



16. Detailed Design Drawings

NASA ESMD Capstone Design

developed by

John K. Gershenson, Ph.D.

Professor of Mechanical Engineering

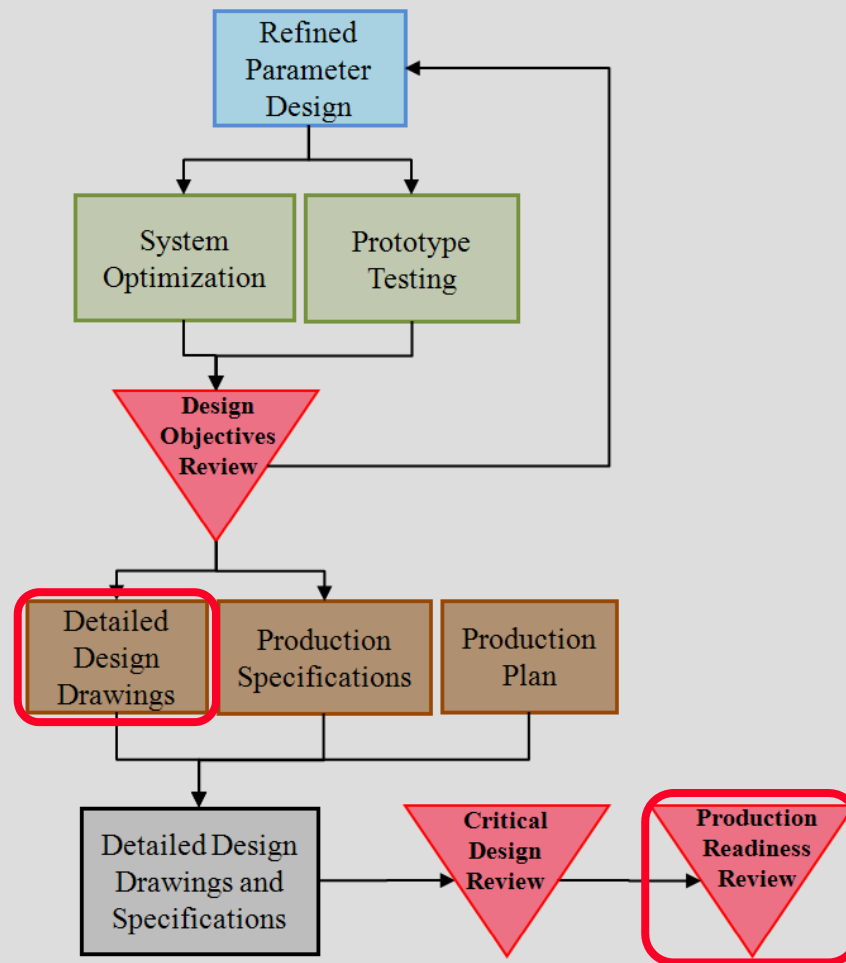
MICHIGAN TECHNOLOGICAL UNIVERSITY

and

Director

the **benshima**group

Where in the Process?



Phase C: Optimized Parameter Design

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Project Tools Covered

◆ Drawings

- A full set of drawings with assembly drawings and BOM. These can be in the appendix of the report.

◆ Production Readiness Review

- Ensures that production plans, fabrication, assembly, and integration enabling products are in place and ready to begin production.

Elements of a Set of Drawings

- ◆ Title block
- ◆ Bill of materials
- ◆ Assembly drawings
- ◆ Part drawings
- ◆ Material specification
- ◆ Tolerance specification
- ◆ Finish specification

Bill of Materials

- ◆ Detail of drawing number or supply source for each component, sub assembly
- ◆ Great for costing
- ◆ With or without overall assembly drawing
- ◆ Don't repeat through drawings
- ◆ Some parts on assembly drawing some in the details but tell me how to get there (where to begin)

Good Prints

- ◆ Title Block
- ◆ Bill of Materials (Quantity required)
- ◆ Tolerances
- ◆ Clear communication of how this part will be used (clearances, fits, surface roughness, heat treatment, coatings)
- ◆ Best way to communicate DFA, DFM information
- ◆ Think about how it is put together and manufactured
- ◆ Can you make it?

References

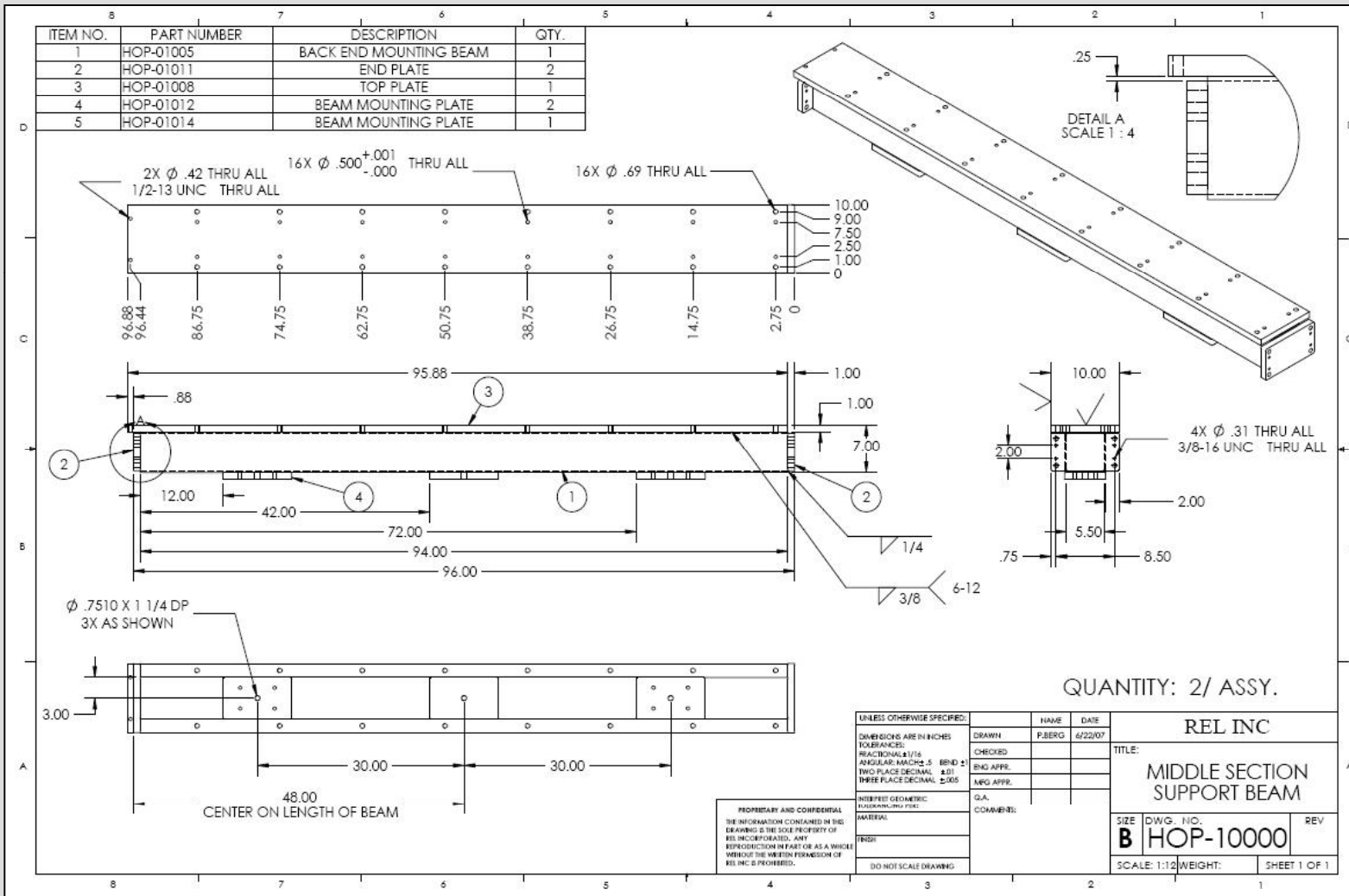
- ◆ “Machinery’s Handbook”
- ◆ Engineering drawings
- ◆ Workshops or training through employer
- ◆ GD&T Procedures
 - ANSI/ASME Y14.5M-1994
 - ISO 9015 and 26921
- ◆ Supplier catalogs (Parker Seals, *etc.*)

Title Block

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				DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL $\pm 1/16$ ANGULAR: MACH $\pm .5$ BEND ± 1 TWO PLACE DECIMAL $\pm .01$ THREE PLACE DECIMAL $\pm .005$	DRAWN	P.BERG	9/18/07	REL INC			
				INTERPRET GEOMETRIC TOLERANCING PER:	CHECKED			TITLE: ALUMINUM COUPLING			
		NEXT ASSY	USED ON	MATERIAL 3" DIAL 6061-T6 ALUM.	ENG APPR.			SIZE	DWG. NO.	REV	A
		APPLICATION		FINISH	MFG APPR.			B	HOP-03017		
		DO NOT SCALE DRAWING	G.A.			SCALE: 1:1		WEIGHT: 0.75	SHEET 1 OF 1		
			COMMENTS:								

(Josh Loukus)

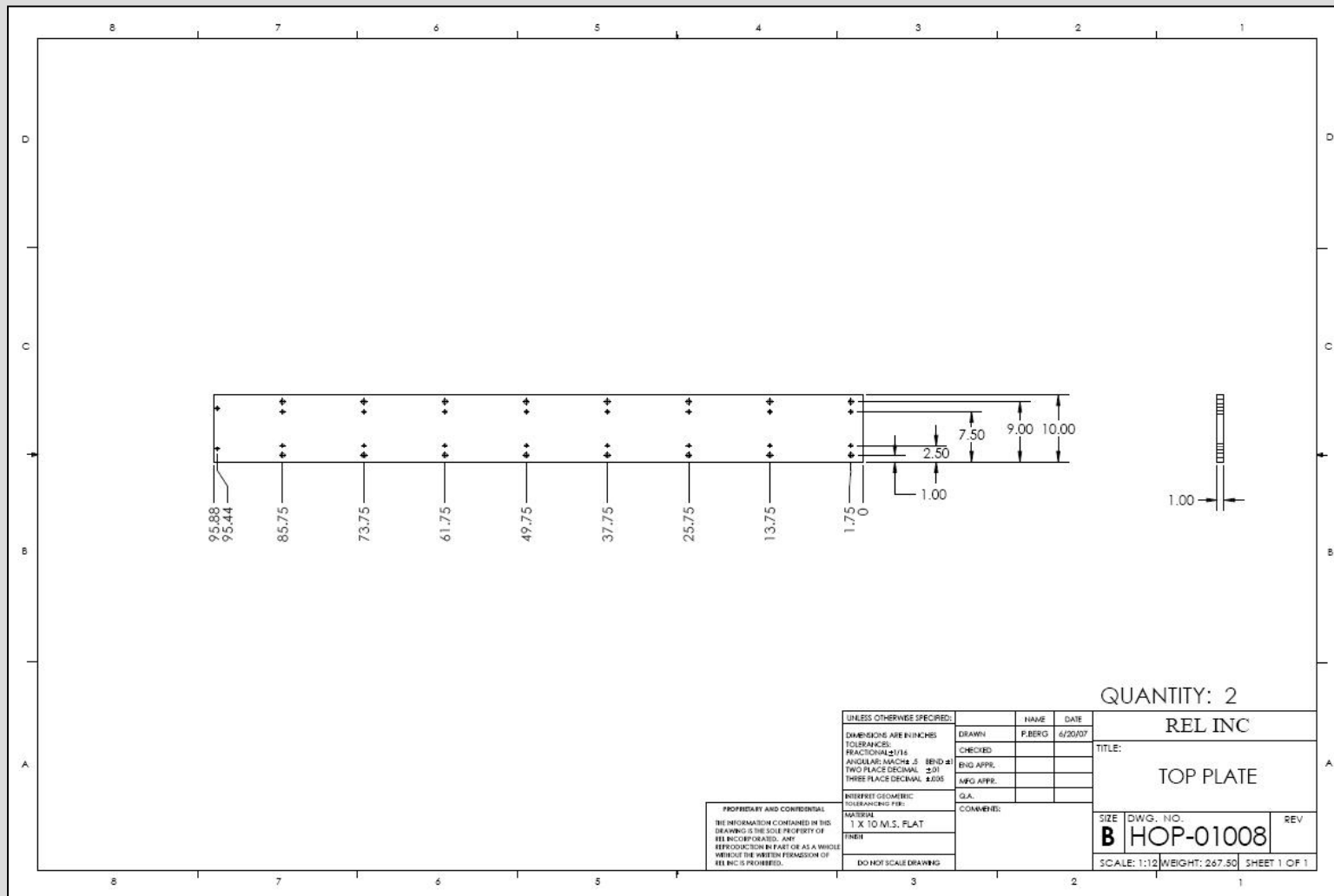
Assembly Drawings



(Josh Loukus)

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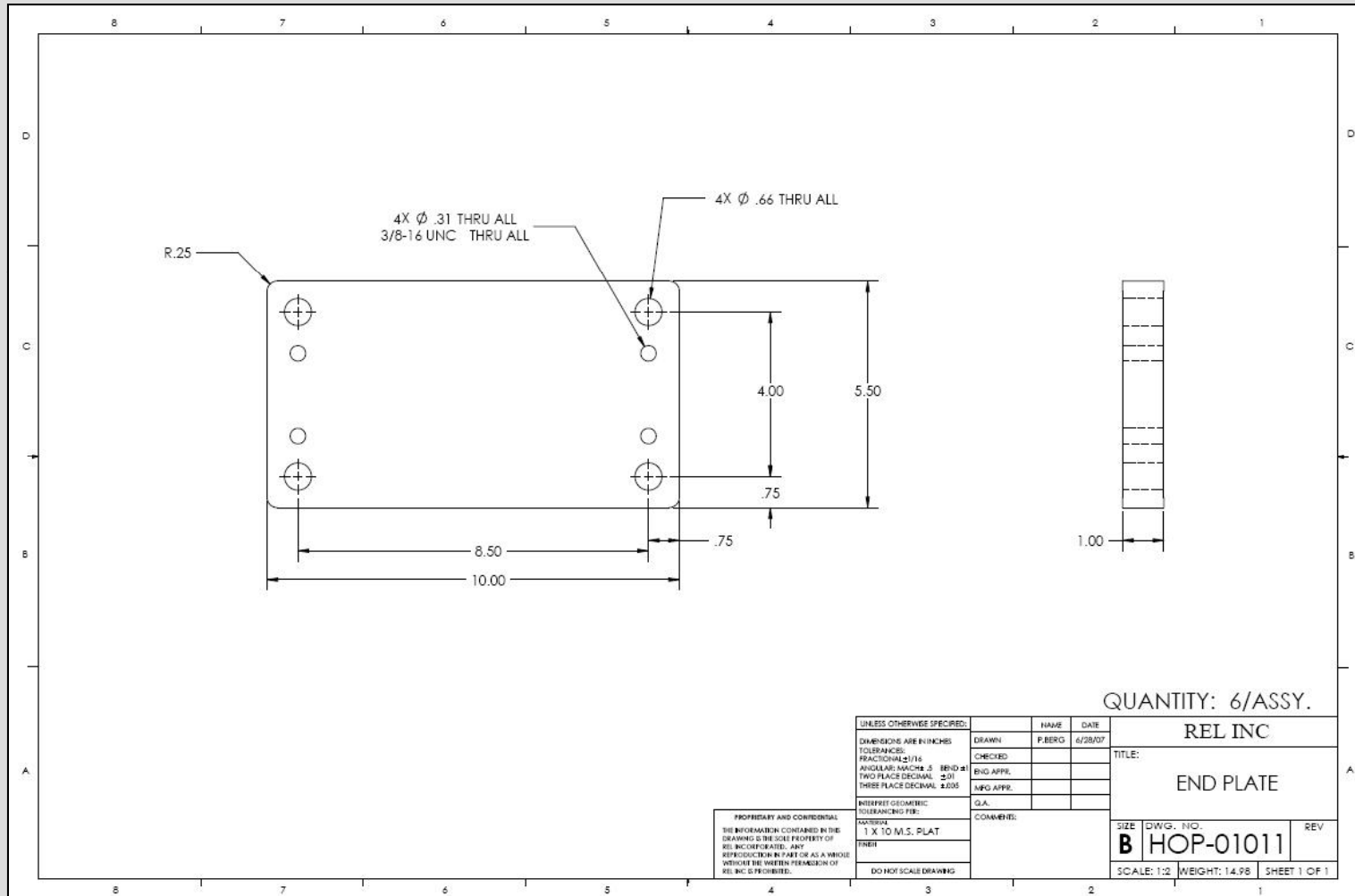
Assembly Part Drawing



(Josh Loukus)

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Assembly Part Drawing



(Josh Loukus)

Detailed Part and Assembly Drawings – Lunar Penetrator

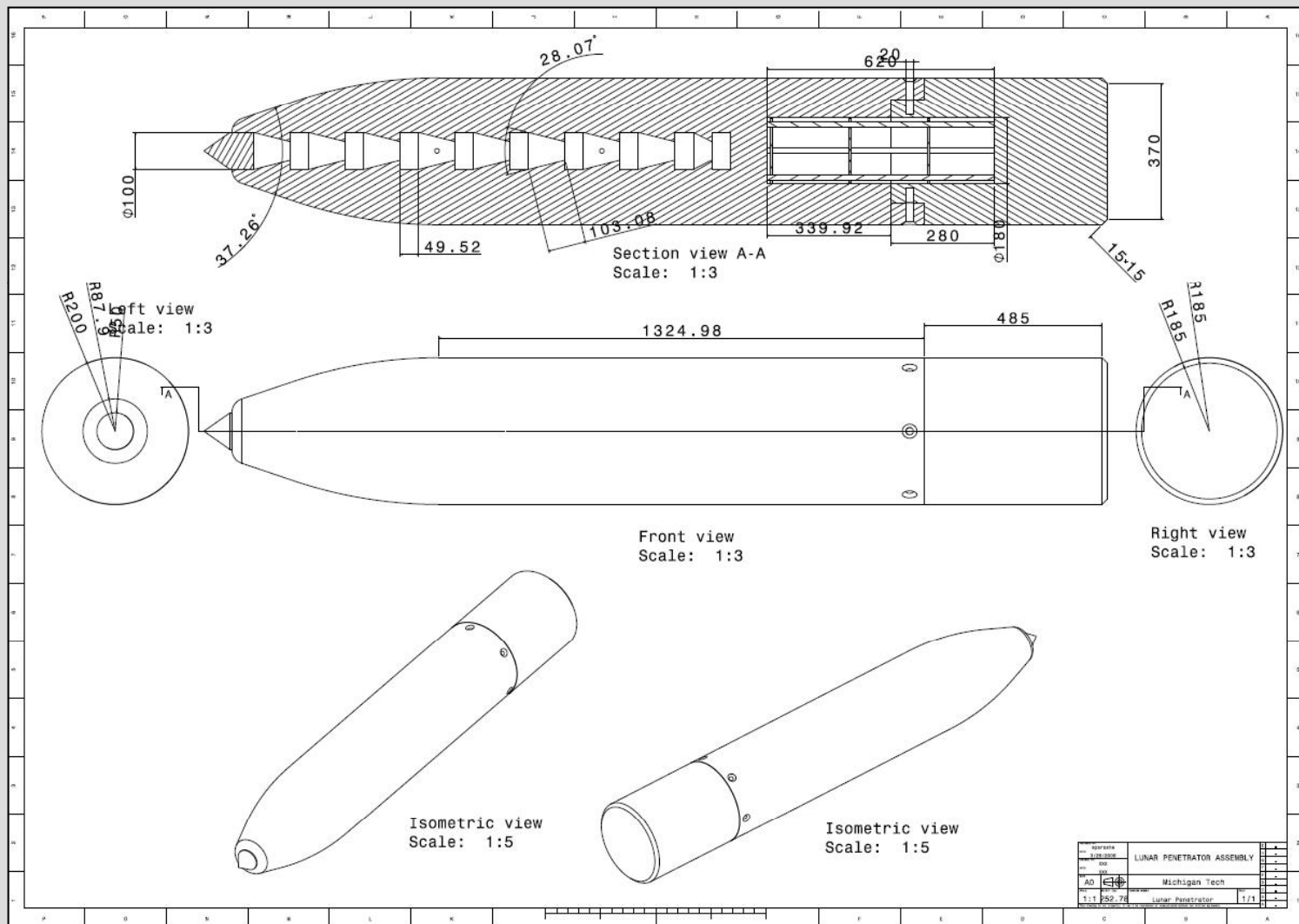


Detailed Drawings

- ◆ Detailed part and assembly drawings were created using modeling and drafting software
- ◆ Care was taken to include title blocks, bill of materials, *etc.*
- ◆ Adequate views were included for clear understanding



Product Drawing – Lunar Penetrator



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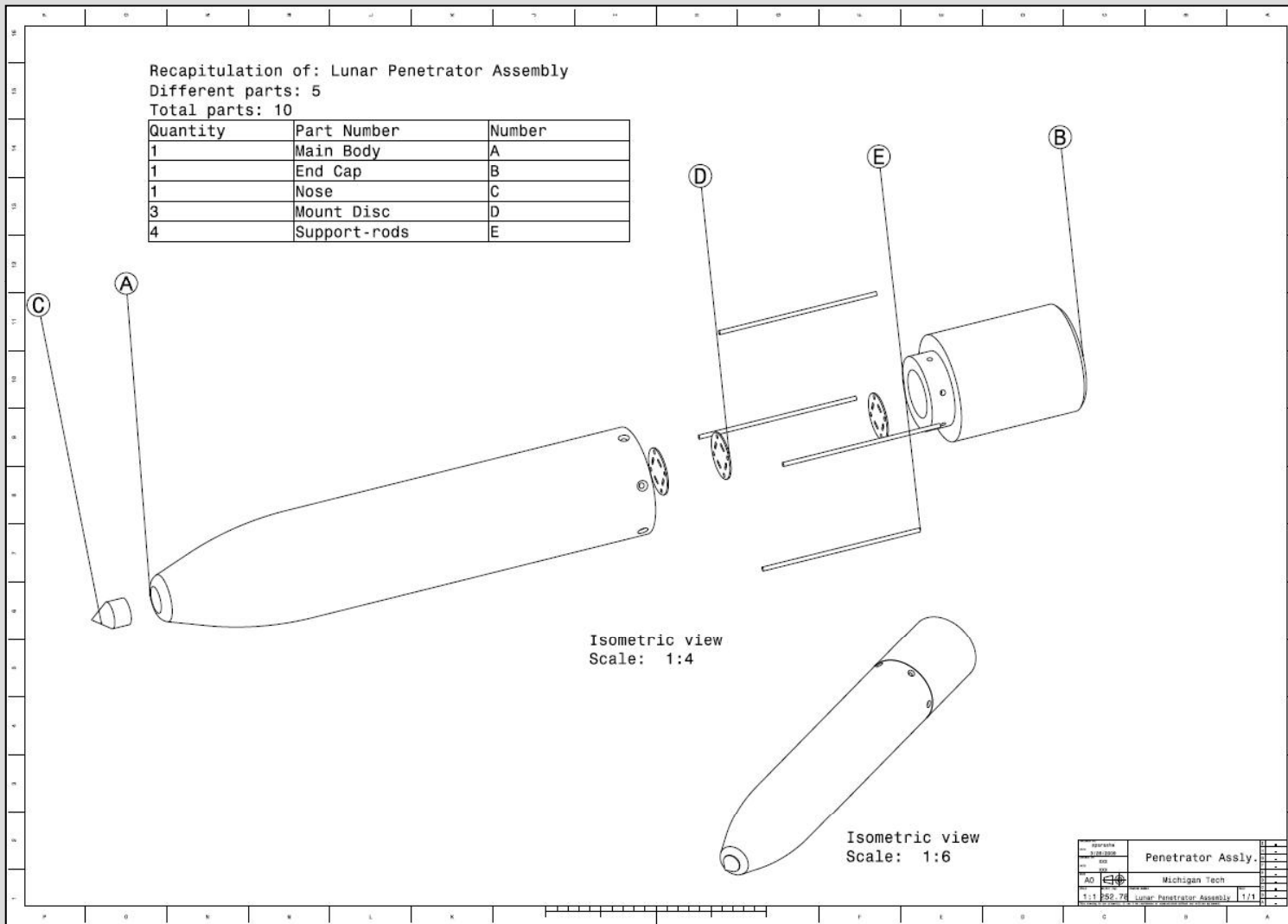
Assembly Drawing – Lunar Penetrator

Recapitulation of: Lunar Penetrator Assembly

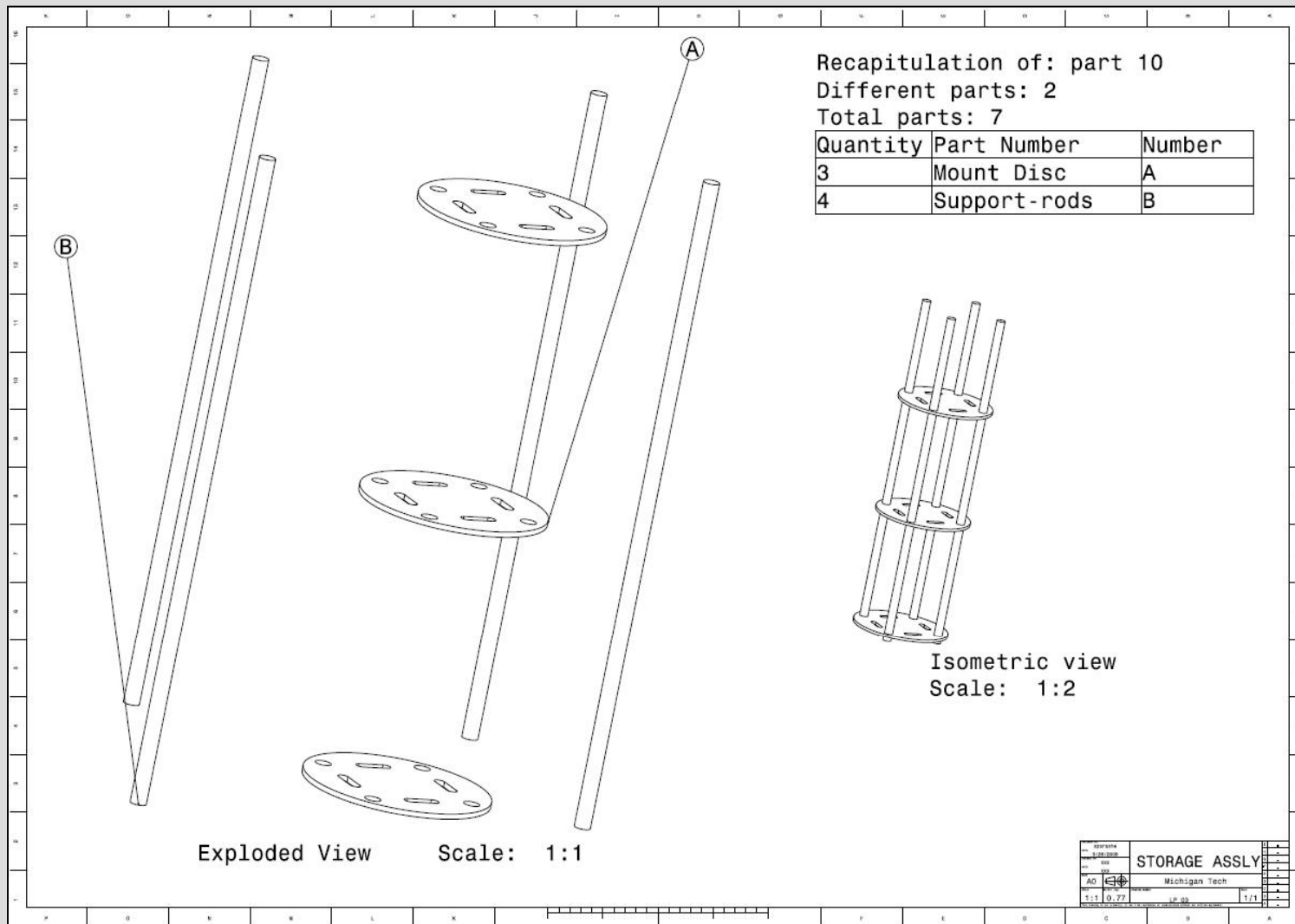
Different parts: 5

Total parts: 10

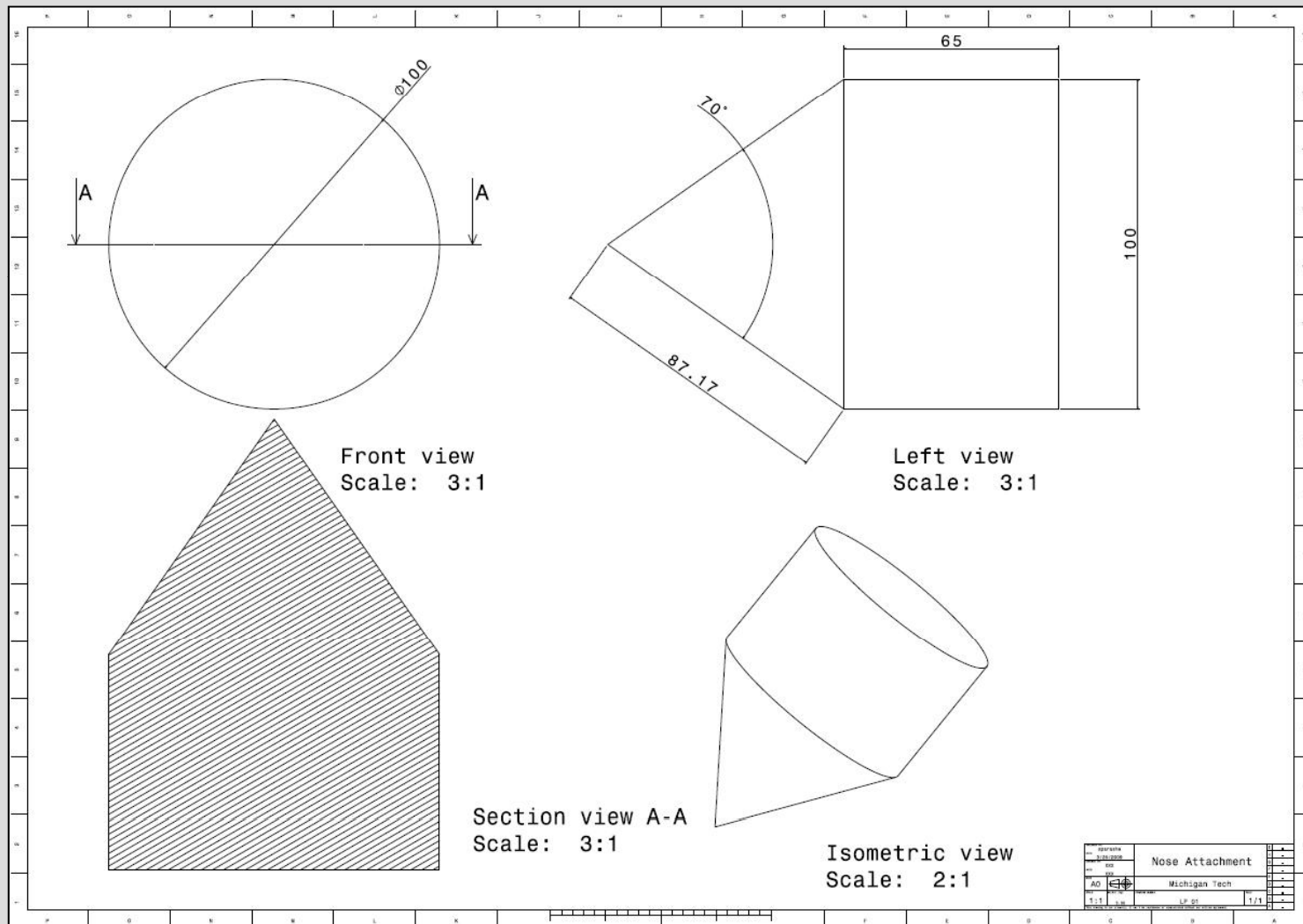
Quantity	Part Number	Number
1	Main Body	A
1	End Cap	B
1	Nose	C
3	Mount Disc	D
4	Support-rods	E



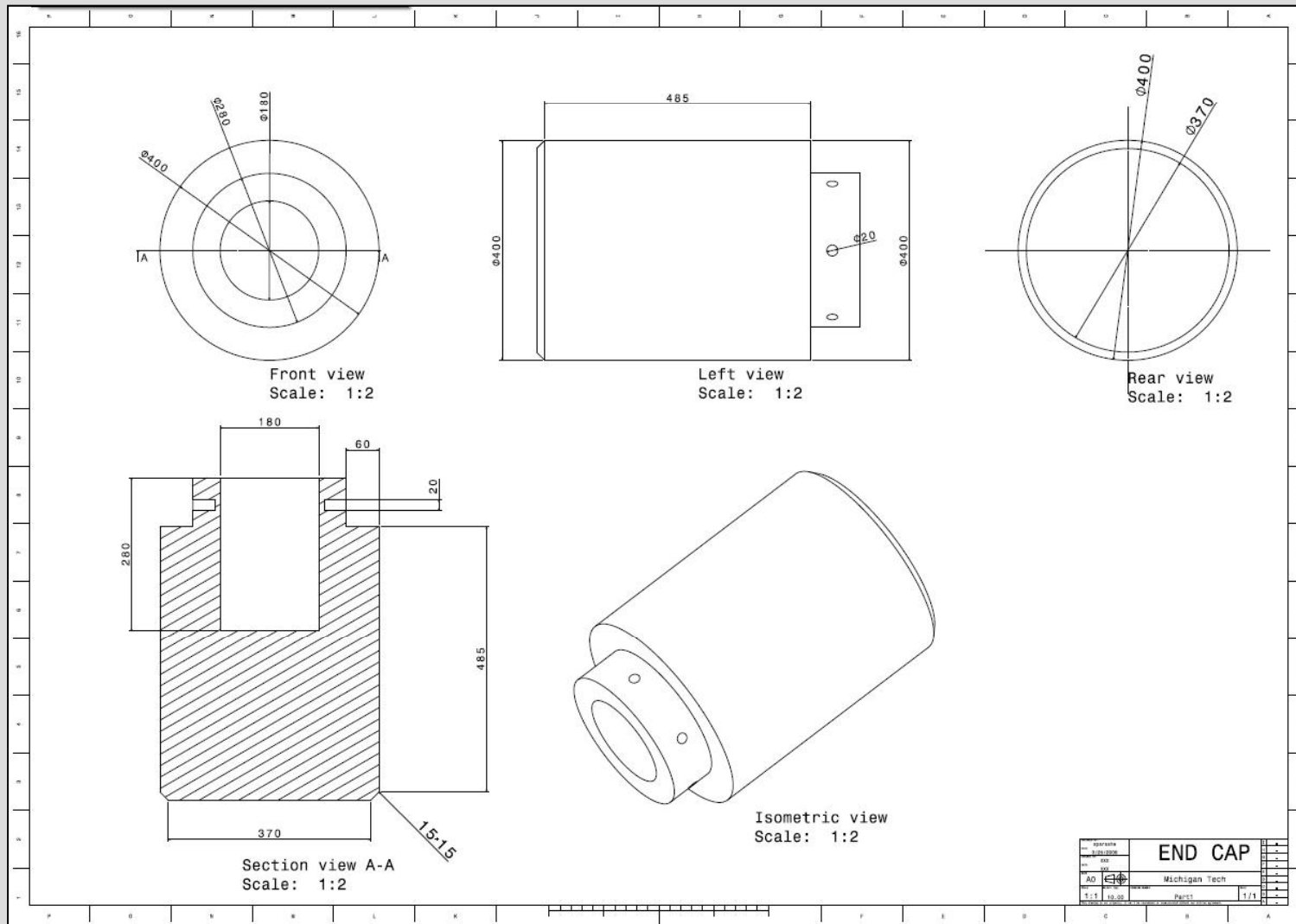
Assembly Drawing – Storage Assembly



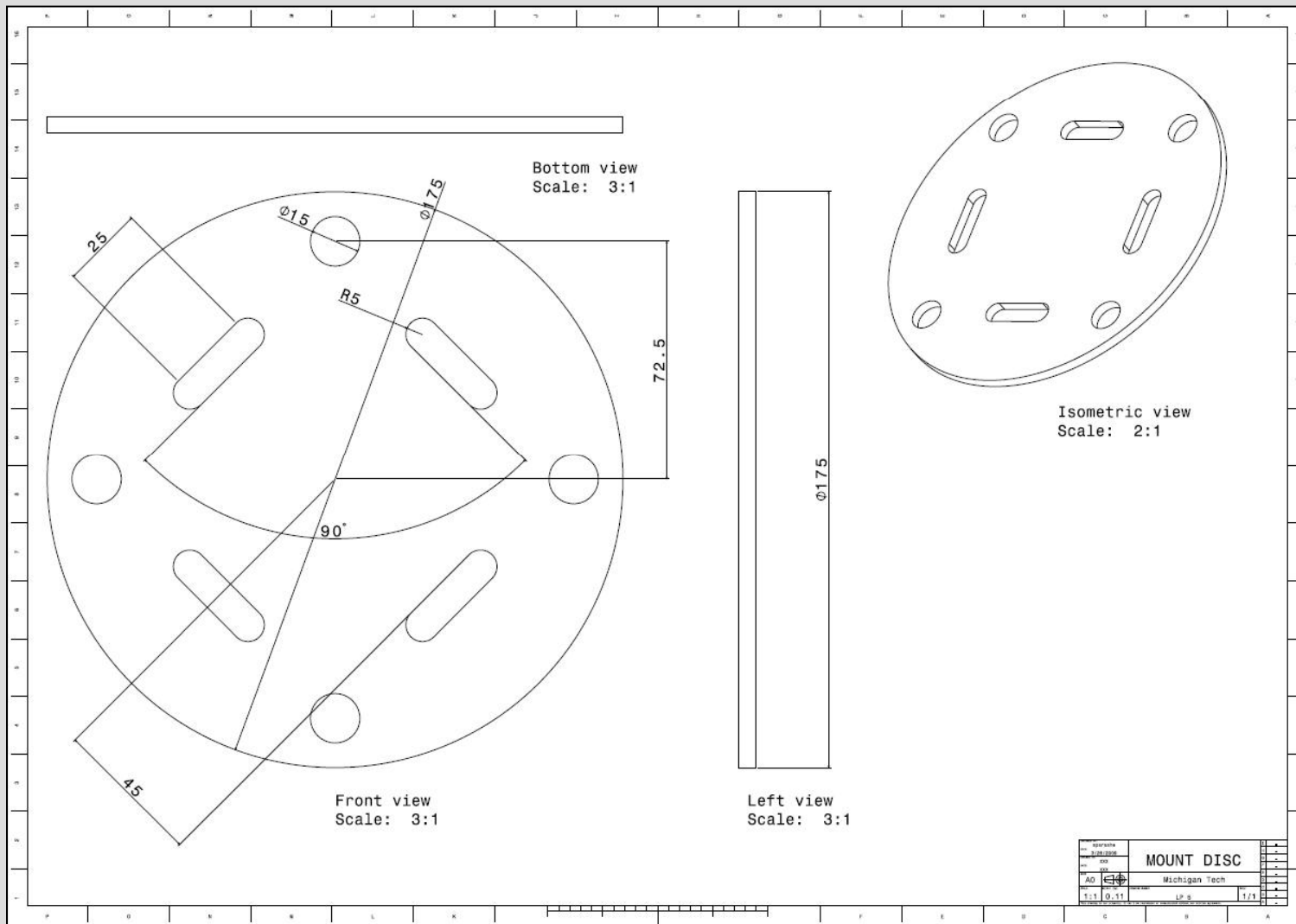
Part Drawings – Nose Attachment



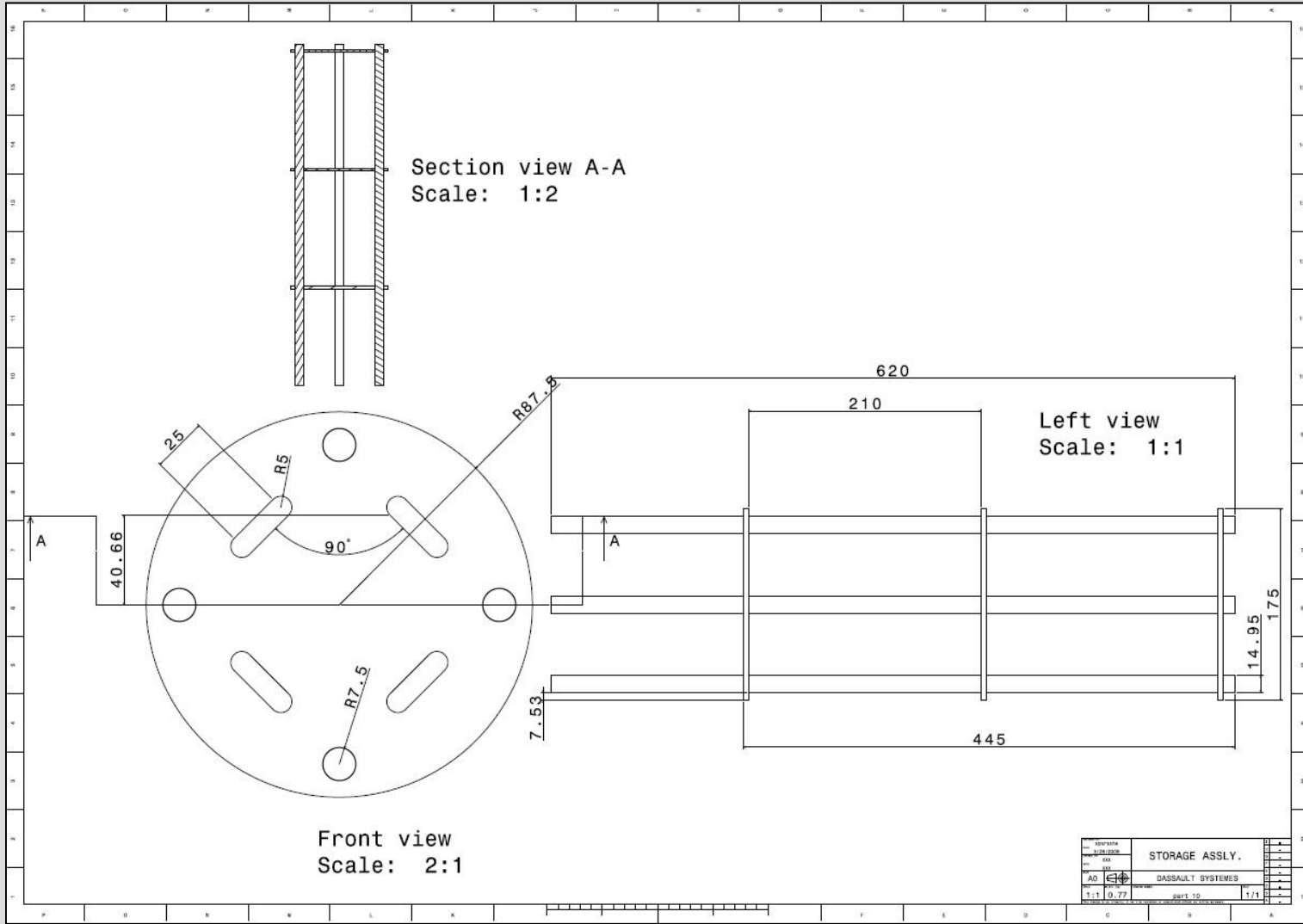
Part Drawings – End Cap



Part Drawings – Mount Disc

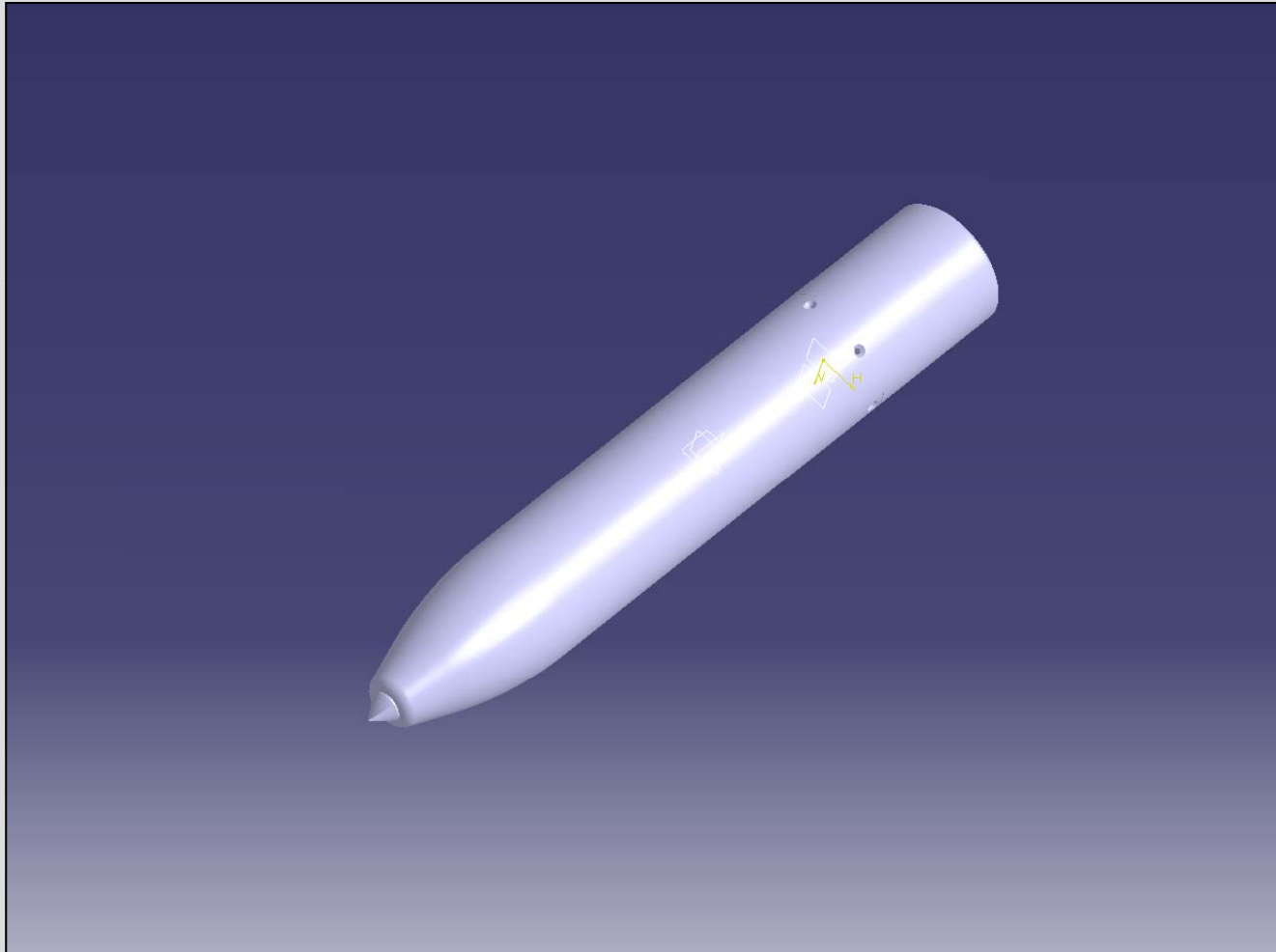


Part Drawings – Storage

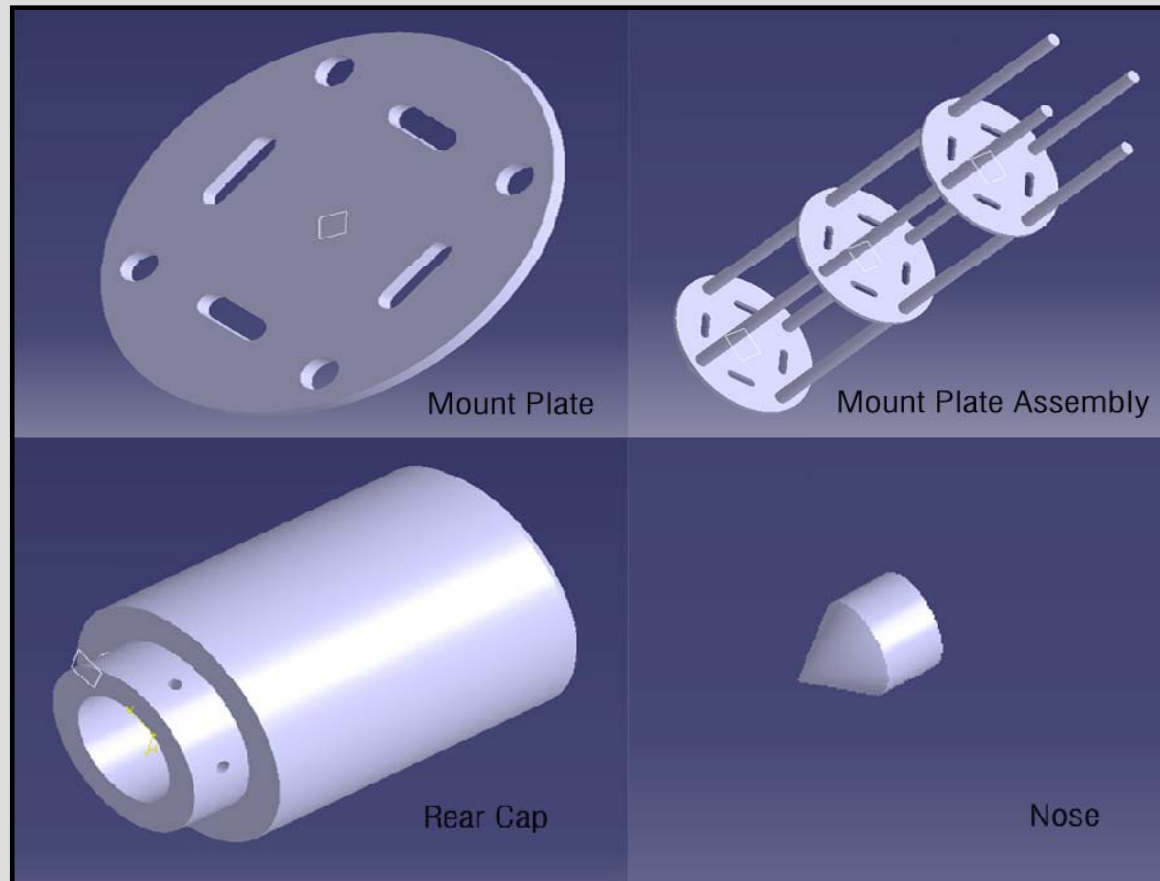


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3-D Model – Lunar Penetrator



3-D Part Models



Production Readiness Review (PRR)

◆ *What?*

- Determines the readiness of the system developers to efficiently produce the required number of systems
- Ensures that the production plans; fabrication, assembly, and integration-enabling products; and personnel are in place and ready to begin production

(NASA Systems Engineering Handbook, SP 2007)

Production Readiness Review (PRR)

◆ *When?*

- Normally held in the final stages of the final optimized parameter design phase (Phase C)

(NASA Systems Engineering Handbook, SP 2007)

Production Readiness Review(PPR)

◆ Results of the review

- Final production build-to baseline, production, and verification plans are approved
- Approved drawings are released and authorized for production
- Successful review authorizes system qualification testing and integration

(NASA Systems Engineering Handbook, SP 2007)

Entrance and Success Criteria

◆ Entrance Criteria

- Significant production engineering problems encountered during development are resolved
- Design documentation is adequate to support production
- The production plans and preparation are adequate to begin fabrication
- Production-enabling products and adequate resources are available, have been allocated, and are ready to support end product production

(NASA Systems Engineering Handbook, SP 2007)

Entrance and Success Criteria

◆ Success Criteria

- The design is appropriately certified
- The system requirements are fully met in the final production configuration
- Adequate measures are in place to support production
- Design-for-manufacturing considerations ensure ease and efficiency of production and assembly

(NASA Systems Engineering Handbook, SP 2007)

Entrance and Success Criteria

- ◆ Success Criteria (continued)
 - Risks have been identified, credibly assessed, and characterized; and mitigation efforts have been defined
 - The bill of materials has been reviewed and critical parts identified
 - Delivery schedules have been verified
 - Alternative sources for resources have been identified, as appropriate

(NASA Systems Engineering Handbook, SP 2007)

Entrance and Success Criteria

- ◆ Success Criteria (continued)
 - Adequate spares have been planned and budgeted
 - Required facilities and tools are sufficient for end product production
 - Specified special tools and test equipment are available in proper quantities
 - Production and support staff are qualified
 - Drawings are certified

(NASA Systems Engineering Handbook, SP 2007)

Entrance and Success Criteria

- ◆ Success Criteria (continued)
 - Production engineering and planning are sufficiently mature for cost-effective production
 - Production methods and processes are consistent with quality requirements and compliant with occupational safety, environmental, and energy conservation regulations
 - Qualified suppliers are available for materials that are to be procured

Entrance and Success Criteria

PRR Entrance and Success Criteria	
Production Readiness Review	
Entrance Criteria	Success Criteria
<ol style="list-style-type: none"> 1. The significant production engineering problems encountered during development are resolved. 2. The design documentation is adequate to support production. 3. The production plans and preparation are adequate to begin fabrication. 4. The production-enabling products and adequate resources are available, have been allocated, and are ready to support end product production. 	<ol style="list-style-type: none"> 1. The design is appropriately certified. 2. The system requirements are fully met in the final production configuration. 3. Adequate measures are in place to support production. 4. Design-for-manufacturing considerations ensure ease and efficiency of production and assembly. 5. Risks have been identified, credibly assessed, and characterized; and mitigation efforts have been defined. 6. The bill of materials has been reviewed and critical parts identified. 7. Delivery schedules have been verified. 8. Alternative sources for resources have been identified, as appropriate. 9. Adequate spares have been planned and budgeted. 10. Required facilities and tools are sufficient for end product production. 11. Specified special tools and test equipment are available in proper quantities. 12. Production and support staff are qualified. 13. Drawings are certified. 14. Production engineering and planning are sufficiently mature for cost-effective production. 15. Production processes and methods are consistent with quality requirements and compliant with occupational safety, environmental, and energy conservation regulations. 16. Qualified suppliers are available for materials that are to be procured.

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