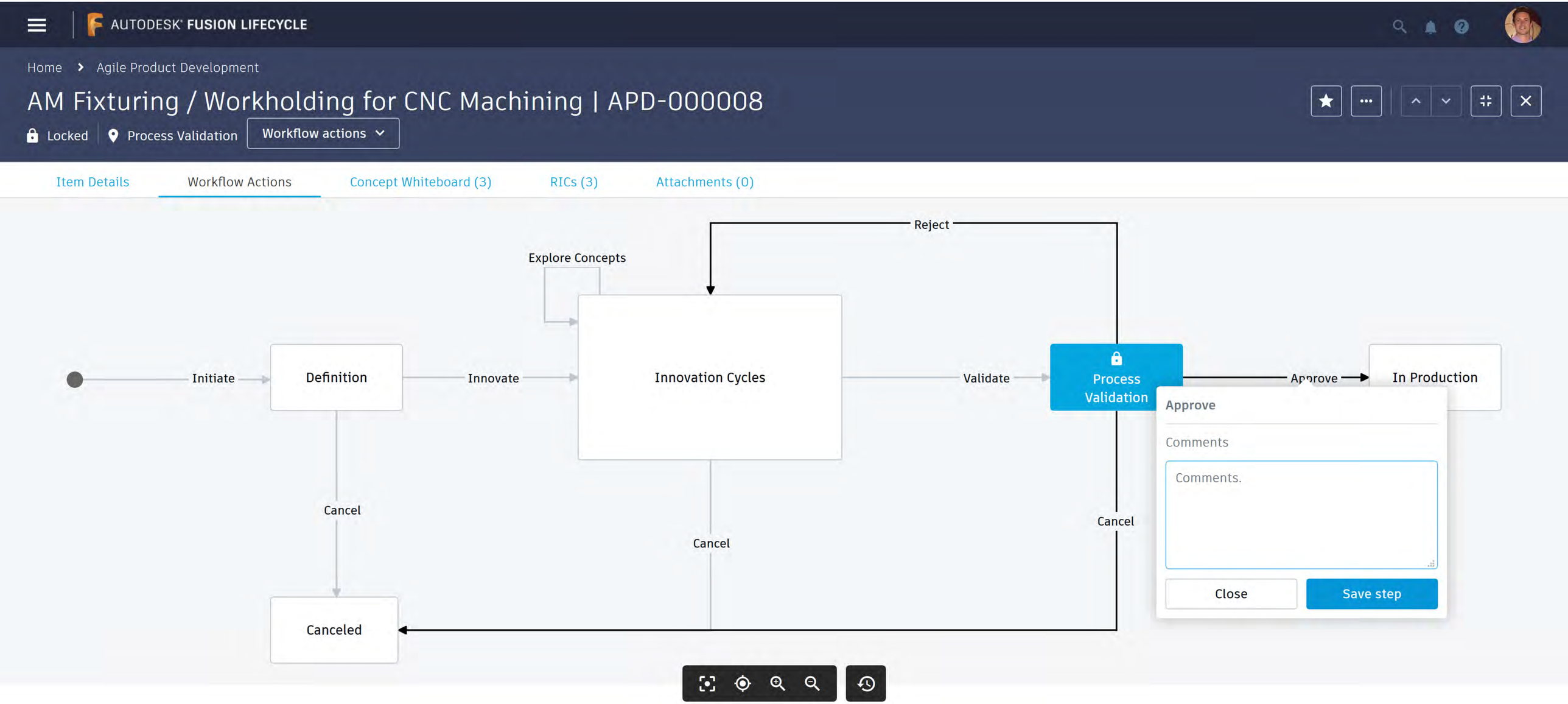
APD | Review Rapid Innovation Cycle States



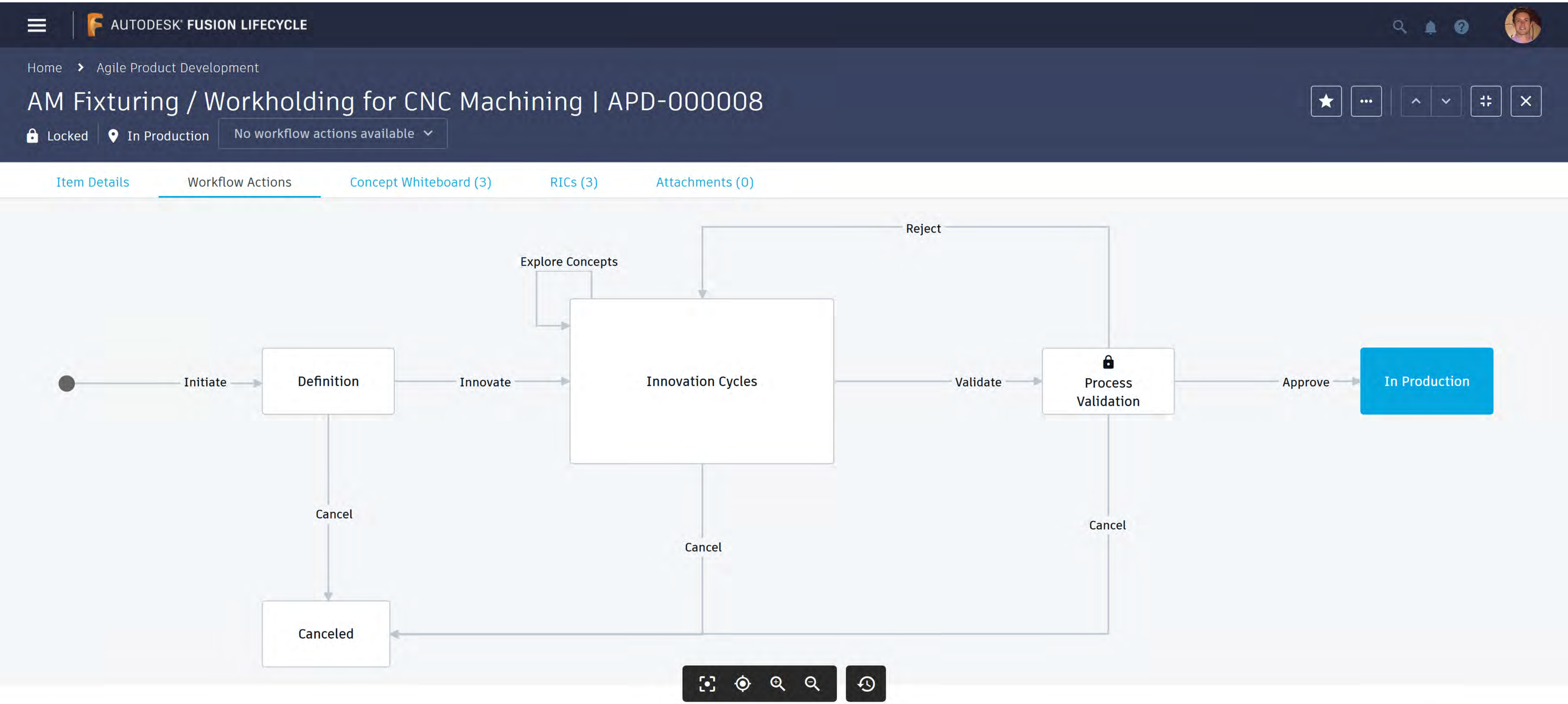
APD | Validate Your Selected Process

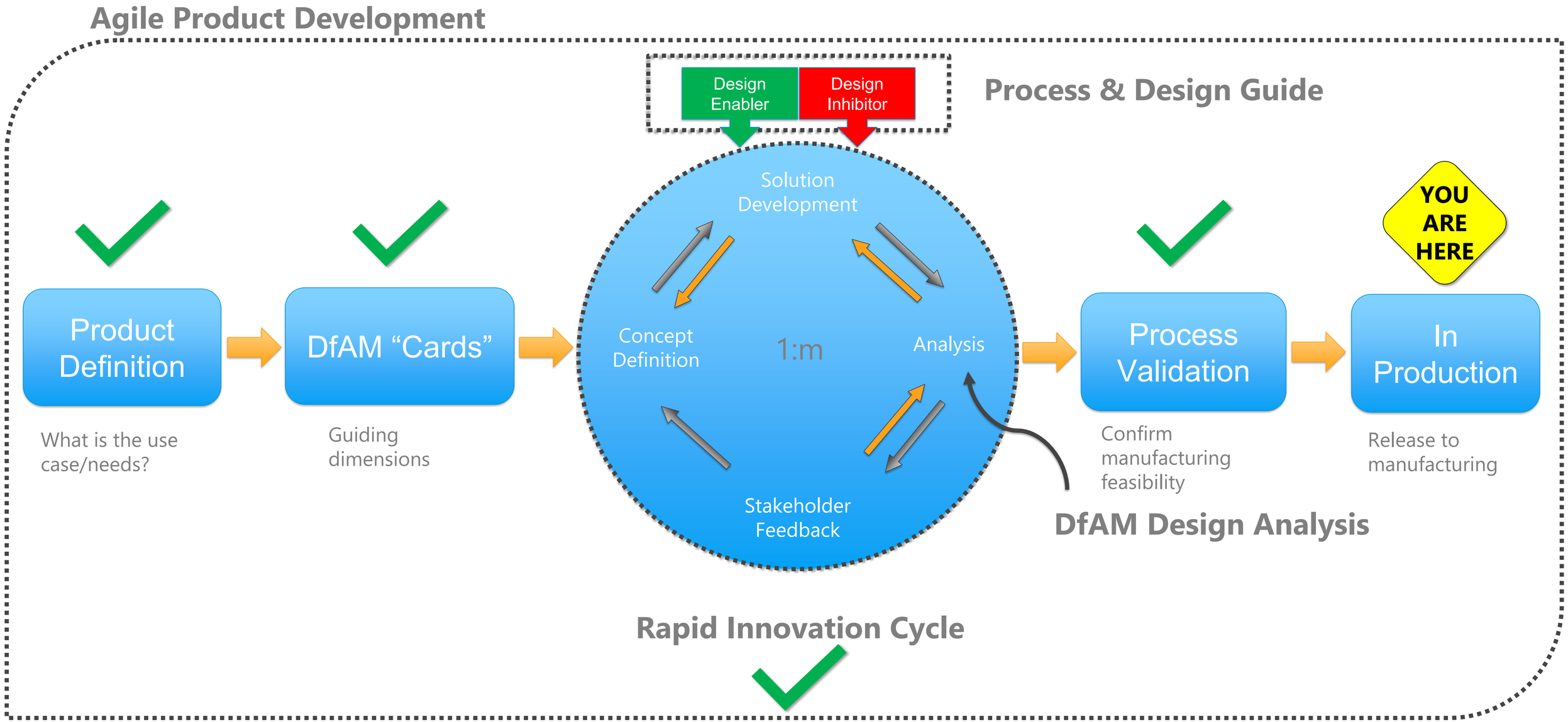


APD | Hand-Off to Product Owner



APD | Ready for Production





Inspired by the MIT course "Additive Manufacturing for Innovative Design and Production"