MSA Spring 1998 Review
April 23, 1998

John Scharf, MSA Team Leader

Mechanical Structure and Analysis Team

John Scharf	Engineering Physics	Senior
Creighton Anderson	Material Science Engineering	Junior
Stephanie Loutzenhiser	Physics	2nd Year Grad
Derek Betts	Mechanical Engineering	1st Year Grad.
John Rascon	Aerospace Engineering	Senior
Matt Johnson	Aerospace Engineering	Senior
Avishkar Madar	Mechanical Engineering	Junior
Bill Oswald	Mechanical Engineering	Senior
Oszkar Bajko	Mechanical Engineering	Junior
David Faulkner	Mechanical Engineering	Junior
Benjamin Peddicord	Electrical Engineering	Sophomore
Jacob Lauser	Electrical Engineering	Freshman

Team Mentor

Dr. Weinong “Wayne” Chen

Assistant Professor of Mechanical Engineering

Overview

Educate and Train

Criteria

Requirements

Design

Analysis

Iterate Design

Manufacturing Process

Documentation

Resources

Educate and Train

This semester's progress

ANSYS

PRO/E

FABRICATION

Double Cylindrical Design

Inner Telescope Tube (I.T.T.)

- Main Load Bearing Structure
  - Marmon Plate Attachment
- Optical Structure
  - Light Baffles

Outer Solar Structure (O.S.S.)

- Large Surface Area for Solar-Foil
- Supports Solar Electronics

Launch-Interface End

- Support Outer Structure
- May be more complex design than the Aperture End

Aperture End

- Supports Outer Structure

Fabrication

- Fiberglass Techniques
  - Wet Lay-up
  - Vacuum Bag
  - Filament Winding
- Experimental Determination of Thickness per Layer
- Machining
- Mock-Up
  - Small Model ==> Full Scale

Initial Criteria

- Volume and Mass Constraints
  - Hitch-Hiker Specifications
    - As close to mass limit as possible to maximize orbital life-time
- Constraints Imposed by Other Sub-Systems
  - Science (C.T.E.)
  - G.N.C. (Bending/Stiffness)
  - Other Teams (Temperature)

Hitch-Hiker Specifications

Maximum spacecraft weight	68 kg	⟺	150 lb
Maximum spacecraft height	52 cm	⟺	20.5 in
Maximum spacecraft diameter	48 cm	⟺	19 in
Canister inside diameter	50 cm	⟺	20 in
Maximum CG location	1.27 cm	⟺	0.5 in
Maximum CG location	26 cm	⟺	10.25 in
Ejection Velocity	0.6 - 1.2 mps	⟺	2 - 4 fps

To Be Determined

- Maximum rotational impulse
- Minimum payload resonant frequency

Define Criteria

- Strength
- Structural Life
- Structural response
- Natural Frequency
    - Fundamental Frequency
- Stiffness
- Damping
- Mass Properties
- Dynamic Envelope
- Positional Stability
- Mechanical Interface

Avoid the need to optimize weight

Pushing mass limit for maximum orbital life

Enough weight to structures and mechanisms for producable designs, simplify analyses, and avoid certain tests

Development of Requirements

Compare design concepts

Identify critical events and environments

How to verify compliance

- Primary Structures
  - Body Structure
  - Launch Vehicle Adapter
- Secondary Structure
  - Appendage Booms
  - Support Trusses
  - Platforms
  - Solar Panels
  - Antenna Dishes
- Tertiary Structures
  - Brackets
  - Electronics Boxes

Support key components in desirable locations

- Thermal control
  - Monitor Temperature Gradient
    - Instrumentation
      - Silicon Sensor
      - AD590 -55 to 125 °C
- Antennae and Sensors F.O.V.
- Length and weight of cables
- Must fit within payload envelope
- Access for installing and maintaining

Component/ Subsystem	Operating Temperature ºC	Survival Temperature ºC
Digital Electronics	0 , 50	-20 , 70
Analog Electronics	0 , 40	-20 , 70
Batteries	10 , 20	0 , 35
Infrared detectors	-269 , -173	-269 , 35
Momentum wheels, motors	0 , 50	-20 , 70
Solar Panels	-100 , 125	-100 , 125

Protect Components from Dynamic Environments

Ground Operations

Launch

Deployment

Mission Operations

Deploy Antennae and Sensors

- stiffness to keep steady

Derived requirements flexible until effectively allocated between structures and subsystems

Number of Sides

Weight

Stiffness

Alignment

Distinguish between requirements and verification steps

Identify required tests

Keep verification steps flexible

Simple Design

Minimize number of parts

Use proven methods

Good reason for added complexity

Materials used must survive ground, launch, on-orbit environment, and help control the temperature

Control Loads and Vibrations Passively

Strategically use highly damped materials

Make natural frequency much different from driving frequency

Mount sensitive components in regions of the structure with low response

Mount actuators in areas that cause little structural excitation

Vibration must not interfere with launch vehicles control system, or it’s own control system in deployed configuration

Sensitivity analysis

Design to tolerate uncertainties in:

- analysis and modeling assumptions
- environments
- manufacturing tolerances

- Design Reviews

    Perspective of outside reviewer

- Iterate design

    identify additional design drivers, and be aware of subsequent changes

    Shorten iteration time by integrating steps that are traditionally separate

    - calculate loads ==> stresses and verification
    - calculate stresses ==> verify compliance directly in loads analysis

Control Manufacturing Process

Proven processes unless development tests show it will achieve the necessary product characteristics with acceptable variation.

Documentation

Requirements

How requirements and designs evolved

Verification Criteria

Deployment Plan

Product Configuration

Manufacturing Process

How Requirements Verified

Critical Data and Math Models

Key decisions, problem resolutions, and rationale

Lessons Learned

Resources

People

Dr. Kumar Ramohalli	(A.M.E.)
Dr. Lyle Broadfoot	(L.P.L.)
Nelson Zabik	(A.M.E.)
and…	(Opt-Sci, Bio-Sci, Phys., A.M.E.)

Facilities and Equipment

Machine Shop	(A.M.E., P.A.S.)
Computer Lab	(A.M.E., F.C.R.)
Composite Lab	(A.M.E.)

Mass and Volume Estimates

Team	Volume	Mass
Science	3,267 cm^3	25.0 kg
Optical Cavity	11,960 cm^3	0.0 kg
M.S.A.	6,745 cm^3	14.2 kg
S.T.I.	6,000 cm^3	6.0 kg
G.N.C.	1,889 cm^3	4.3 kg
P.G.D.	???	???
D.C.H.	???	???
T.T.C.	???	???
Total	**29,861 cm^3**	**49.5 kg**
Max. Allowed	**87,000 cm^3**	**68.0 kg**

We Have:

Programs

Facilities and Equipment

People

A place to work

We Need:

More Freshman and Sophomore Students

Money

Guidance

Analysis

General Types: Static and Dynamic

Specific Types:

- --thermal

- --stress
  - -displacement, stresses, and strains

- --vibrational
  - -natural frequencies and mode shapes

- --time history

Goals: 1. To produce a model to obtain the necessary information and accuracy.

2. To simplify the problem to the greatest extent while satisfying the above goal.

Finite Element Methods

-A way to get an approximate numerical solution to a specific problem using piecewise polynomial interpolation.

A. Break a structure into elements whose shapes are defined by nodes. Each element has its own mass and stiffness matrices, and using these the behavior of each element can be determined.
B. Reconnect the elements at the nodes to obtain a set of simultaneous equations that are equilibrium equations of the nodes.

In finite element analysis, the analyst must discretize the structure by dividing it into finite elements and prescribe how it is loaded and supported. The software should then generate the stiffness matrices of each element, connect the elements and obtain the global load vectors, solve the global equations, and postprocess the information.

Finite Element Analysis Software: ANSYS/ED

-tutorials
- -draw
- -mesh
- -apply constraints and loads
- -find deformed shapes and stresses

Problems:
1. no manuals, only online help
2. interfacing with Pro/Engineer

Proposed Work

A. cantilever beam

B. cantilever shell

C. two shells coupled

D. add details such as trusses and mass loads

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Pro/E

Why Pro/E?

It is the top-end industry standard.

UASat has access to Pro/E facilities.

Has many design advantages over AutoCAD.

Can modify any part without redrawing it.
Easier to create, manipulate, and view 3D parts.
2D drafts of the 3D parts can be created quickly.
Superior assembly capabilities.

Basic Pro/E Methodology

Part Creation Begins with a basic 2D sketch.

Pro/E will automatically refine the cross-sectional sketch with assumptions and allow more details to be added easily.

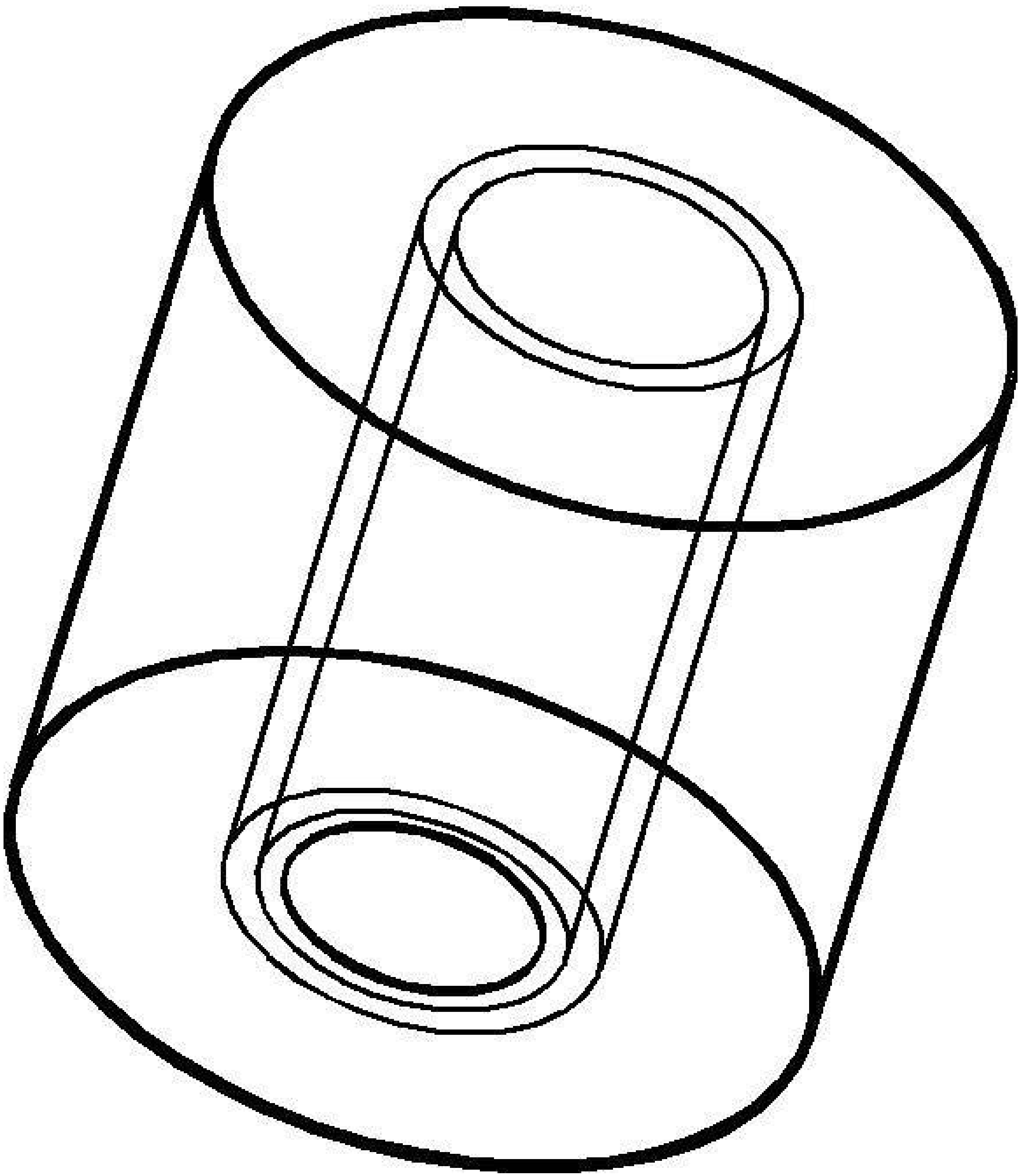
Sketch is then transformed into a 3D “feature”.

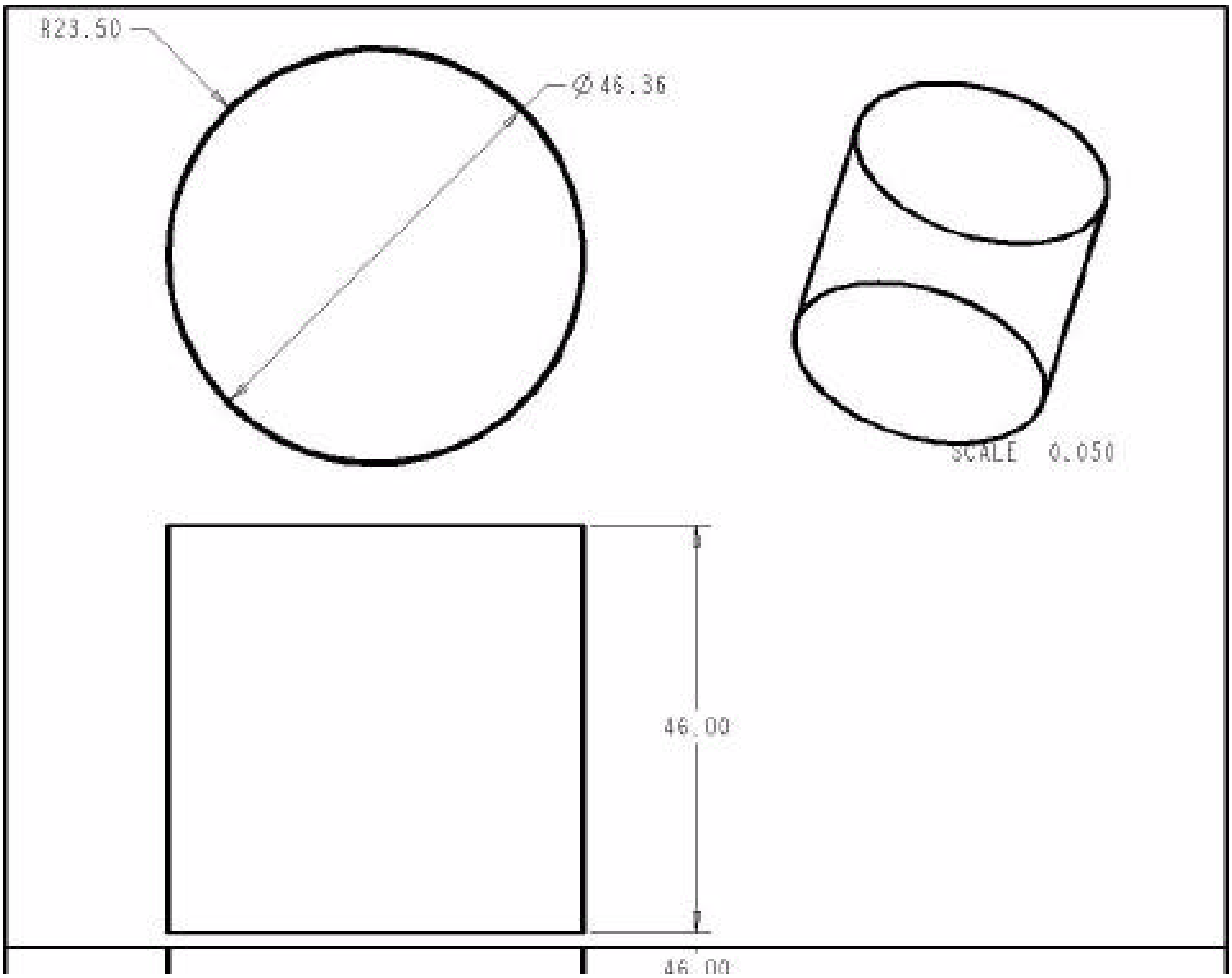
3D model may be rotated, cross-sectioned, shaded, etc. for easy viewing.

The design may be later changed using redefine and modify commands.

Dimensions may be modified by typing in another value.
Parent/Child relationships are upheld.
Model may then be “regenerated” to display the modifications.
The part is automatically updated everywhere it appears.

Assemblies of existing parts may be created for viewing and analysis.

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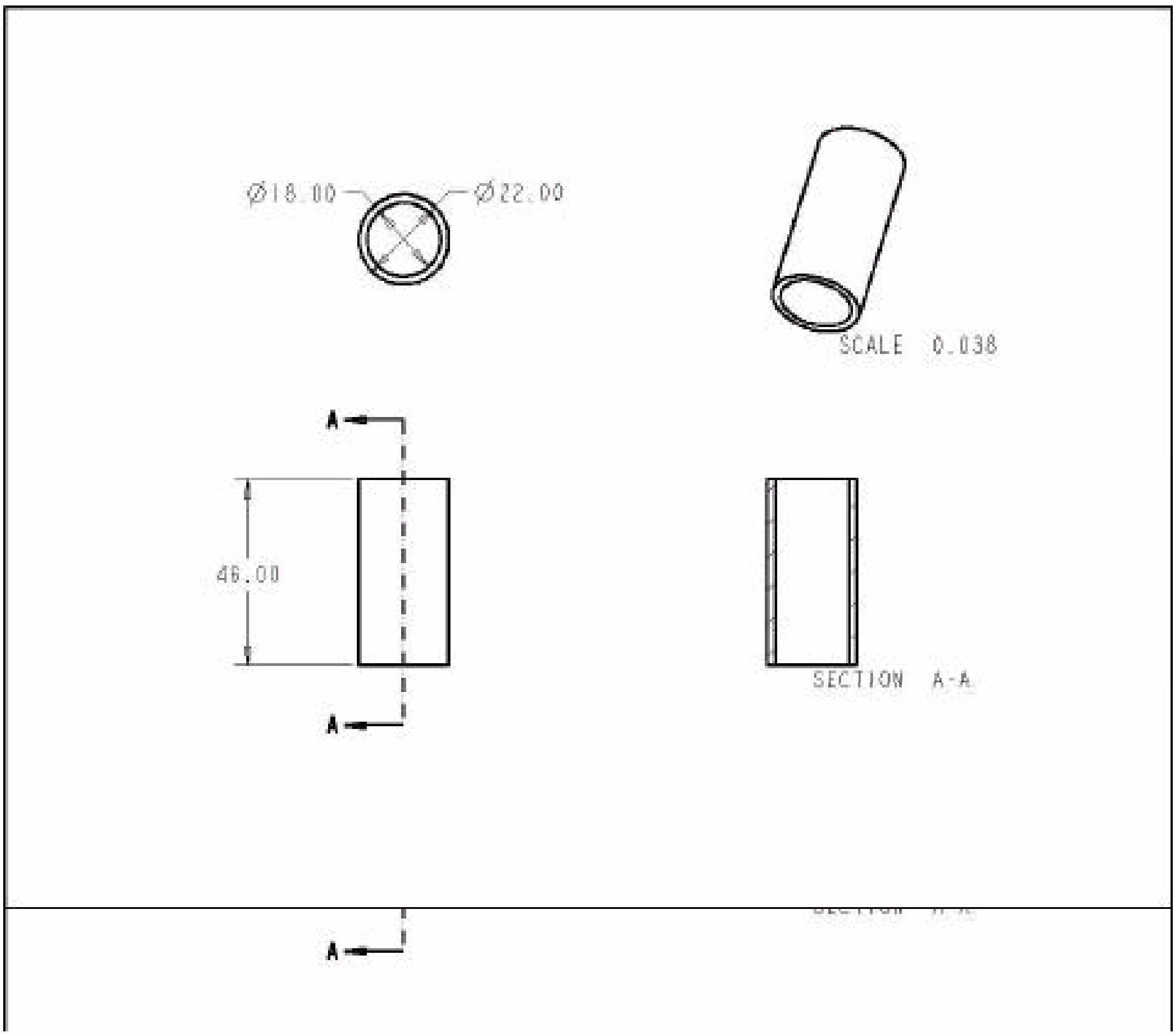
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A
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A
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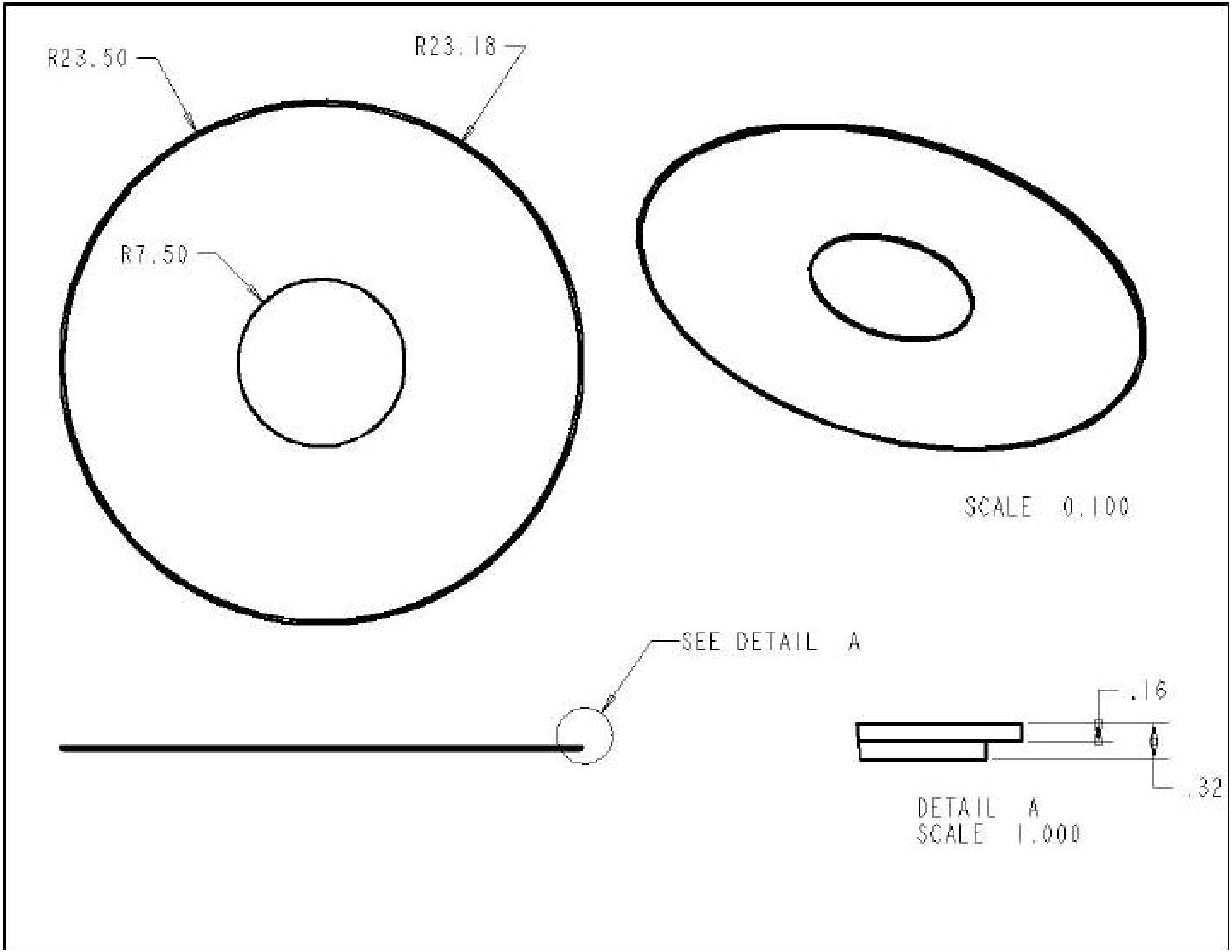
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DETAIL A
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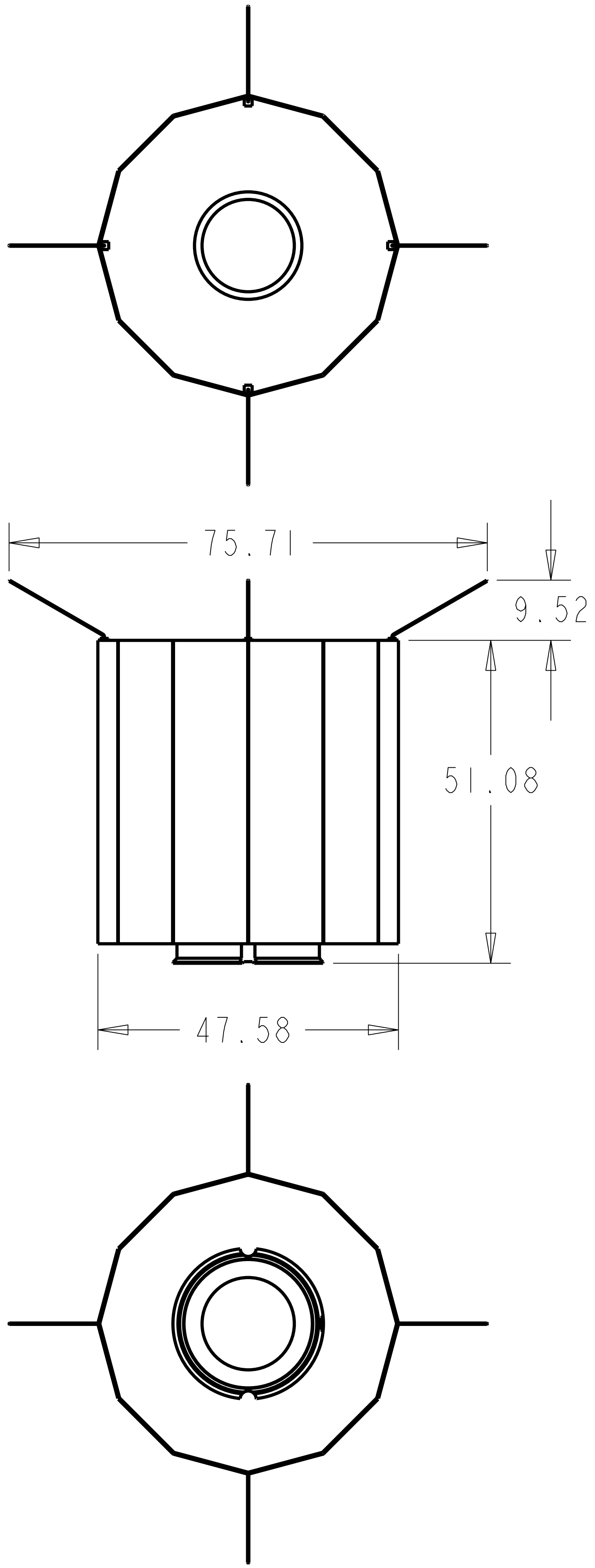

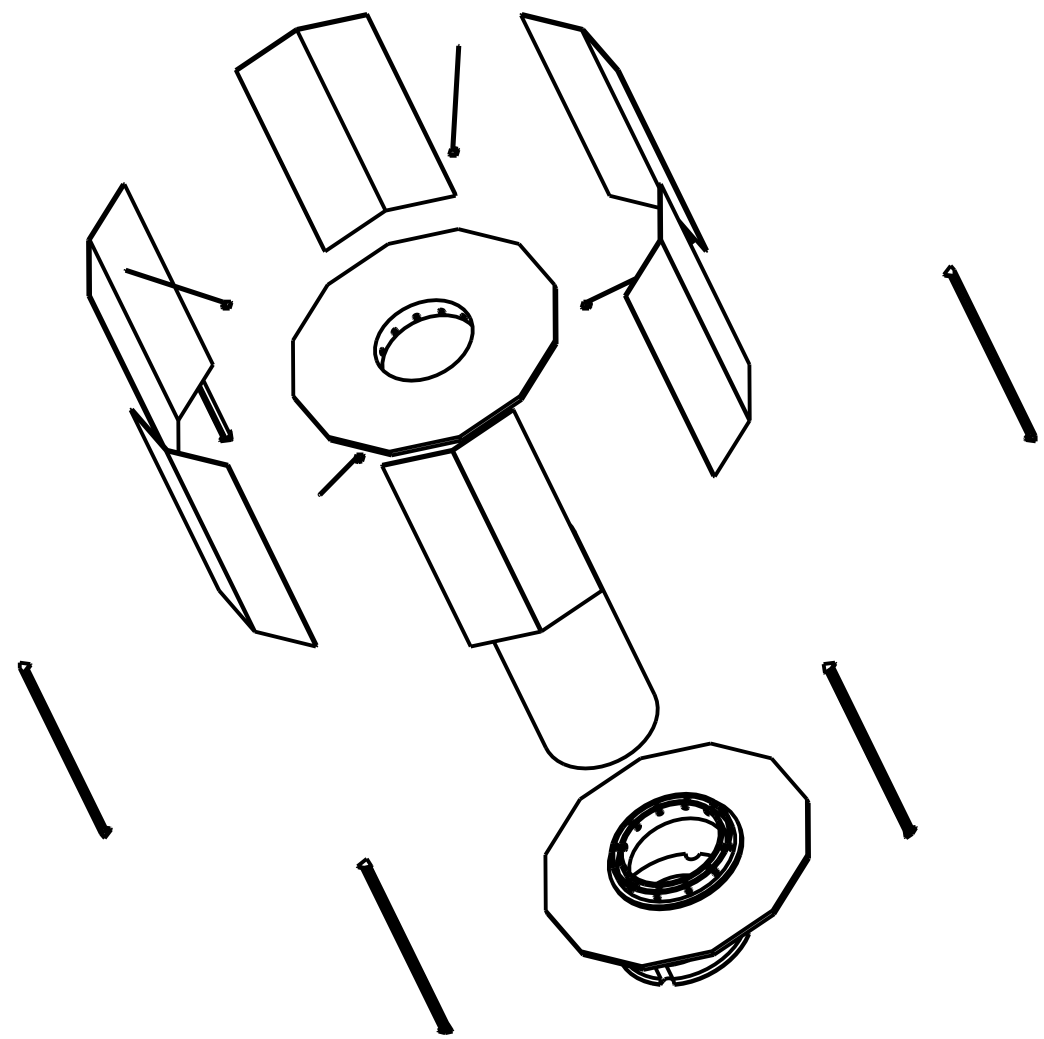

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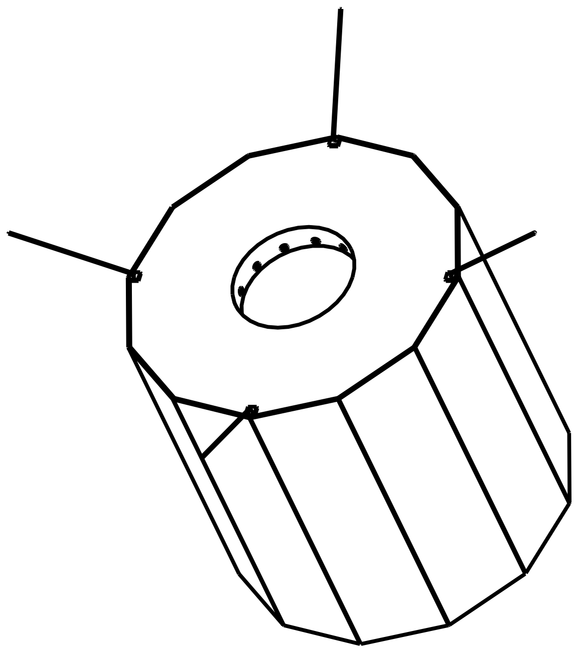

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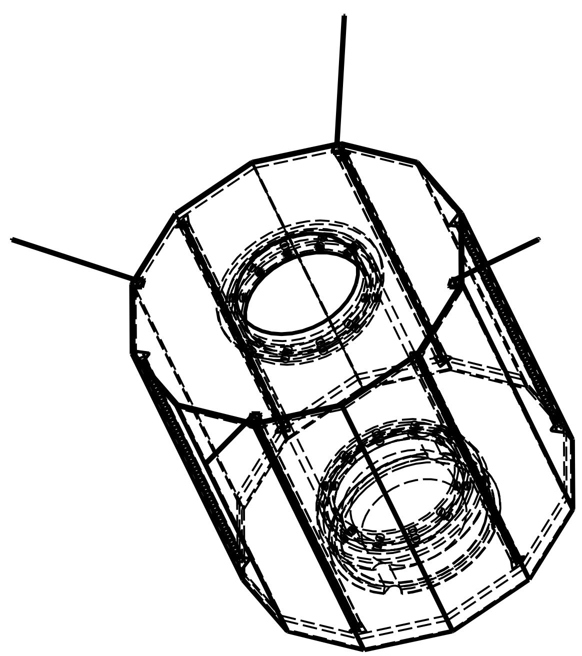

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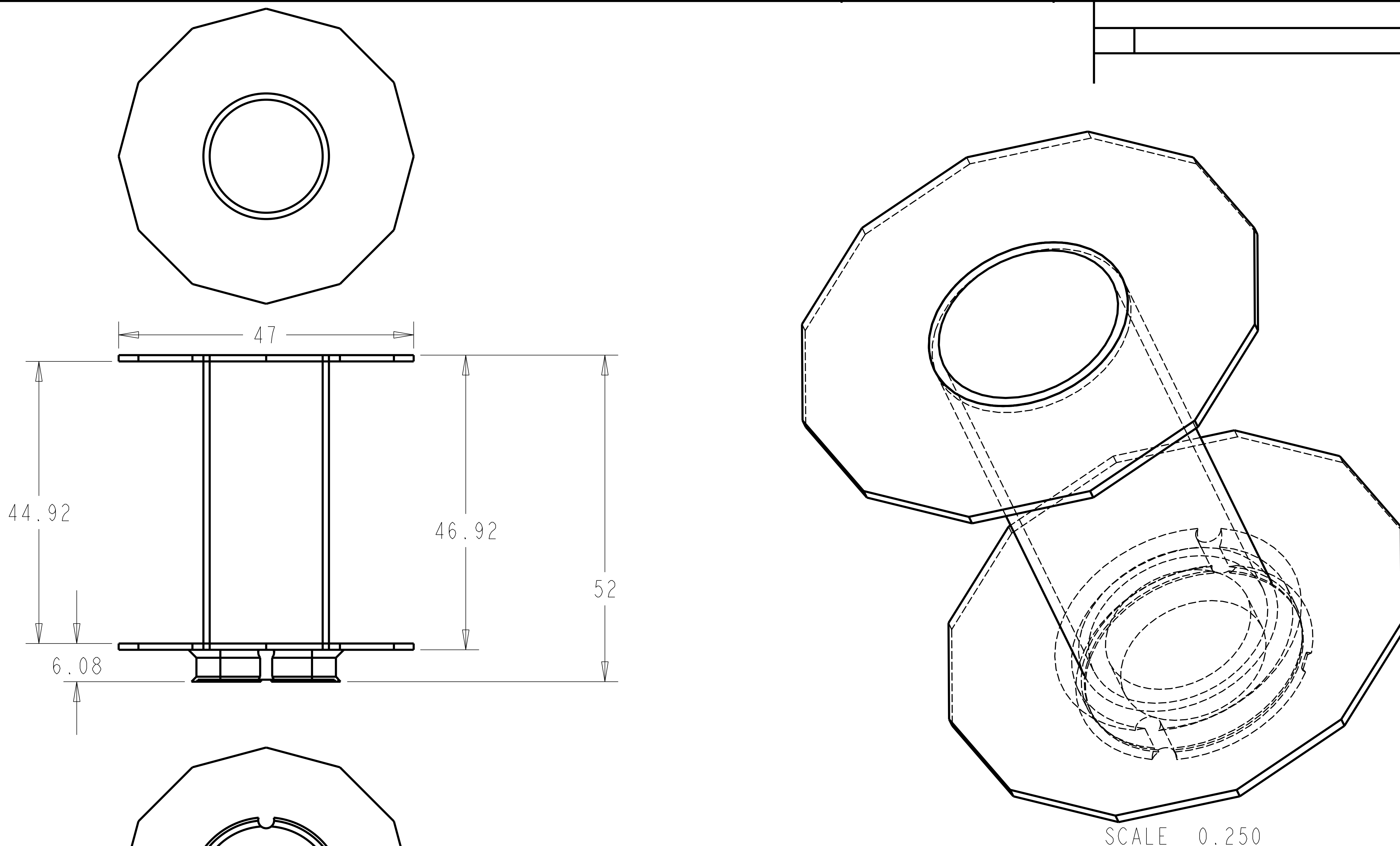
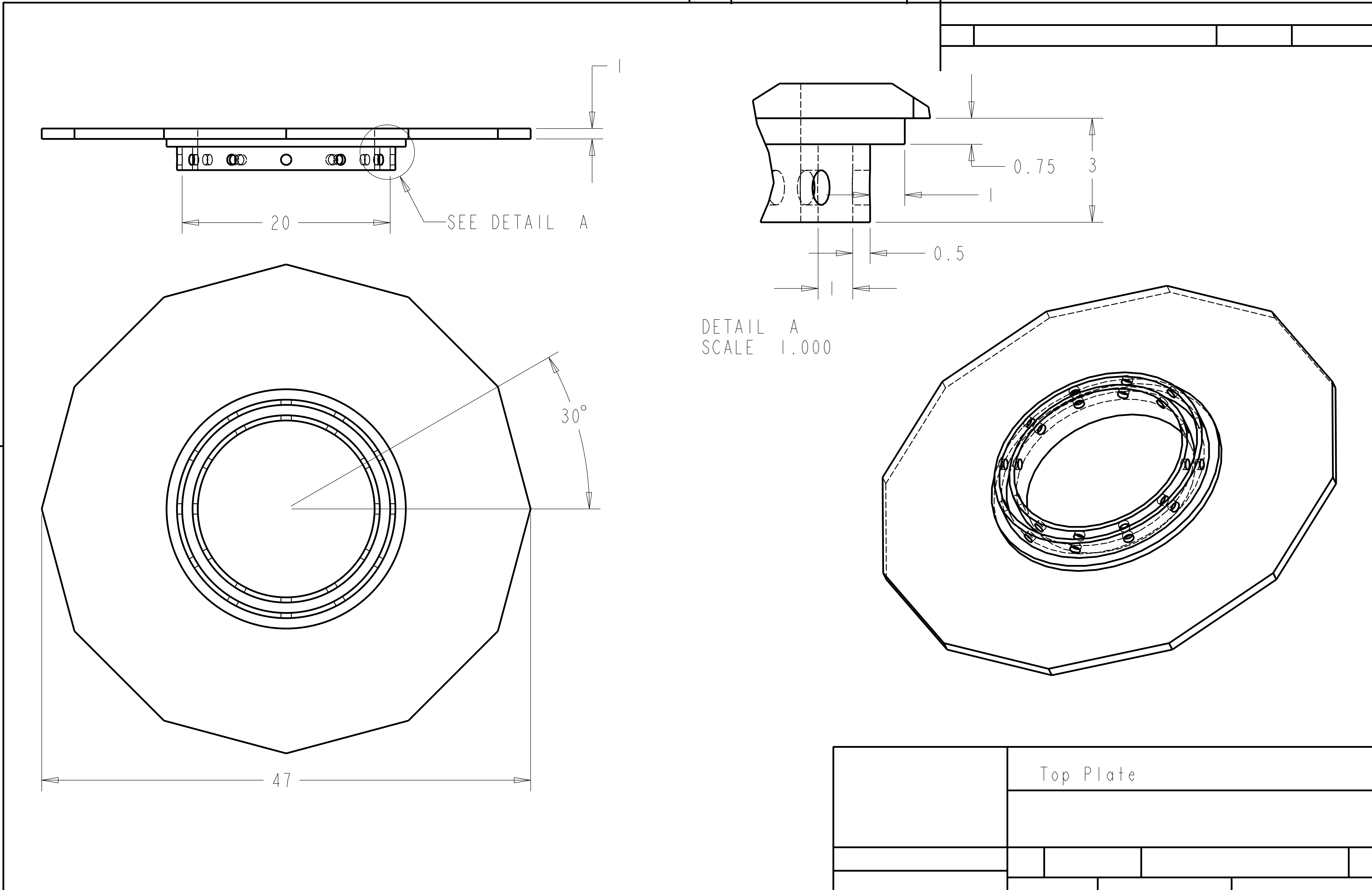


Satellite Assembly


1
20
SEE DETAIL A
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3
1
0.5
1
DETAIL A
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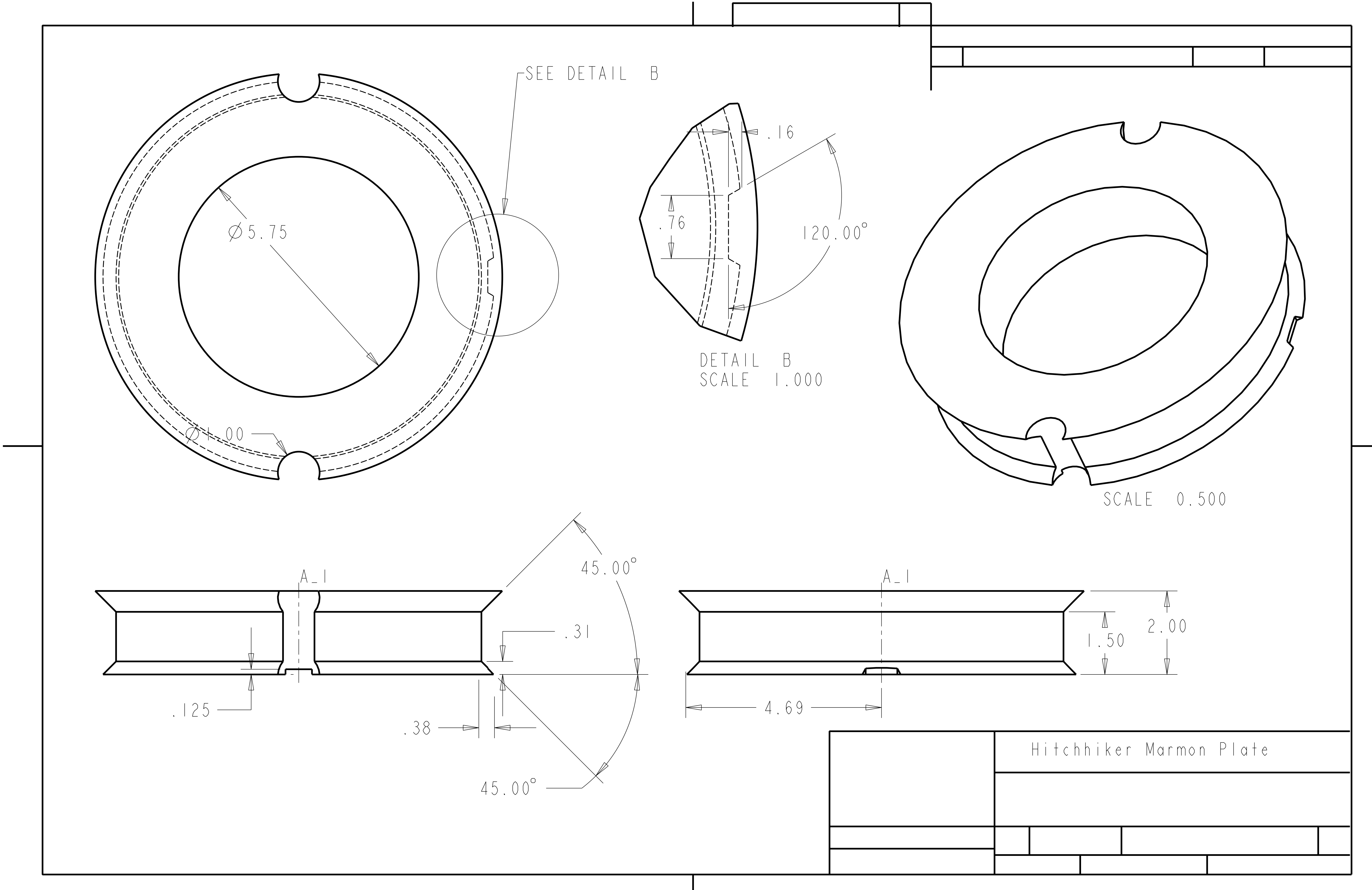
30°
47
Top Plate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∅1.00
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.125
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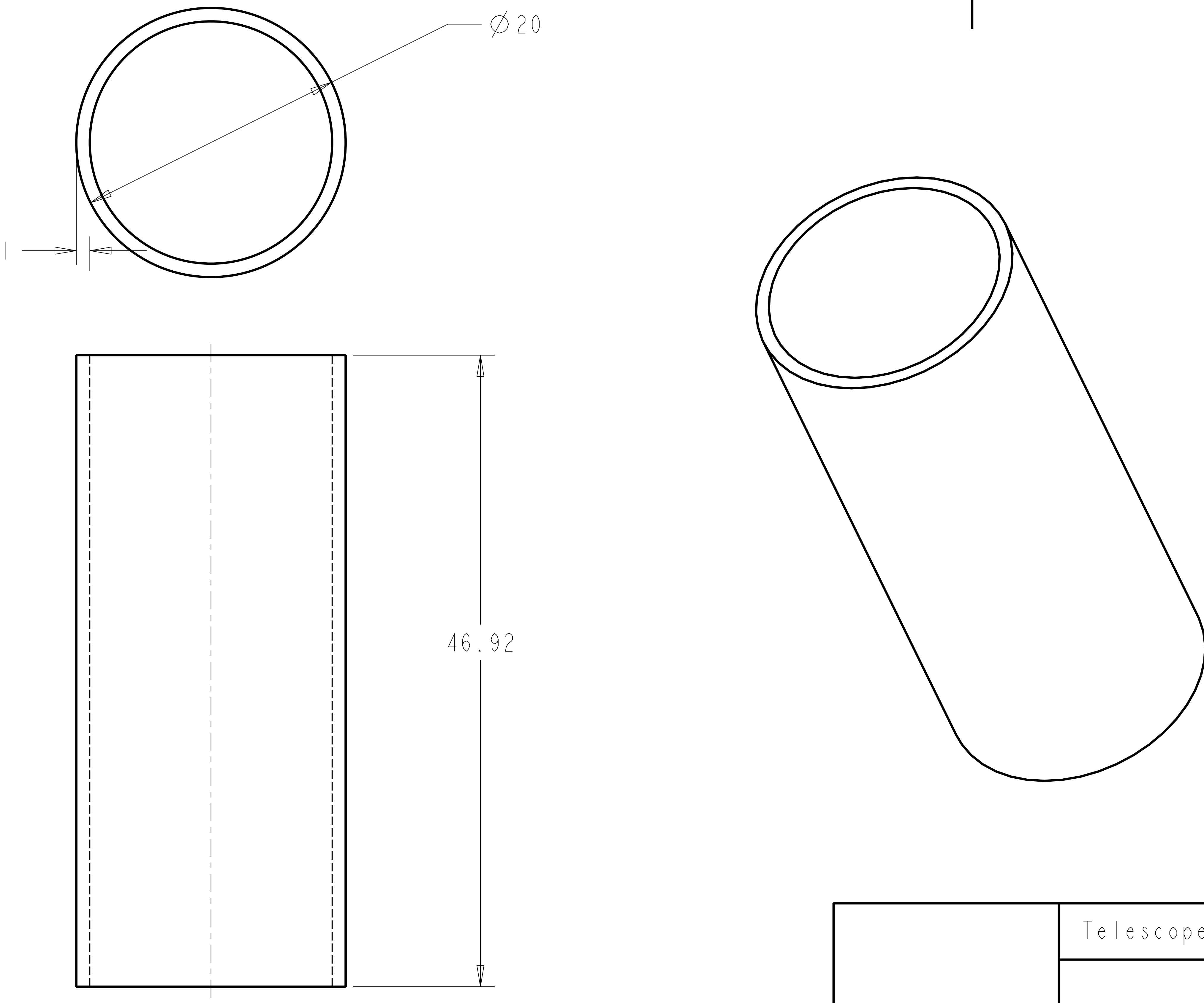
A_1
1.50
2.00
4.69
Hitchhiker Marmon Plate



Telescope Tube