

GALORATH



AI Powered Cost Estimation

Translating 2D Diagrams for Obsolescence & Sustainment Solutions

Christopher Rush (PhD)

Industry Challenges

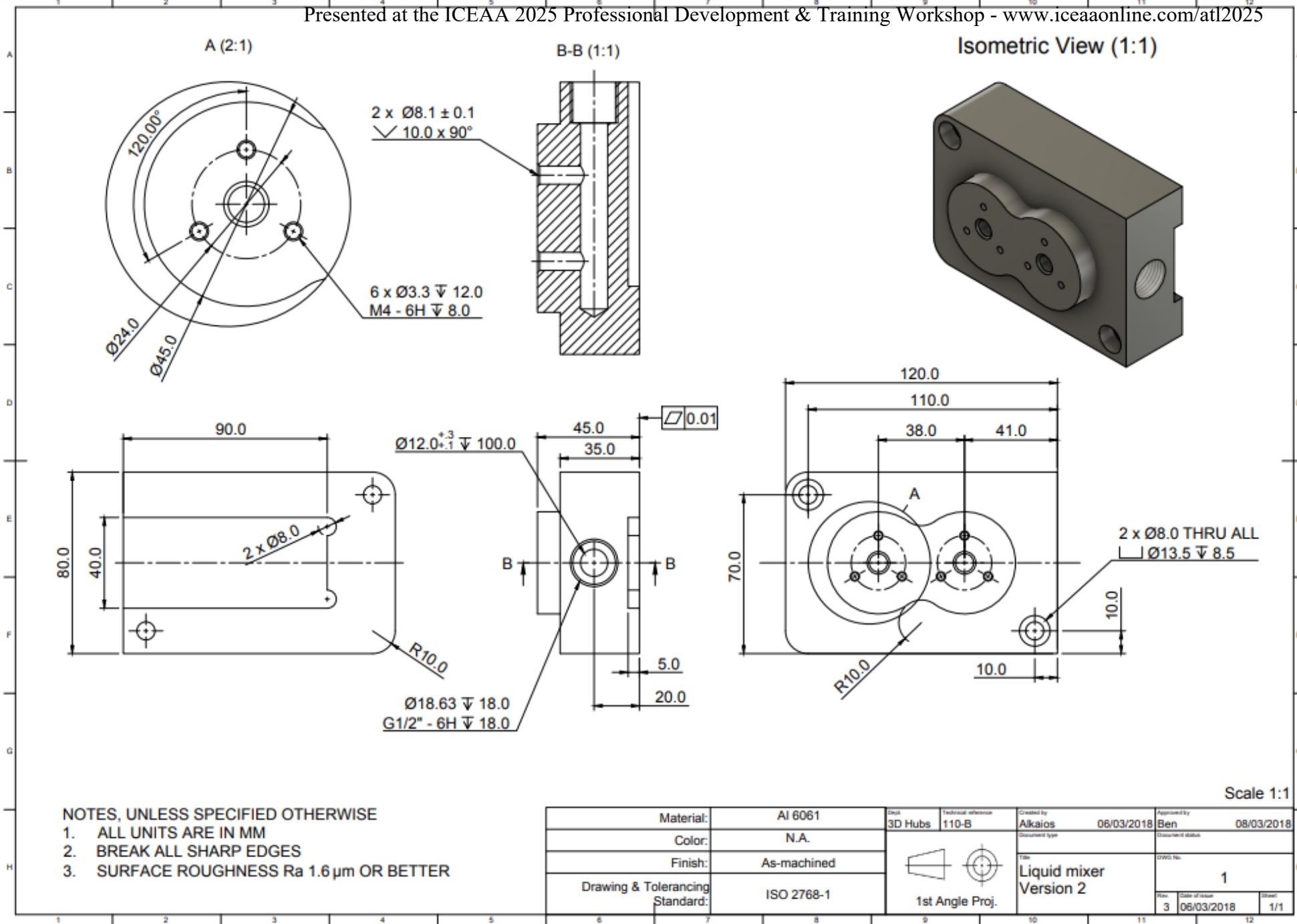
Part obsolescence
common issue in
many industries

Obsolete parts often
documented in 2D
drawings

Manual 2D drawing
conversion averages **1
to 8 hours** per
part/component

- Labor-intensive manual measurements
- Error-prone data entry
- Inconsistent cost estimates
- Delayed procurement decisions

Example Drawing

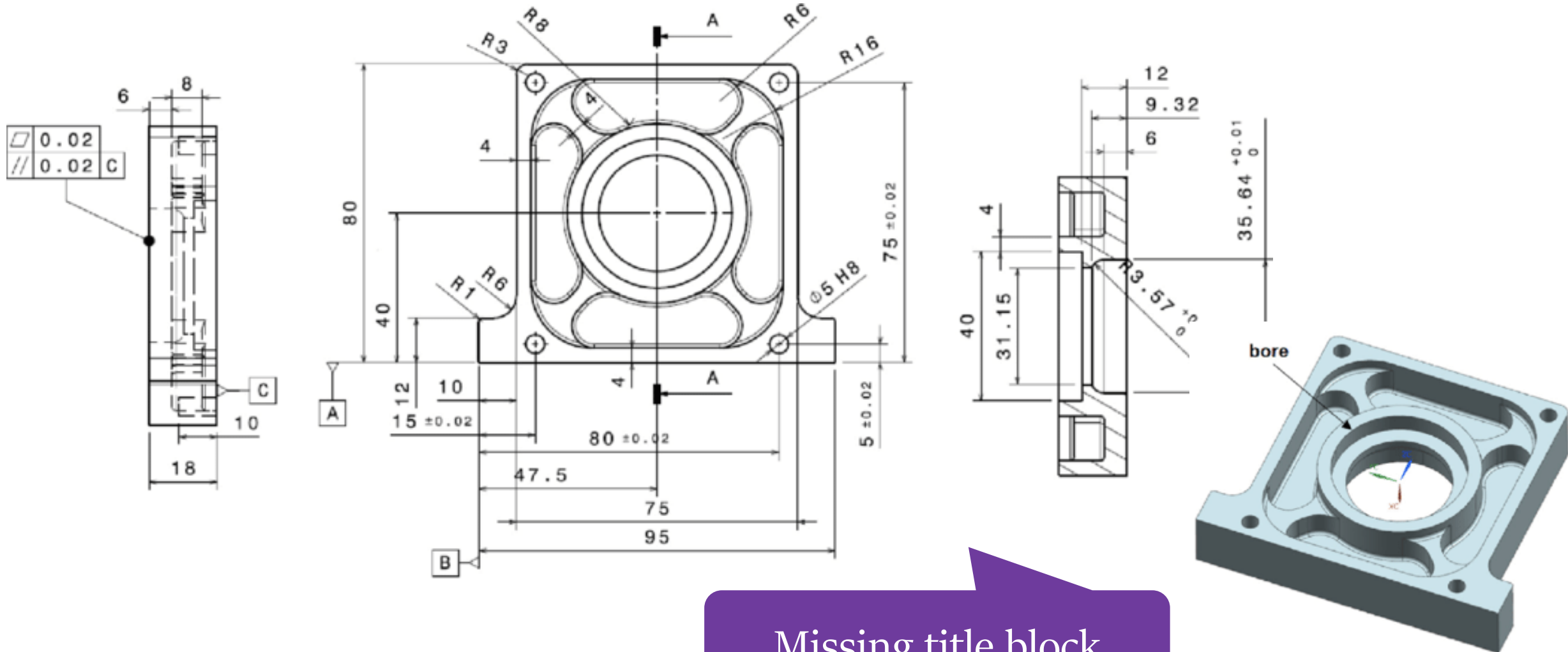


- NOTES, UNLESS SPECIFIED OTHERWISE
1. ALL UNITS ARE IN MM
 2. BREAK ALL SHARP EDGES
 3. SURFACE ROUGHNESS Ra 1.6 μm OR BETTER

Material:	Al 6061	Days:	3D Hubs	Technical reference:	110-B	Created by:	Alkaios	06/03/2018	Approved by:	Ben	08/03/2018
Color:	N.A.					Document type:		Document status:			
Finish:	As-machined					Title:		DWG No. 1			
Drawing & Tolerancing Standard:	ISO 2768-1			1st Angle Proj.		Liquid mixer Version 2					
		Rev:	3	Date of issue:	06/03/2018	Sheet:	1/1				

Scale 1:1

Example Drawing



Manual vs AI processing

LLMs are increasingly capable of processing 2D drawings

Manual Processing



Engineer Reviews Drawing



1 – 8 Hours Per Part



Error-Prone Data Entry



High Labor Cost

Inconsistent Cost Estimates

AI Processing



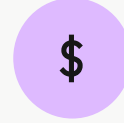
Automated Analysis, features, operations, material, stock size



Seconds Per Part



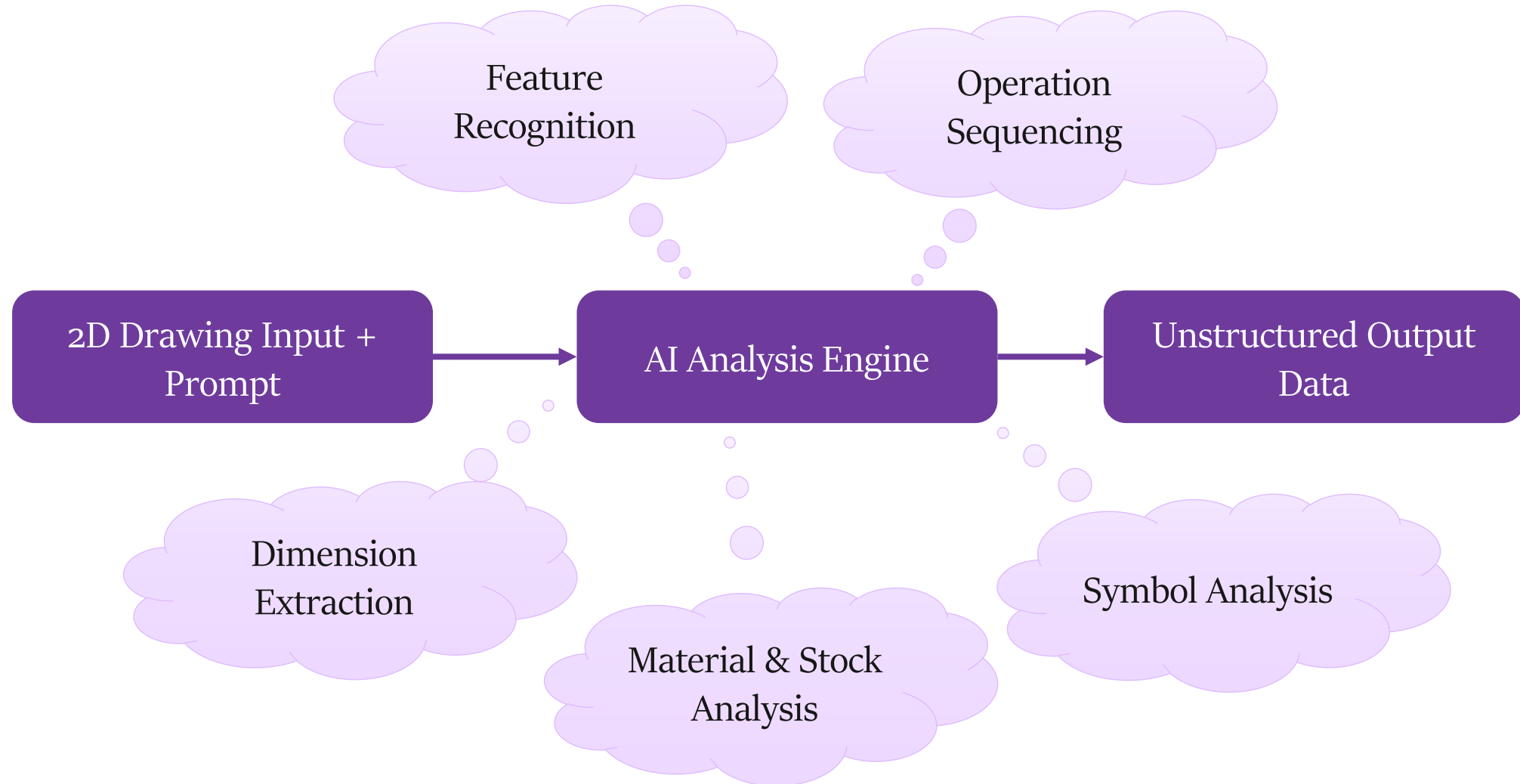
+/-0.1mm Accuracy



Reduced Labor Cost

Consistent, Data-Driven Estimates

AI Drawing Analysis Process Flow



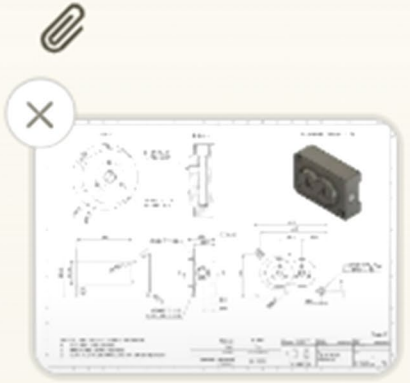
Example AI Prompt with Drawing Included

Your role is a cost engineer, analyze the provided 2D drawing in in great detail, and generate a manufacturing estimate. The part is for an aerospace application, it will be made in the USA, with a production qty of 300.



Claude 3.5 Sonnet Choose style

Use **shift + return** for new line



Use a project

input to AI with no guidelines on output

AI Output Analysis Unstructured

Material Analysis:

- Material specified: Al 6061
- Raw material stock needed: Approximately 120mm x 80mm x 45mm block
- Material cost per piece (including waste factor): ~\$18-22

Key Manufacturing Considerations:

1. Complex Features:

- Dual precision bores with tight tolerances
- G1/2"-6H threaded features
- Multiple M4-6H threaded holes
- Surface finish requirement of Ra 1.6µm or better
- Geometric tolerance callout of 0.01
- Through holes and counterbores

Additional Considerations:

1. Aerospace requirements will necessitate:

- Material certification documentation
- First Article Inspection (FAI)
- Process documentation
- Traceability requirements
- Specialized handling procedures

Manufacturing Process Steps:

1. CNC Milling Operations:

- Initial facing and squaring
- Roughing of external profile
- Precision boring operations
- Threading operations
- Final finishing passes Estimated machine time: 45-55 minutes per part

2. Secondary Operations:

- Deburring (spec calls for "break all sharp edges")
- Surface finishing to meet Ra 1.6µm
- Quality control/inspection Estimated time: 15

2. Lead time estimate: 6-8 weeks for complete order

3. Cost reduction opportunities:

- Optimize tooling for longer production runs
- Consider fixture design for multiple part machining
- Material blanking optimization

Cost Breakdown (per unit):

1. Raw Material: \$20
2. CNC Machine Time: \$85-95
3. Secondary Operations: \$25-30
4. Quality Control: \$15-20
5. Setup/Programming Amortized: \$10-12
6. Aerospace Documentation/Certification: \$18-22

Total Estimated Cost Per Unit (300 pc production run):

- Manufacturing Cost: \$173-199
- Overhead & Profit (30%): \$52-60
- Final Unit Price: \$225-259

How can we get AI to structure its response for use in other applications?

AI Can Map Symbols to Operations

Operation Number	Operation Type	Related Symbols	Symbol Meaning	Manufacturing Requirements
Op 1	Surface Skim Rough	120.0 110.0	Linear dimensions (mm)	Face both ends to overall length dimensions
Op 2	End Mill Rough	Ø45.0	Diameter dimension	Rough main body to 45mm diameter
Op 3	End Mill Finish	Ø45.0 Ra 1.6	Diameter and surface finish	Finish main body to 45mm diameter with Ra 1.6 finish
Op 4	End Mill Slot Rough	2 x Ø8.0 THRU ALL	Quantity/diameter/through	Rough cut two through slots 8mm diameter
Op 5	End Mill Slot Finish	2 x Ø8.0 THRU ALL Ra 1.6	Quantity/diameter/finish	Finish cut slots to Ra 1.6 finish
Op 6	Drill (Center)	6 x Ø3.3	Quantity and diameter	Center drilling for 6 mounting holes
Op 7	Drill	6 x Ø3.3	Quantity and diameter	Drill six 3.3mm holes
Op 8	Tap	M4 - 6H	Thread specification	Tap M4 internal threads with 6H tolerance
Op 9	Drill (Center)	2 x Ø8.0	Quantity and diameter	Center drilling for the holes
Op 10	Drill	2 x Ø8.0 THRU	Diameter and condition	Drill two 8mm thru holes
Op 11	Bore Rough	Ø18.63 ±0.01	Diameter with tolerance	Rough bore to 18.63mm diameter
Op 12	Bore Finish	Ø18.63 ±0.01 Ra 1.6	Diameter/tolerance/finish	Finish bore to 18.63mm diameter with Ra 1.6 finish
Op 13	Tap	G1/2" - 6H	Thread specification	Tap G1/2" internal threads
Op 14	Profile Rough	120.0° 90.0°	Angular dimensions	Rough cut hexagonal profile
Op 15	Profile Finish	120.0° 90.0° Ra 1.6	Angular dimensions/finish	Finish hexagonal profile to Ra 1.6
Op 16	Deburr	Ra 1.6 µm	Surface finish symbol	Deburr all edges to meet surface finish

Ask AI for mapping of drawing symbols to specific operations

Current AI Processing Challenges

Drawings need to be clear, without missing or faded data

Provide Inconsistent Output

Operation Hallucinations

No clear structure for downstream application use

Difficult to assess if any drawing data was missed

Requires human validation

What we are developing: SEERai

Dedicated Ai Agents to process 2D drawings

Creates consistency in data extraction and conversion

Editable rule data set for rapid iterations during development

Automated feature recognition and measurement extraction

Automated script formatting and creation for downstream use

Output qualitative choices for complexity, efficiency, inspection, rework etc.

Direct integration with the SEER-MFG costing platform

2D Drawings

OneDrive > ... 2 Search 2D

New -

Home

Gallery

Chris - C

Name

Status

Drawing-and-CAD-model-of-the-part.png

Liquid-mixer_v2+Drawing+v21.pdf

Liquid-mixer_v2+Drawing+v21 conv 1.png

1092.pdf

1095.pdf

1096.pdf

1118.pdf

1121.pdf

1134.pdf

1137.pdf

1147.pdf

1092_Claude_Tri-arm Mounting Flange.mfg

1095_Claude_Bracket with Cylindrical Mount.mfg

1096_Claude_Complex Plate with Pockets.mfg

1118_Claude_Angled Bracket with Hole.mfg

1121_Claude_Complex Bracket Assembly.mfg.BAK

1134_Claude_Flange with Central Bore.mfg

1137_Claude_Circular Disc with Central Bore.mfg

1147_Claude_Complex Bracket with Cylindrical End.mfg

1095_chatGPT_Bracket-1095.mfg

1096_chatGPT_Plate-1096.mfg

1118_chatGPT_Block-1118.mfg

1121_chatGPT_Bracket-1121.mfg

1134_chatGPT_Flange-1134.mfg

1137_chatGPT_Wheel-1137.mfg

1147_chatGPT_Bracket-1147.mfg

4677 x 3308 626.5 KB

54 items 1 item selected 626 KB Available on this device

Liquid-mixer_v2+Drawing+v21 conv 1.png

A (2:1)

B-B (1:1)

Isometric View (1:1)

2 x $\varnothing 8.1 \pm 0.1$
 $\nabla 10.0 \times 90^\circ$

6 x $\varnothing 3.3 \pm 0.2$
 M4 - 6H $\nabla 8.0$

90.0

80.0

40.0

2 x $\varnothing 8.0$

R10.0

$\varnothing 12.0 \pm 0.1 \nabla 100.0$

45.0

35.0

0.01

70.0

120.0

110.0

38.0

41.0

2 x $\varnothing 8.0$ THRU ALL
 $\nabla \varnothing 13.5 \nabla 8.5$

10.0

10.0

5.0

20.0

$\varnothing 18.63 \pm 0.18$
 G1/2" - 6H $\nabla 18.0$

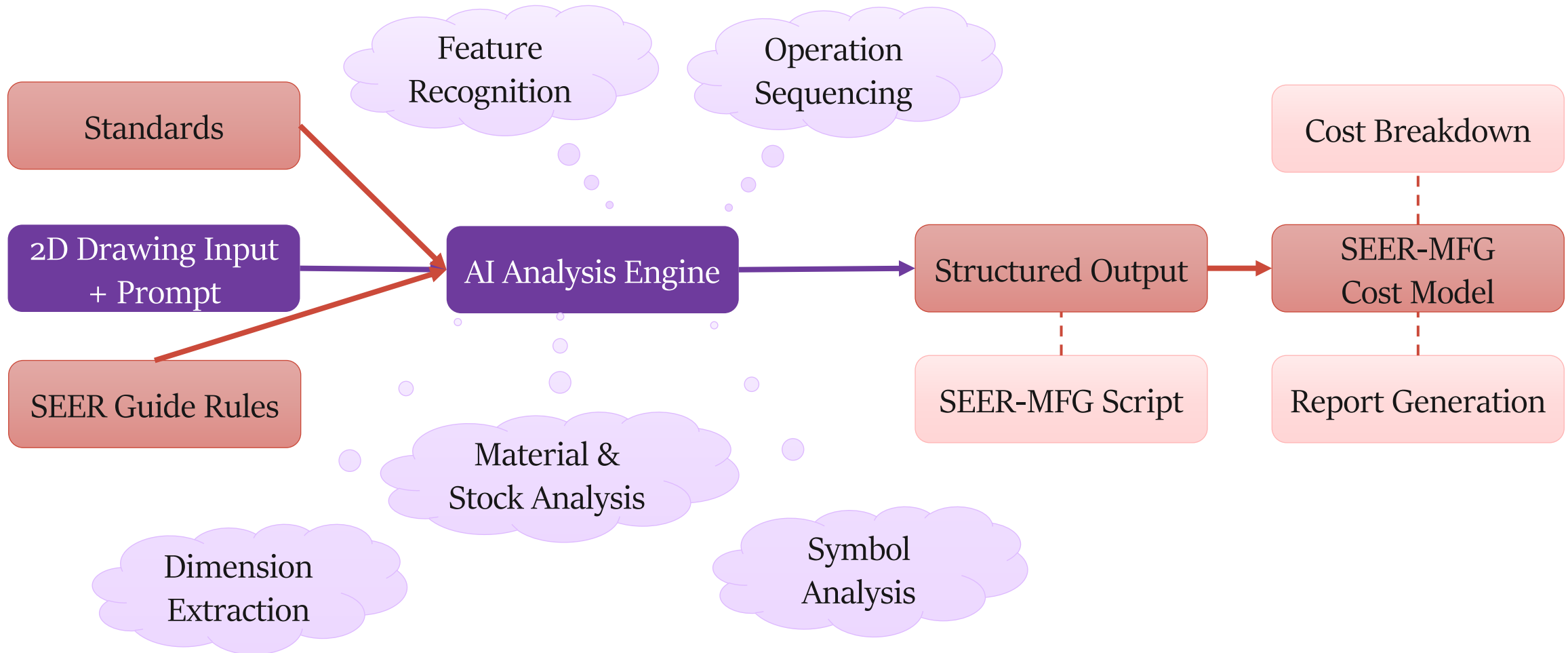
Scale 1:1

NOTES, UNLESS SPECIFIED OTHERWISE

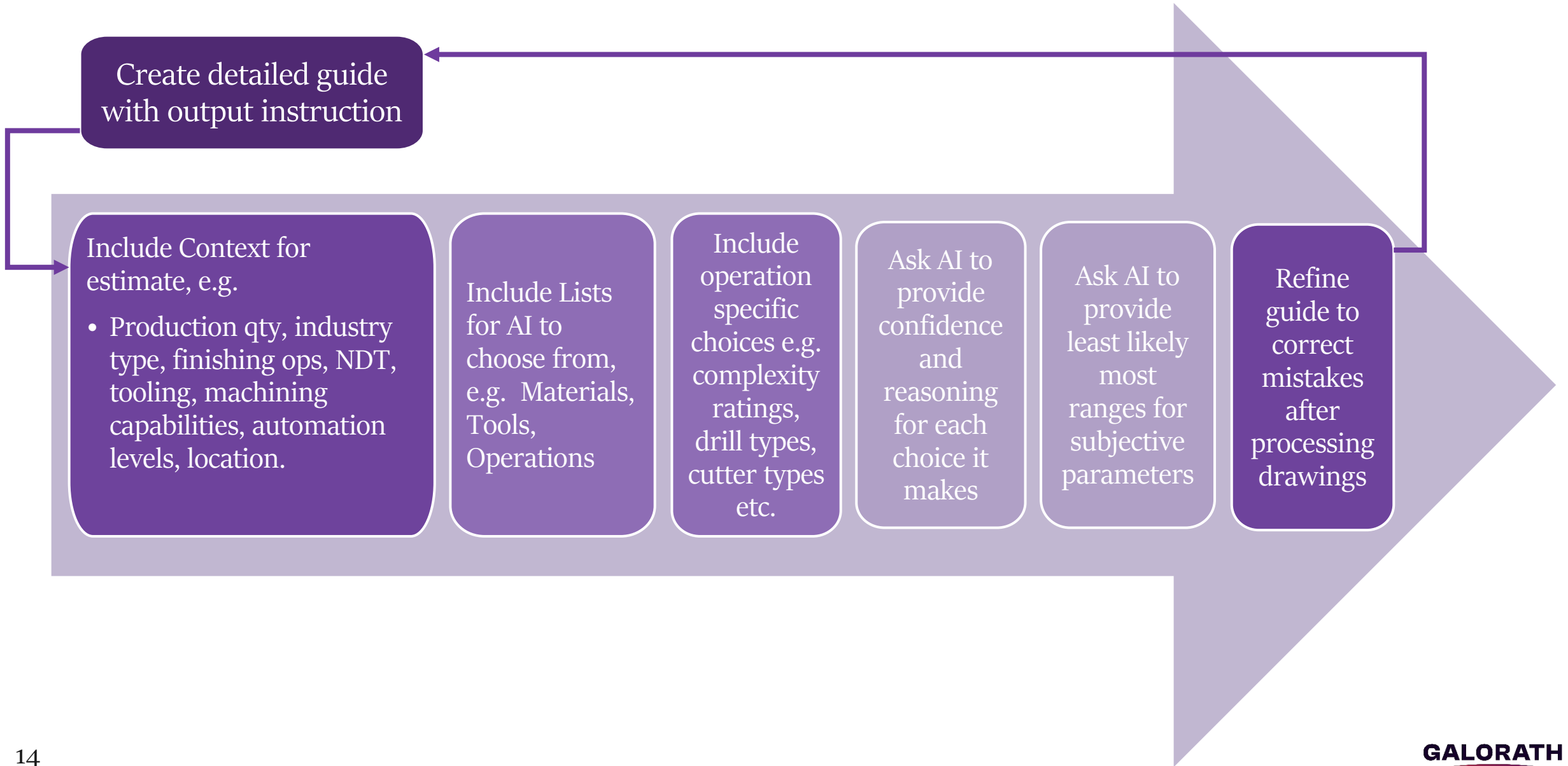
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- BREAK ALL SHARP EDGES
- SURFACE ROUGHNESS Ra 1.6 μm OR BETTER

Material	Al 6061	Part Name	3D Hubs 110-B	Created By	Alkaios	Created Date	06/03/2018	Reviewed By	Ben	Reviewed Date	08/03/2018
Color	N.A.	Revision		Part Number		Version		Quantity		Scale	
Finish	As-machined	Project		Project Name	Liquid mixer	Version	2	Sheet	1	Total	1
Drawing & Tolerancing Standard	ISO 2768-1	Projection	1st Angle Proj.	Sheet	3	Date	06/03/2018	Scale	1:1		

SEERai Drawing Analysis Process Flow



AI Requires Detailed Prompt & Rules



Start with general context and AI role



Drawing Analysis:

- Examine drawing thoroughly for all features (holes, pockets, chamfers, etc.) with dimensions and locations.
- Note overall dimensions, tolerances, and surface finish requirements.
- Use standards provided.



Manufacturing Operations:

- Determine necessary operations in a logical sequence.
- Use the appropriate script format documents for guidance on available operations and data requirements for each operation selected.



Script Generation:

- Create a continuous script.
- Output Script in tab delimited format.
- Include required details (dimensions, tolerances, tools, etc.).
- Ensure all identified features have an appropriate machining operation.



Verification:

- Cross-check script against drawing for completeness and accuracy.
- Report confidence and reasoning.
- Verify logical operation sequence and efficiency.
- Verify scripts are valid against standards provided.

Add specific rules e.g. Product Classification Rule

Set product classification according to these ratings:

If classification is stated as Aerospace, Space, or Military, classification should be set to VHi.

If classification is stated as Automotive, Industrial, High End Consumer Item, Power Plants, Computers, Machine Tools, classification should be Hi.

If classification is stated as Consumer, Home or Business use, Home Appliances, classification should be set to Nom.

If classification is stated as Household Furnishings, classification should be set to Low.

If classification is stated as Toys, or simple Household items, classification should be set to VLo.

PRODUCT DESCRIPTION - Product Classification	[classificationLeast]	[classificationLikely]
[classificationMost]	[Descriptive Note]	

Add Operation Specific Rules and Script Guide

If a **Profile Finish** operation is required, use the following script format: note, only replace bracketed information with the size values in millimeters, replace [Setup] with a Yes or No, replace [load/unload] with a Yes or No, add symbols, symbol meaning, manufacturing reasoning, and confidence of choice in [Descriptive Note].

If you use profile finish operation, you must choose one of these three options: Edge Mill 3 Axis, Edge Mill 5 Axis, or Scan:

OPERATIONS - Operation [operation sequence number] Profile Finish
Description] [surface finish microns] [thickness] [periphery length] [profile type]
[qty of same sized cuts] [Setup][Load/Unload] YES [Descriptive Note]

OPERATIONS - Operation [operation sequence number] - Cutter Diameter (mm) [cutter
diameter] [Descriptive Note]

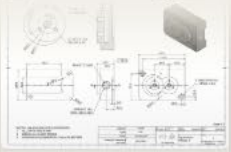
OPERATIONS - Operation [operation sequence number] - Teeth/Flutes [cutter teeth]
[Descriptive Note]

Direct AI to provide Script
for different operational
parameters

AI Can now Create output based off your Guidelines

Paste Drawing and Prompt Document for processing

Machining Part Estimator / Untitled



PDF

c The part is for an aerospace application, it will be made in the USA, with a production qty of 300.

I'll help analyze this liquid mixer drawing and create a SEER-MFG script for aerospace production. Let me break this down systematically.

 **SEER-MFG Machining Script - Liquid Mixer**
Click to open code



Script Ready to Use in SEER-MFG Costing Platform

Script Output Formatted to Guideline Rules

```
SEER-MFG Machining Script - Liquid Mixer  
WBSCreate Liquid_Mixer_110B Machining 2  
PRODUCT DESCRIPTION - Lot 1 300 2024  
PRODUCT DESCRIPTION - Production Quantity 300  
PRODUCT DESCRIPTION - Set-up Amortization Quantity (Optional) 50 Medium volume aerospace  
PRODUCT DESCRIPTION - Quantity Per Next Higher Assembly 1  
PRODUCT DESCRIPTION - Product Classification VHi VHi VHi Aerospace liquid mixer compon  
PRODUCT DESCRIPTION - Direct Hourly Labor Rate 0 Yes  
PRODUCT DESCRIPTION - Setup Hourly Labor Rate 0 Yes  
MATERIAL - Material Origin Raw Stock Complex aerospace component
```

Reply to Claude...

Claude 3.5 Sonnet ▾  Choose style ▾

Last edited just now

  Publish

Example SEER-MFG Model Created from AI Script

Presented at the IFMA 2025 Professional Development & Training Workshop - www.ifmaonline.com/atl2025

WORK ELEMENTS

- Σ 1: Liquid_Mixer
 - Σ 1.1: Liquid_Mixer
 - 1.1.1: Liquid_Mixer

Inputs

General Process Specific Tooling Inspection/Rework Mark/Package Classifiers & Properties

Machining - Liquid_Mixer

OPERATIONS	Operation Type										
Face milling of block to square up	Surf. Skim Rough	125.0000	75.0000	50.0000	2.5000	6	YES	YES	YES		
Main body rough machining	End Mill Rough	Volume	85,000.0000	1	0	YES	NO	YES			
Main body finish machining	End Mill Finish	Surface Area	24,000.0000	1	0.0500	1.60	0	NO	NO	YES	
Center drilling for threaded holes	Drill	Center Drill	12	1.0000	1.0000	No	No	YES	NO	YES	
M4 threaded holes	Drill	Twist	12	10.0000	3.3000	Yes	No	NO	NO	YES	
M4 threads	Tap	12	4.0000	8.0000	No	0.70	No	NO	NO	YES	
Main bore roughing	Drill	Twist	1	100.0000	11.8000	Yes	No	YES	NO	YES	
Main bore finish	Bore Finish	Surf. Area Dim.	100.0000	12.0000	1	0.0500	1.60	0	NO	NO	
8mm thru holes	Drill	Twist	2	45.0000	8.0000	Yes	No	NO	NO	YES	
External chamfers and radii	Profile Finish	1.60	10.0000	240.0000	Scan	1	NO	NO	YES		

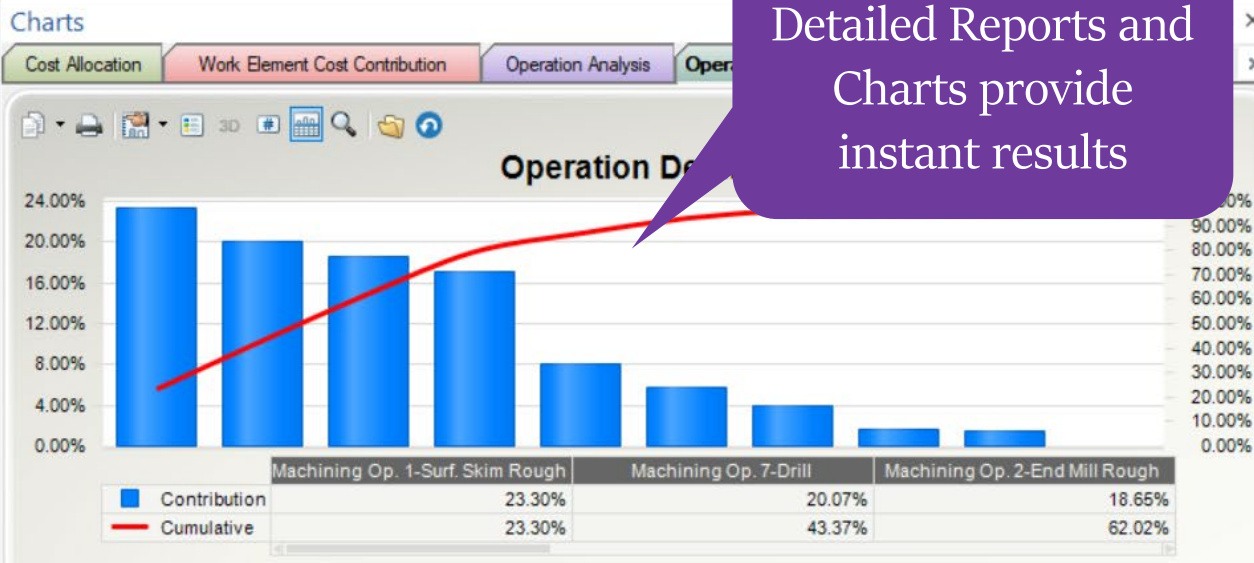
Add Next Operation Here

Operations Sequenced to Manufacture Part

Reports

Quick Estimate Detailed Analysis Operation Details Material Details Process Step Details Energy and CO2e Firm

	Minutes/Unit	Cost/Unit	Cost for 300 Units
LABOR TOTAL	40.08	66.81	20,042.00
Manufacturing Labor Total	40.08	66.81	20,042.00
Set-up	27.95	46.58	13,973.31
Direct	10.97	18.28	5,484.59
Inspection	0.94	1.57	471.96
Rework	0.22	0.37	112.14
Assembly Labor Contribution	0.00	0.00	0.00



Detailed Reports and Charts provide instant results

Ai suggests Tooling Choices

Tooling			
Machining - Liquid_Mixer			
TOOL DESCRIPTION			
Size Factor		1.00	1.00
Tool Length (mm)		0.00	0.00
Tool Width (mm)		0.00	0.00
Tool Area (sqmm)		0.00	0.00
Number of Tool Parts	3	4	5
Multiple fixture components needed	2	3	4
Tool Complexity	Hi	Hi	Hi+
Tool Prep		Yes	
Clean, Package & Store		Yes	
Initial Tool Fabrication & Design		Yes	
Tooling Type Selection		Tooling Type	Fab. Hours
Primary machining fixture	Mill Fixture (Met...	YES	
Quality verification fixture	Check Fixture	YES	YES

AI makes assumptions about tool parts, and complexity

AI Choses Tools from List Provided

Reasoning For Qualitative Choices

Inspection/Rework			
Machining - Liquid_Mixer			
INSPECTION/REWORK			
In-Process Inspection	15.00%	20.00%	25.00%
Critical aerospace component	5.00%	8.00%	10.00%
<<QA Inspection>>	2.42%	2.42%	2.42%
<<Rework>>	0.57%	0.57%	0.57%
Inspection Delay		No	
Non-Destructive Testing (NDT)		No	

INSPECTION/REWORK - In-Process Inspection

Notes: Notes and Attachments...

Least: 15.00 | Likely: 20.00 | Most: 25.00

Critical aerospace component

OK | Cancel | Prev | Next | KBase | More Help

Use Expression Editor

Inspection

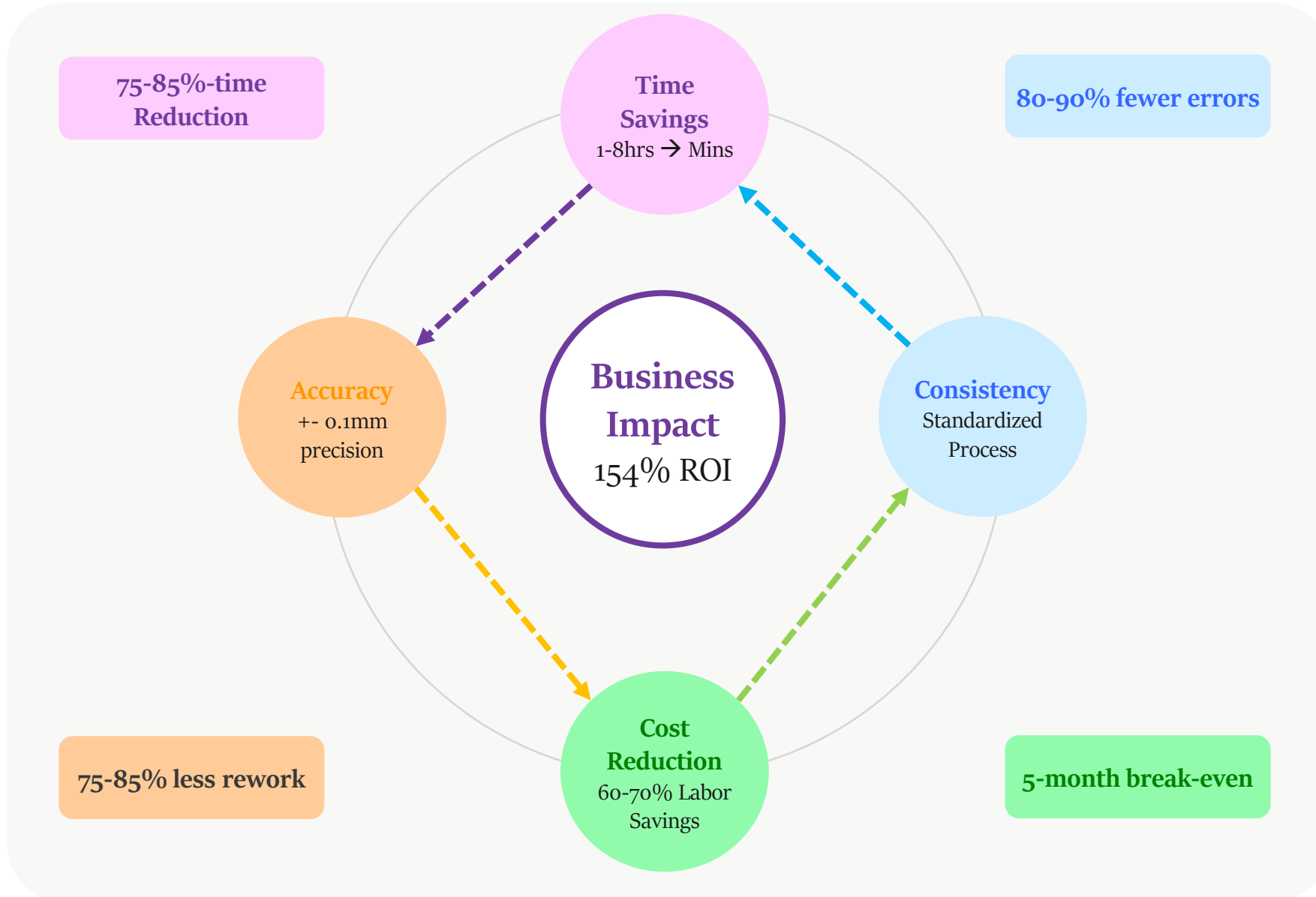
In-process inspections by the mechanic are a direct charge and are set as a percentage of the process time. The mechanic performs in-process inspection during the process operational cycle time. Typically a visual check but can be as extensive as using gages and calibrated inspection tools. An example is fasteners or fastener holes that will be sample checked to insure that great quantities are not drilled or installed incorrectly.

In-process inspections by the mechanic are a direct charge and are set as a percentage of the direct process time. This is not inspection time for QA, which is included in QA inspection. Enter the percentage of total direct process time devoted to in-process inspection, usually based on the historical average at your facility or company but possibly based on your knowledge of the specific process.

Refine Rules to get outputs as needed

AI Adds Notes for decisions it made

AI Integration Life Cycle Benefits



Assumptions:

Manual processing avg. 4 hours per part at \$75/hour = \$300 per part

AI processing 0.5 hours = \$37.50 per part

Savings of \$262.50 per part.
For 1000 parts/year = \$262,500 annual savings

If implementation, licenses, training, = \$100,000, break-even = ~5 months

Future Applications: Enhanced Capabilities

Real-time cost impact analysis of alternatives e.g. additive manufacturing vs machining

Batch process drawings

AI agents to process and validate scripts before use

Automated verification against original drawings

Confidence scoring for extracted features

Manual review triggers for complex cases

Automated model creation no manual intervention required

AI not a Panacea

Cost of hosting,
developing, and
running models

Security Data
Concerns

Image Size/Clarity

Difficulty
interpreting and
validation data

Hallucinations – AI
may choose an
incorrect raw
shape, remove too

May choose
inappropriate
operations

Created models
need review for
accuracy



GALORATH

**We look forward to being
part of your success**

Galorath Incorporated
info@galorath.com
galorath.com

ROI Assumptions

Initial Investment:

Software + Training \$100,000

Annual Software Related Costs:

Software maintenance/updates: \$40,000/year

Additional computing resources: \$20,000/year

Occasional retraining: \$10,000/year

Total annual costs: \$70,000/year

Labor Savings:

Manual processing avg. 4 hours per part at \$75/hour = \$300 per part

AI processing 0.5 hours = \$37.50 per part

Savings of \$262.50 per part.

Volume Benefits:

For 1000 parts/year Total annual benefits: = \$262,500 annual savings

3-Year ROI Calculation:

Initial investment in AI system: \$100,000

3-year ongoing costs: $\$70,000 \times 3 = \$210,000$

Total 3-year costs: \$310,000

3-year benefits: $\$262,500 \times 3 = \$787,500$

Net benefit over 3 years: $\$787,500 - \$310,000 = \$477,500$

3-year ROI: $(\$477,500 \div \$310,000) \times 100\% = 154\%$