Mechanical Design Guidelines

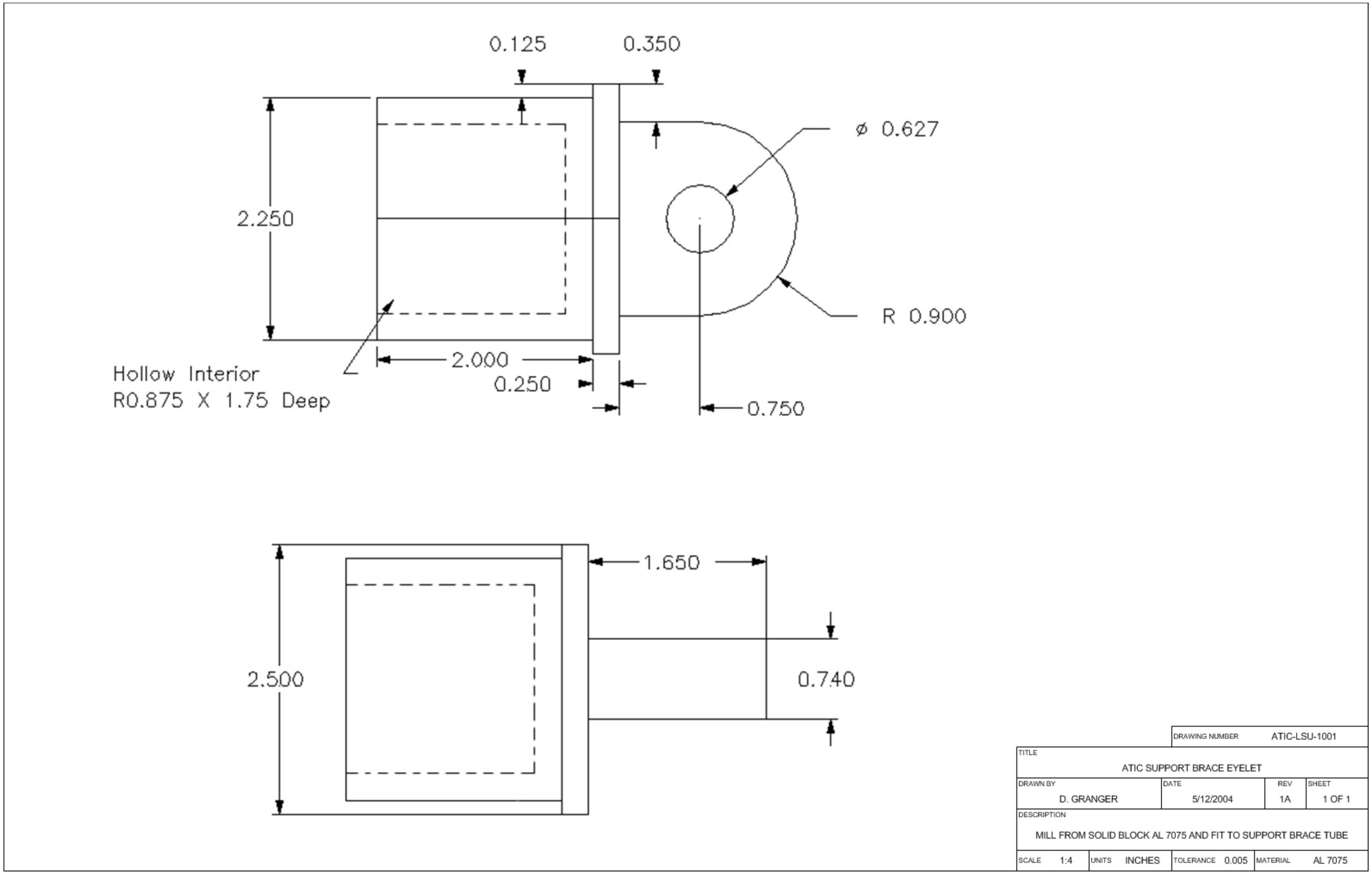
Mechanical Design Topics

- How to produce mechanical drawings
- What mechanical interfaces do you need to specify
- How do material choices affect your payload
- What are the steps for producing a sound mechanical design
- What should your testing procedure be
- Handy, pocket size reference book is "Pocket Ref" by Thomas J. Glover available at ACE Hardware stores.

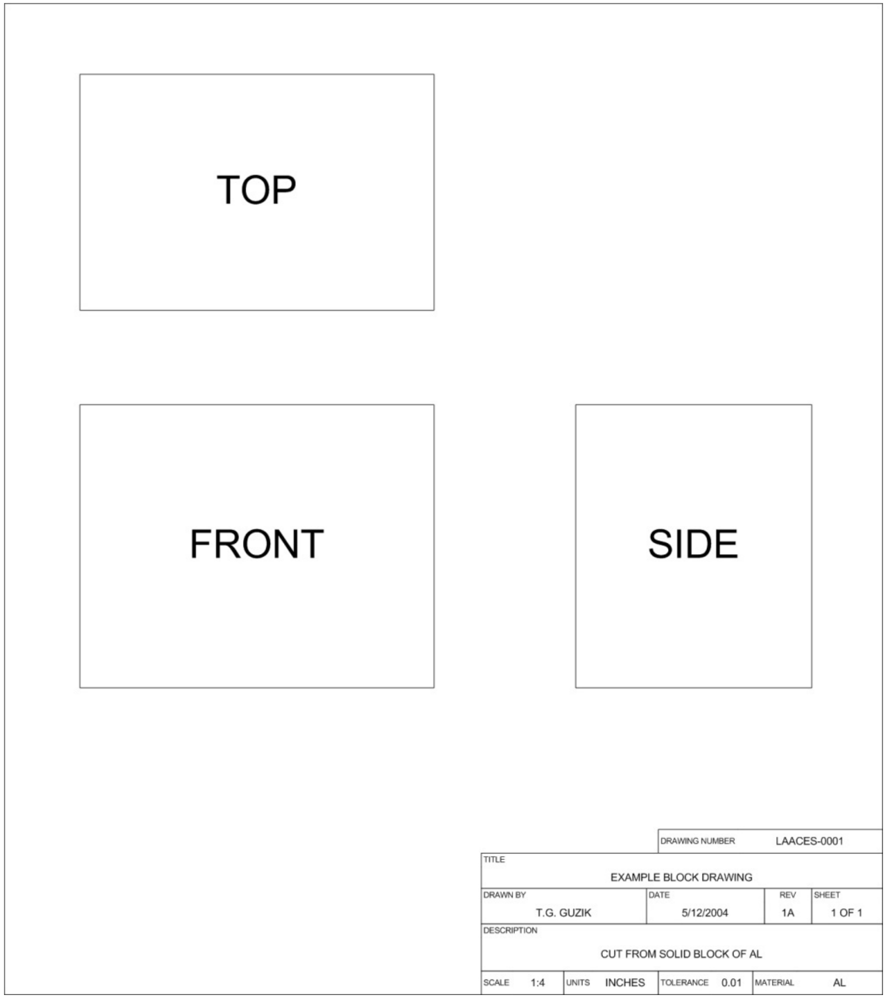
Reasons for Producing Drawings

- Aide to configuration planning
  - Help determine what components are needed
  - Determine how components will go together
  - Check that dimensions & locations are consistent
- Specify what is to be built
  - Proper drawings are needed by shop personnel
  - Communicate with management & reviewers
- Document what has been built
  - Track changes in the configuration
  - Provide record of experiment configuration

Sample Drawing



Basic Views in a Drawing



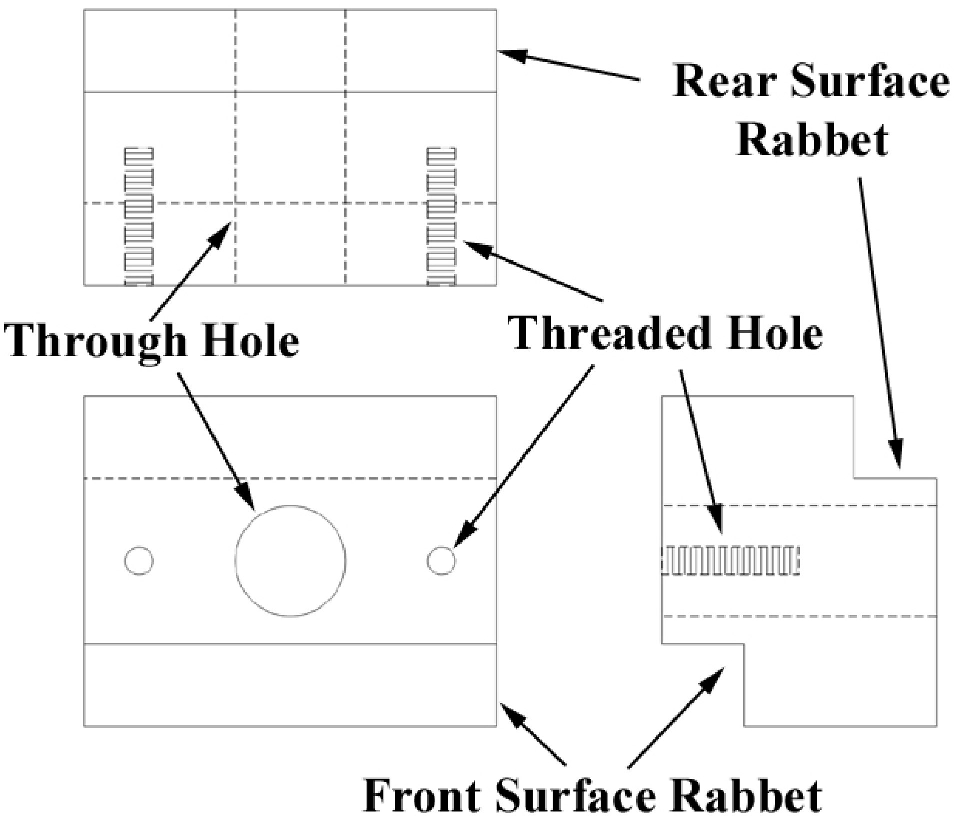
- Most drawings provide Top, Front and Side views
- What the component would look like if viewed from that direction
- Views arranged usually as if object were unfolded
- Sometimes an isometric (3D) view is provided

Drawing Label

- The label provides all of the information necessary to interpret the drawing and track revisions
- Included in the label should be a drawing number, title, author, date, revision number, sheet number, scale, units, tolerance, material and a description of any other relevant information

				DRAWING NUMBER		LAACES-0001	
TITLE EXAMPLE BLOCK DRAWING							
DRAWN BY T.G. GUZIK			DATE 5/12/2004		REV 1A	SHEET 1 OF 1	
DESCRIPTION CUT FROM SOLID BLOCK OF AL							
SCALE	1:4	UNITS	INCHES	TOLERANCE	0.01	MATERIAL	AL

Representing Hidden Surfaces



- Surfaces that can be seen in a particular view are indicated by a solid line
- Surfaces that are “hidden” are indicated by a dashed line
- Through holes are solid circles face on and dashed for side view
- Threaded holes have perpendicular or diagonal dashing to indicate screw threads

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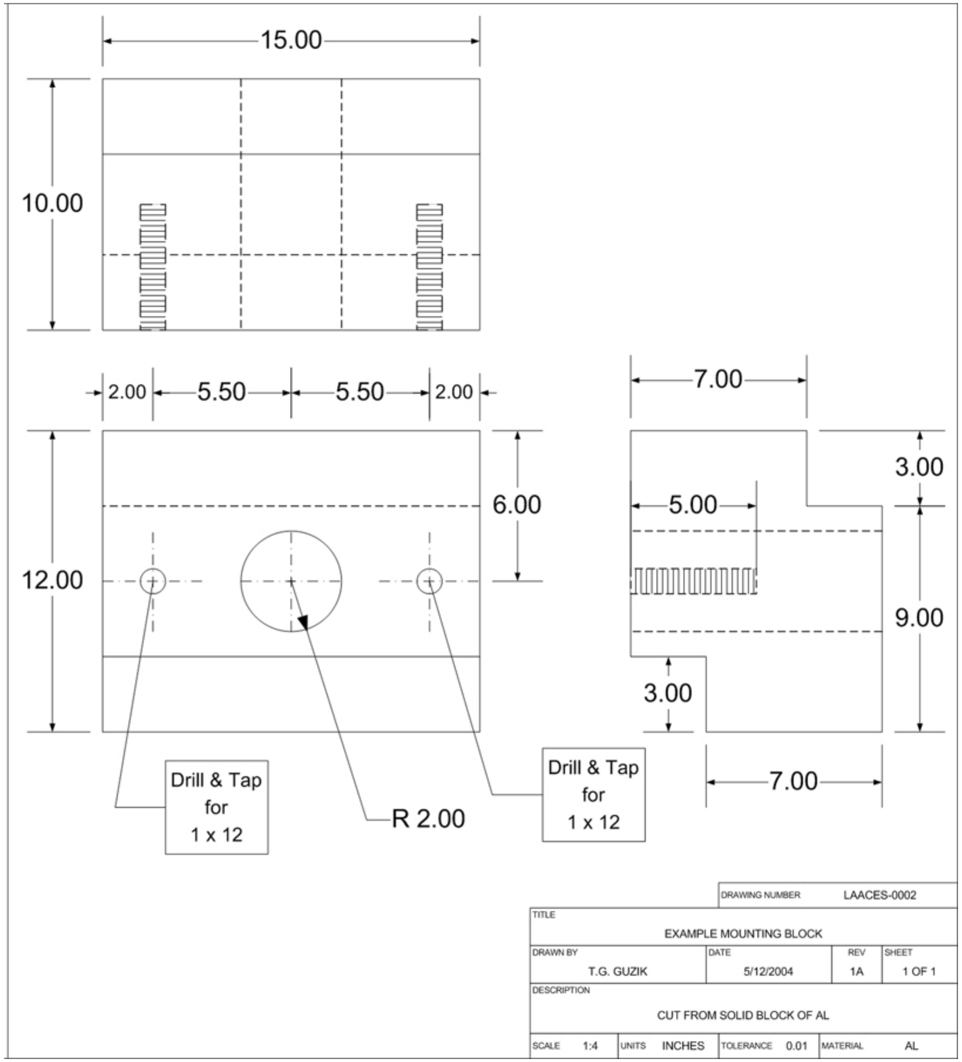
Putting Dimensions on the Drawing



- All surfaces, holes & cuts should be dimensioned to specify location, width, length & depth
- Consistent with units and tolerance specified in label
- Reference to common surface or point
- Holes are specified with a radius for clearance
- Threaded holes are specified with a screw size & depth
- Callout boxes provide addition information

Mechanical Interfaces

- There are multiple interfaces that you will need to identify, specify and control
- Component to component interfaces
  - Where and how does each part of your experiment contact another part?
  - Electrical connectors, motors, actuators, hinges
- Component to payload structure interfaces
  - Where and how do you secure your experiment components within the payload box?
- Payload to balloon vehicle interface
  - Interface already specified in LaACES balloon vehicle lecture
  - How will you implement this interface?
- Your documentation should list all your interfaces and specify how they will be implemented and controlled

Material Considerations

- When you choose materials for your payload you need to consider how they will affect your payload
- How will a material affect your sensors?
  - Iron / steel will distort the readings of a magnetic sensor
  - Will your observation port window transmit the desired frequencies?
  - Will the material outgas and affect the sensor readings?
- How will a material be affected by the environment?
  - The intense cold can embrittle many plastics and glues
  - Non-rigid, closed cell foam will expand dramatically in vacuum
- How much does a material weigh? Is there a lighter material that will do the same job?
- When in doubt obtain a material sample and test it.

Weight Budget

- Early on in your project establish a weight budget
- List of ALL payload parts, their weight, a weight uncertainty, the weight total and the uncertainty in this total
- Weights can be estimated, calculated or measured
  - Largest uncertainty for estimated, smallest uncertainty for measured
- Initially keep a contingency of ~20% to cover missing items and weight uncertainty
  - The more complete (number of items, measurements instead of estimates) your weight budget is, the lower the contingency needed
- As your design matures your weight budget should include more details, more measured components, lower uncertainty and lower contingency

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Payload Design Questions 1

- Component Layout:
  - How many components does your experiment have?
  - Where do these components need to be located?
  - Are there issues where components need to be kept separate?
- Component Access:
  - What components need to be frequently accessed (e.g. on/off switch)?
  - What components need to be infrequently accessed (e.g. configuration DIP switches)?
  - If a component needs to be replaced how will this be done?
- Component Mounting:
  - Are there any critical alignment issues with sensors?
  - How will components be secured to not come loose during flight?

Payload Design Questions 2

- Payload Integration:
  - In what order are components assembled to produce the completed payload?
- Thermal Control:
  - What payload surface treatments are necessary to control thermal properties?
  - How much insulation of what type located where is necessary to protect critical components?
  - Do you need active thermal controls (e.g. heaters)?
- Strength:
  - How will you determine that your structure is strong enough to survive the balloon flight without falling apart?

Develop a Testing Plan

- Many design issues can be quantified by testing under controlled conditions
- Such a Test Plan needs to address the following issues:
  - What components or systems need to be tested?
  - What test data needs to be collected?
  - What tests need to be performed?
  - What is the test procedure?
  - How will the data be recorded, analyzed and documented?
- Need to assure payload will survive the flight environment
  - Thermal testing for the extremes of hot and cold
  - Vacuum testing for the low pressure at high altitude
  - Shock testing for when balloon bursts and payload lands

Major Tests

- Develop prototypes or mock-ups
  - Test component layout and mounting
  - Develop specifications for mechanical interfaces
  - Thermal Vac chamber testing and shock testing for strength
- Thermal testing using dry ice
  - Tropopause temperature get down to ~-60° C and dry ice surface temperature is –78.5° C
  - Test glues and other materials for embrittlement
  - Test thermal insulation properties
- A small vacuum bell jar can simulate the pressure environment
  - Material outgassing, expansion, high voltage corona / arcing, etc.
- Major shock is on landing
  - Nominal decent rate is 20 fps, so drop test article about 10 feet

References

- “Pocket Ref” by Thomas J. Glover, 3rd Edition, 2003, Sequoia Publishing, Inc. P.O. Box 620820, Dept. 101, Littleton, CO 80162-0820, http://www.sequoiapublishing.com/ , also available in ACE hardware stores