PITT | AERO

SOCIETY OF AUTOMOTIVE ENGINEERS

- PRESENTS -

AERO 101

PREPARED BY:

MICHAEL
O'DONNELL

Overview

- Basics of Aeronautics
- SAE Aero Design West
- Aero Society of Automotive Engineers
- Communication & Collaboration
- The Design Process
- Manufacturing
- Team Building Exercise
- Holistic Engineering
- Looking Forward

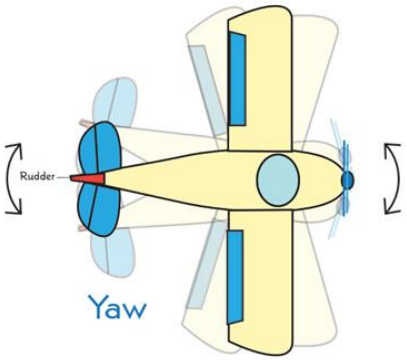
Basics of Aeronautics

What is Aeronautics?

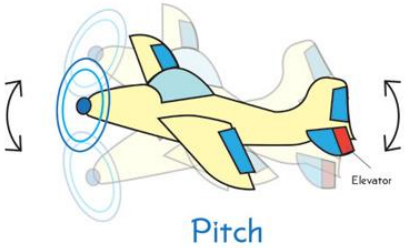
- **AEROSPACE ENGINEERING:** The overall field of engineering concerned with the development of aircraft and spacecraft.
- **AERONAUTICS:** The science or art involved with the study, design, and manufacturing of air flight capable machines, and the techniques of operating aircraft and rockets within the atmosphere
  - **AERODYNAMICS:** The motion of air and the way that it interacts with objects in motion
- **ASTRONAUTICS:** The theory and practice of navigation beyond Earth's atmosphere

Anatomy of an Airplane

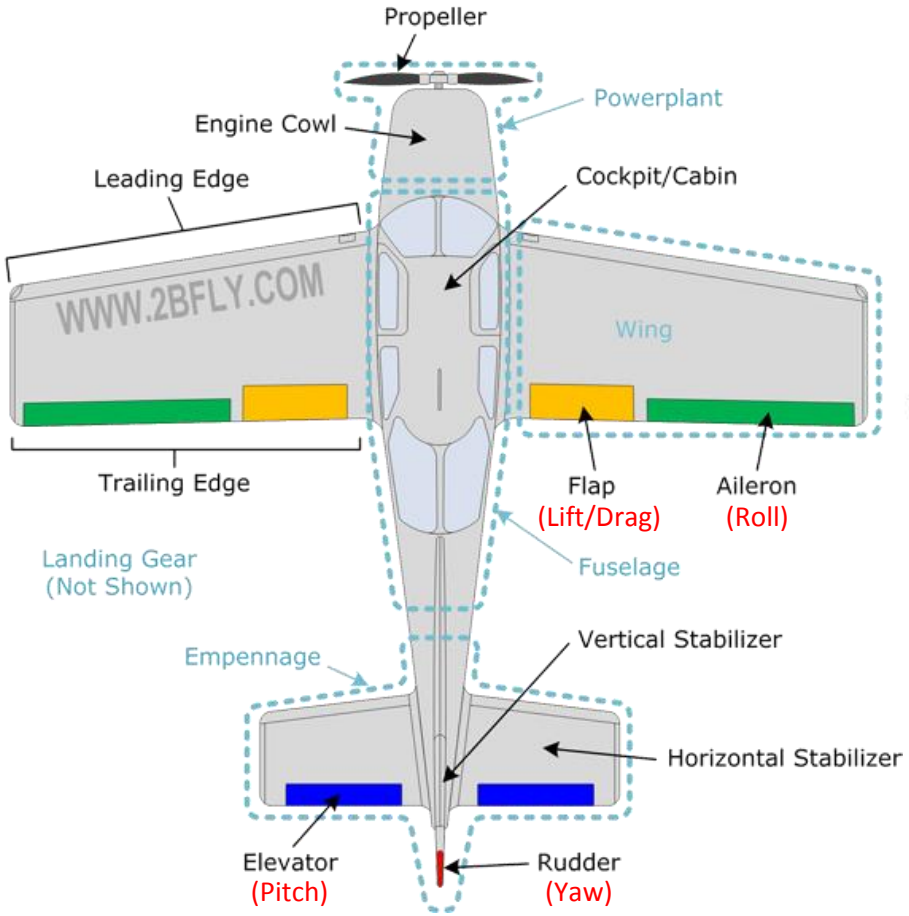
Use the ailerons to control
Roll

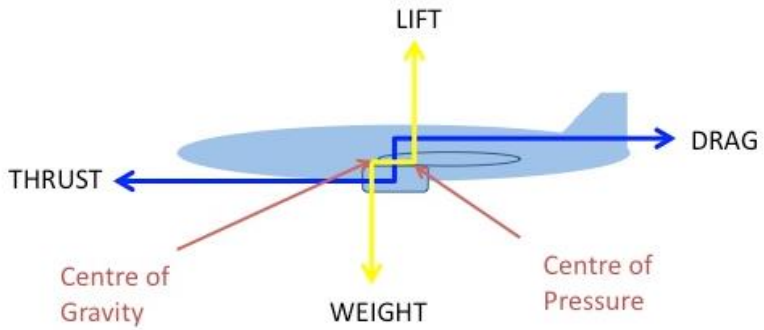


Use the rudder to control
Yaw



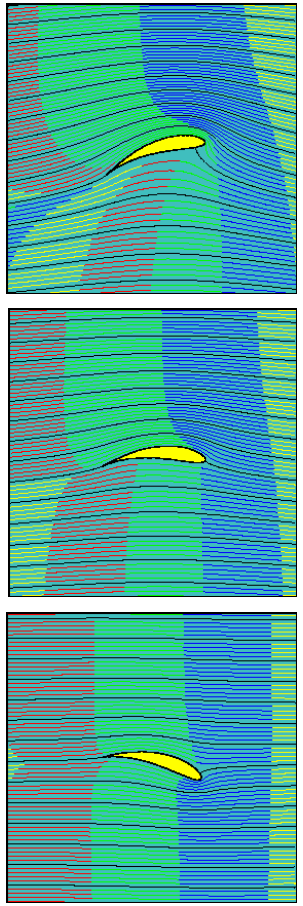
Use the elevators to control
Pitch



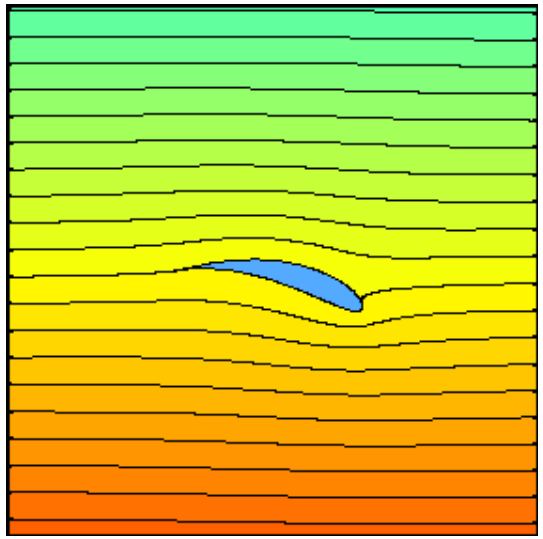


Flight Condition	Effect
Lift > Weight	Aircraft Rises
Lift < Weight	Aircraft Falls
Drag > Thrust	Aircraft Slows
Drag < Thrust	Aircraft Accelerates

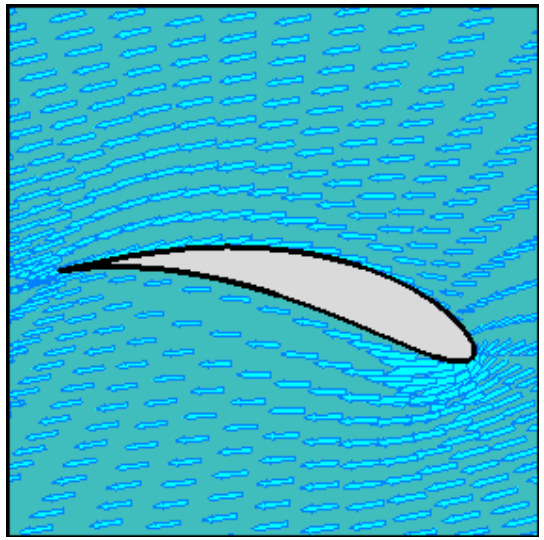
Flight Mechanisms



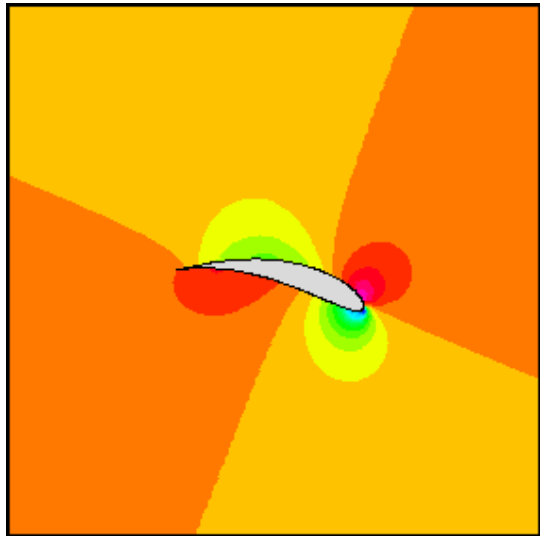
Streak Lines



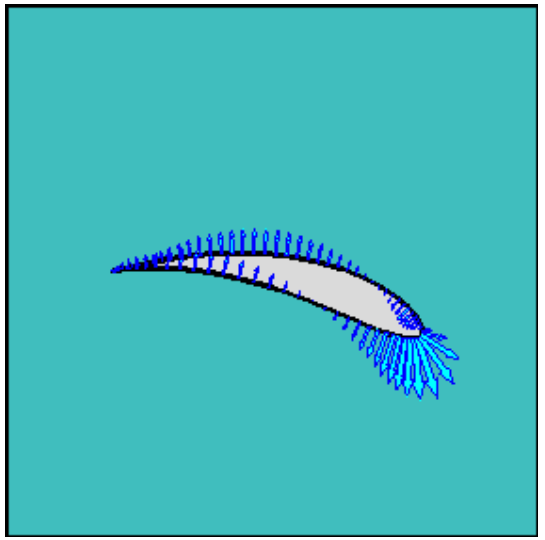
Stream Lines



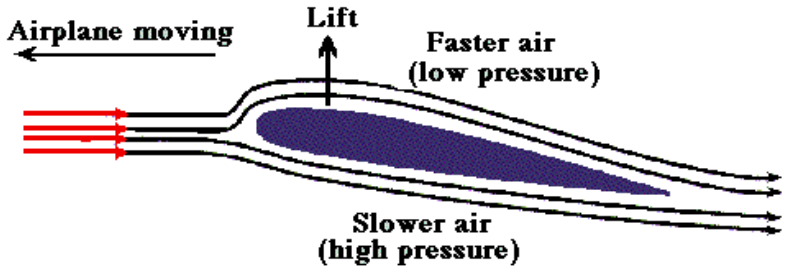
Velocity Field



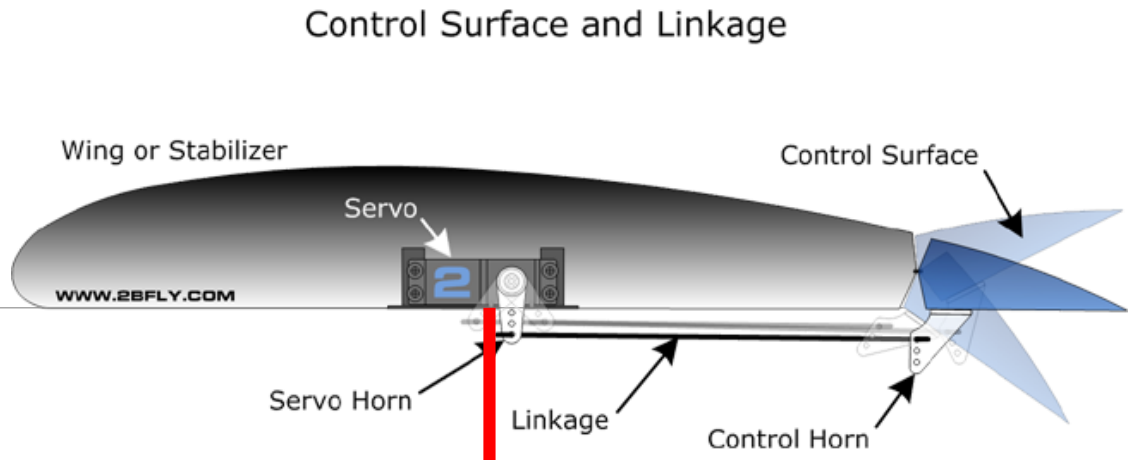
Pressure Field



Forces on the Airfoil

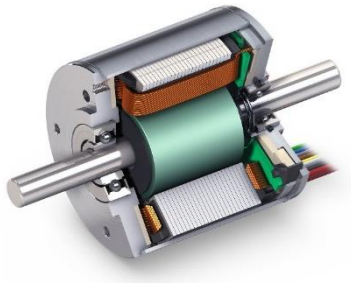


Avionics


Control Surface and Linkage
Wing or Stabilizer
Servo
Control Surface
WWW.2BFLY.COM
Servo Horn
Linkage
Control Horn


SPEKTRUM
DX6i


SPEKTRUM
AR9210




AGM

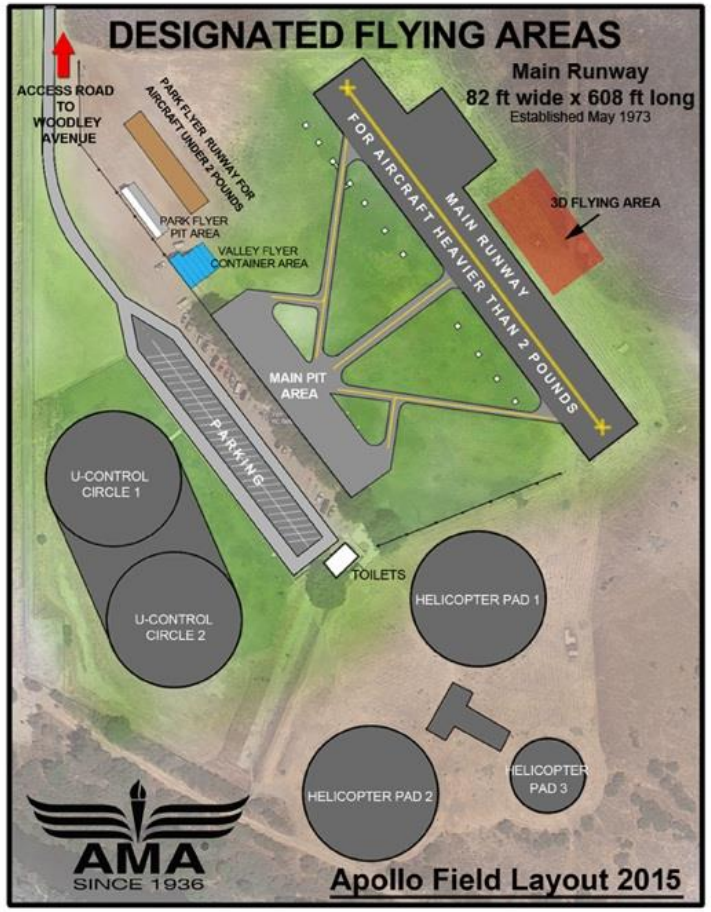

TURNIGY
5.0
5000mAh
6 CELL 22.2V
HIGH DISCHARGE LI-PO BATTERY

SAE Aero Design West

2018 | LOS ANGELES, CA

About

- Apollo 11 Field
- April 6-8th
- 75 teams from around the world
- Competition is sponsored by: Lockheed Martin
  - They actively send recruiters to these competitions
- 3 Different Classes:
  - Micro
  - **Regular**
  - Advanced



Regular Class

- To design an aircraft that can generate revenue by carrying as much payload
- Payload will consist of passengers, represented by tennis balls, and luggage, represented by weights
- Accurately predicting the lifting capacity and overall sizing of the aircraft
- Design Restrictions:
  - Must be propelled by a single electric motor with a non-metallic propeller
  - No fiber-reinforced plastics (carbon fiber)
  - Must use a 6-cell battery pack in conjunction with a mandatory power limiter
- Scoring:
  - Technical Inspection/Drawings
  - Technical Presentation
  - Flight Score

Why?

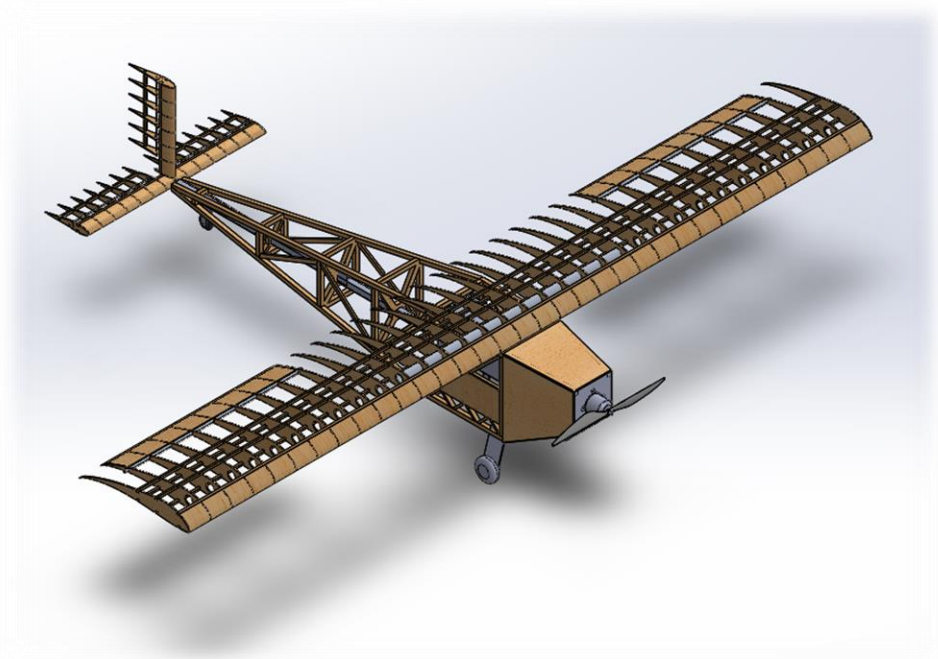
- Awards:
  - Elliott & Dorothy Green Overall Regular Class Award - $1000
  - Regular Class Written Design Report
  - Regular Class Oral Presentation
- Experience:
  - Technical
  - Critical Thinking
  - Interpersonal
  - Teamwork
- Résumé Builder
- Expand your professional and personal networks

Aero Society of Automotive Engineers

UNIVERSITY OF PITTSBURGH

About Us

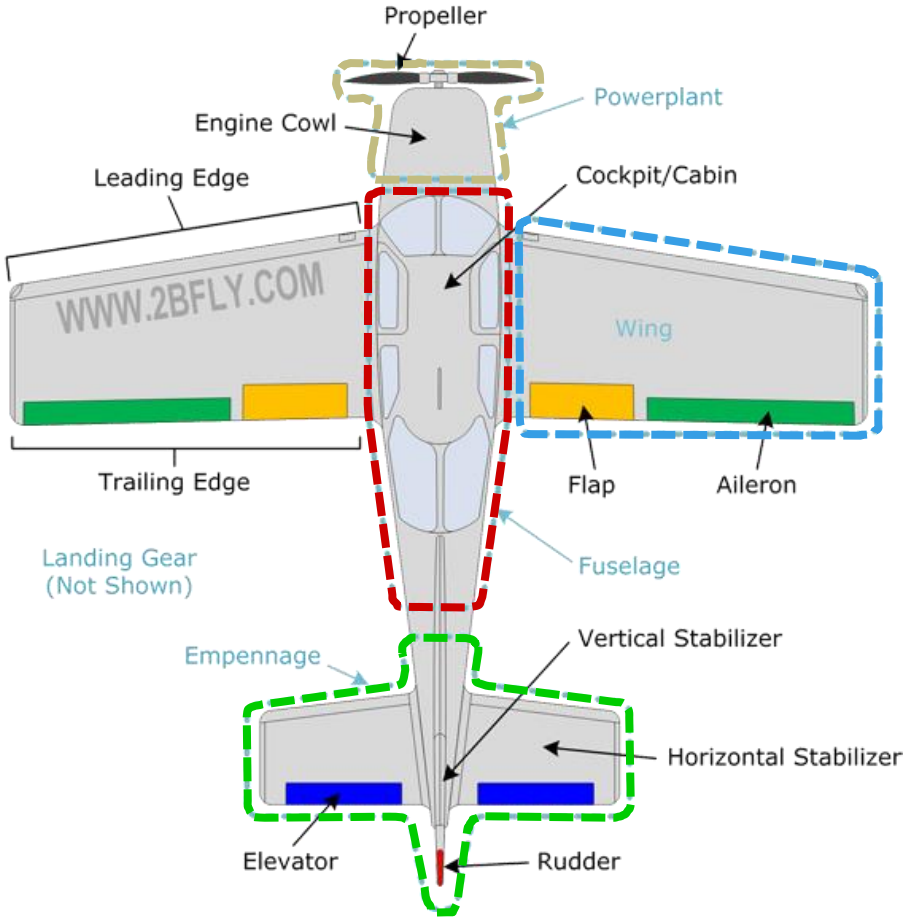
- Founded 2014
- Board of Directors:
  - **President:** Michael O'Donnell (mho9@pitt.edu)
  - **Business Director:** Rina Zhang (riz5@pitt.edu)
  - **Technical Director:** Zach Reger (zmr2@pitt.edu)
  - **Secretary:** Aaron Wannemacher (ajw95@pitt.edu)
  - **Chief Electronics Engineer:** Shamus O'Haire (jjo40@pitt.edu)
  - **Chief Fuselage Engineer:** Noah Perryman (nep36@pitt.edu)
  - **Chief Tail Engineer:** Mark Jordan (maj108@pitt.edu)
  - **Chief Wing Engineer:** Ryan Edelson (rde13@pitt.edu)
- Academic Advisor: Dr. William "Buddy" Clark



First build #23

Sub-Teams

- **Electronics:** the heart and brains of the aircraft
  - Schematics
  - Thrust Testing
  - Wind Tunnel Testing
- **Fuselage:** the structural backbone of the aircraft
  - Houses payloads & electrical components
  - Landing gear
  - Joins everything together
- **Tail:** providing direction for the aircraft
  - Stability
  - Steering (Yaw)
- **Wing:** the heavy-lifter of the aircraft
  - Aerodynamics
  - Roll



Communication & Collaboration

- Contact us at pittaero@gmail.com
- **Join our Slack at pittaero.slack.com**
  - Main source of communication within the Organization
  - App available for iOS & Android
  - Integrated meeting notifications
  - MUST use your Pitt Email to register
- Like our official Facebook Page at: www.facebook.com/PittAeroSAE/
- Join our Team's Facebook Group at: www.facebook.com/groups/pittaeroteam
- **Fill out the following form to obtain access to the team's Google Drive and to get swipe access to the Pitt Aero lab here: https://goo.gl/3ES3K5**

The Design Process

THE PITT AERO WAY

Problem Definition

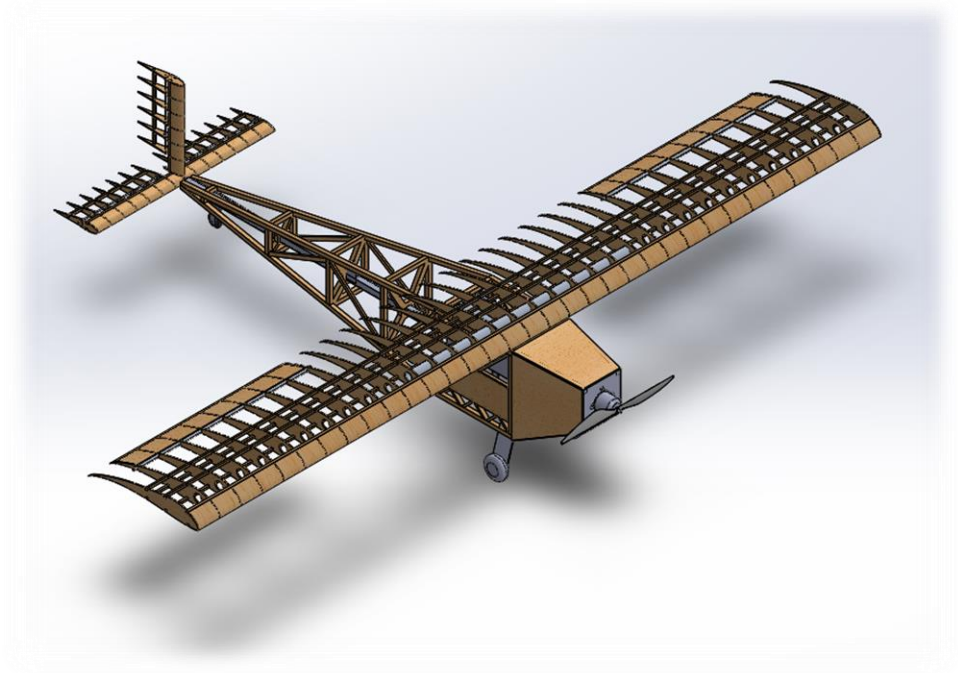
- Identify the problem
- Example: The UAV needs a way to securely hold 10 tennis balls to count as passengers
- First Meeting
  - Identify all design problems
  - Designate team members for each problem

Functional Requirements

- Fundamental design constraints
- Ask “What does the design need in order to function?”
- Passenger Bay example
  - Securely hold 10 tennis balls through flight
  - Hold passengers on a single geometric plane
  - Passengers must be 0.25” from each other
  - Passengers must be easily visible for counting
  - Passengers must be easily accessible for loading

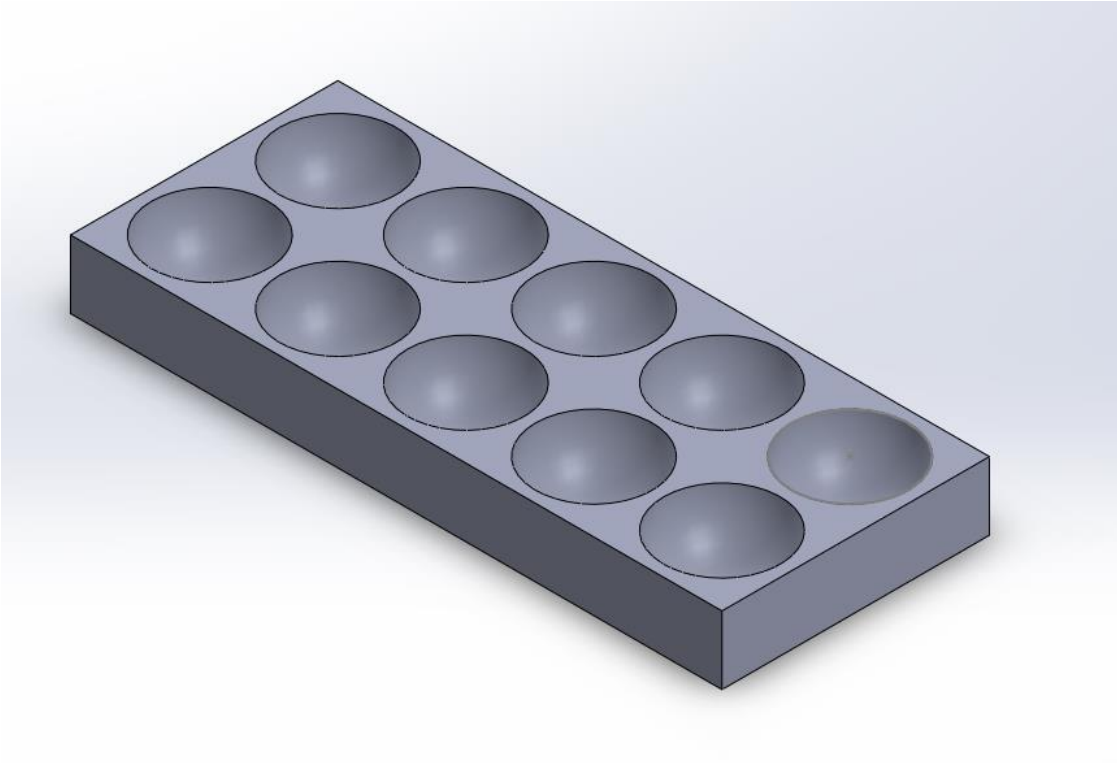
Development Plan

- Chief Engineers control the design plans
  - Timelines
  - Team members for each project
  - Running design document
    - Design reasoning
    - Sketches
    - Models
    - Drawings
    - Calculations



Design Synthesis

- Create multiple designs that abide by all functional requirements
  - Solid models
  - Detailed sketches
- Teams
  - Upperclassman MechE
  - Solidworks drafter
  - Design idealists



Ordering & Manufacturing

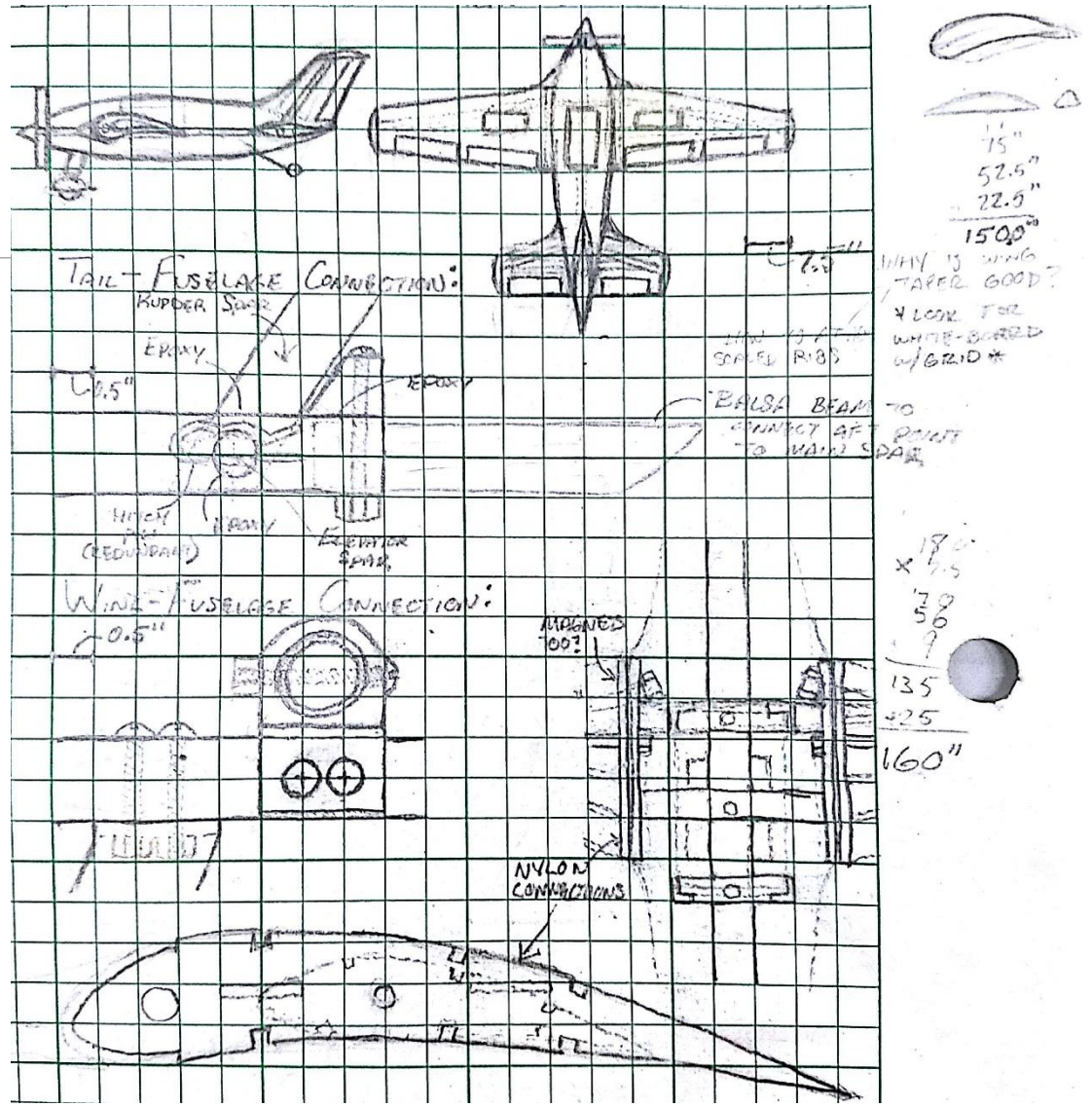
- Create Bill of Materials
  - Part numbers
  - Product description
  - Vendor
  - Price
  - Quantity
  - Website link
- Order parts
  - Send BOMs to

  Technical Director, Chief Engineers
- Begin Manufacturing

Bill of Materials						
Part	Size	Vendor	Material	Part Number	Qty.	Price $
Gear 1	6 mm bore x 12 teeth	Stock Drive Products	Acetal (no insert)	A 1M 2MYZ10012A	1	$4.23
Gear 2	8 mm bore x 48 teeth	Stock Drive Products	Acetal (no insert)	A 1M 2MYZ10048	1	$6.49
Gear 3	12 mm bore x 140 teeth	Stock Drive Products	Acetal (no insert)	A 1M 2MYZ10140	1	$14.08
Shaft 1	6 mm OD x 100 mm	Stock Drive Products	303 Stanless Steel	A 7X 1M060100	1	$5.74
Shaft 2	8 mm OD x 100 mm	Stock Drive Products	303 Stanless Steel	A 7X 1M080100	1	$5.28
Shaft 3	12 mm OD x 150 mm	Stock Drive Products	303 Stanless Steel	A 7X 1M120150	1	$12.98
Bearing 1	6 mm ID	McMaster-Carr	Nylon with Plastic Housing	6687K32	1	$3.67
Bearing 2	8 mm ID	McMaster-Carr	Nylon with Plastic Housing	6687K33	1	$4.42
Bearing 3	12 mm ID	McMaster-Carr	Nylon with Plastic Housing	6687K35	1	$6.44
3M Epoxy	Scotch Weld 37 ml	Grainger	2-Part Metal to Plastic included	2RUC8	1	$31.45
Wood	Scrap		Pine	N/A	N/A	$0.00
Disco Ball	200 mm OD		Plastic/mirrored	N/A	1	$0.00
					Total	$94.78

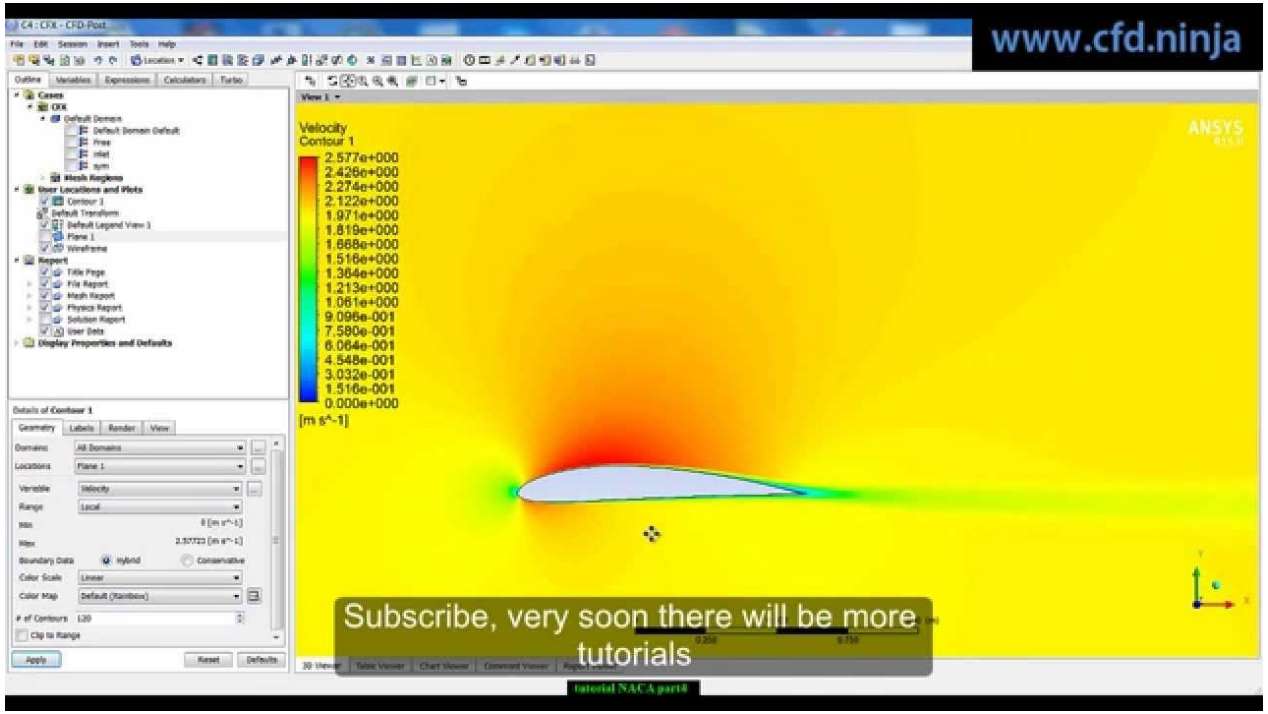
Modeling Tips

- Make a hand sketch first
- Don’t make 1 huge running part
- Constrain everything
- Specify materials
  - Center of Mass calculations
- Follow naming scheme
  - Description_TEAM_initials
    - Passenger Bay_FUSE_RAB.assy
      - Tennis balls_FUSE_NEP.stp
      - Seats_FUSE_MLO.stp
      - Passenger bay base_FUSE_JTB.stp



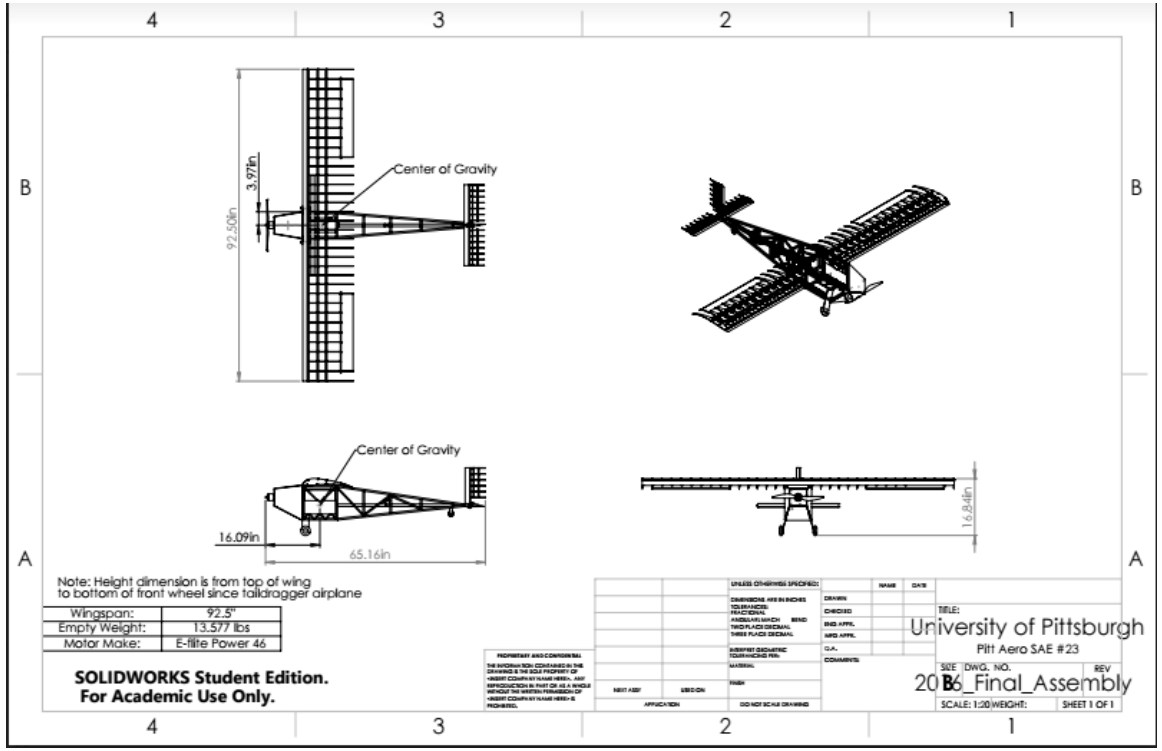
Design Analysis & Optimization

- Choose a single design
  - Functionality
  - Machinability
- Optimize the design
  - Make smaller
  - Cheaper
  - Aesthetics
- Calculations
  - Hand calcs
  - ANSYS simulation



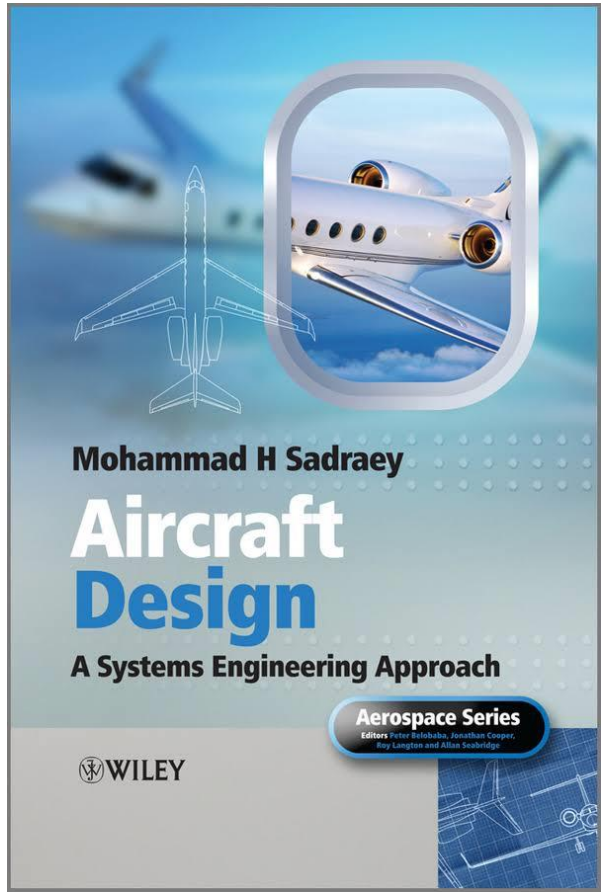
Finalization & Documentation

- Finalize Model
  - Tolerances
  - Materials
  - Bolts/screws
  - Review calculations
- Make 2D Drawings
  - Dimensions
  - Prep for presentation
- Complete design document



Resources

- President, Technical Director, Chief Engineers, Team members
- *Aircraft Design: A Systems Engineering Approach*
  - by Mohammad H. Sadraey
- Prior Technical Report
- Pitt Aero Team Handbook



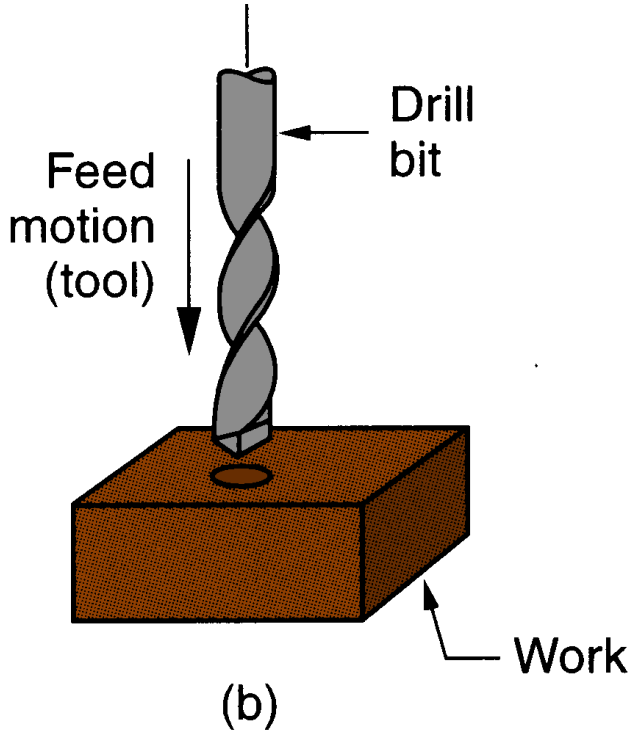
Manufacturing

THE PITT AERO WAY

Conventional Machining

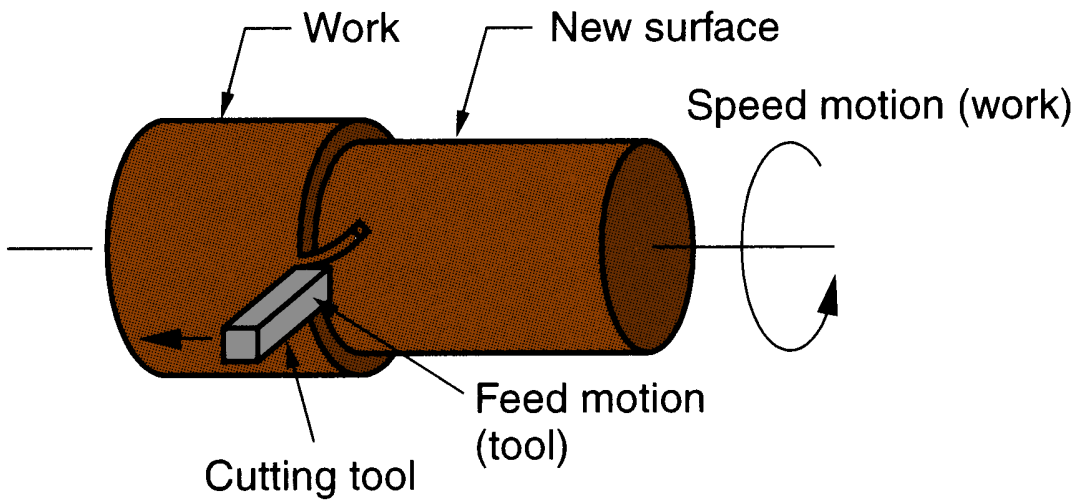
WHERE A SHARP, HARD TOOL IS USED TO CUT AWAY MATERIAL

Machining Operations: Drill Press & Lathe



(b)

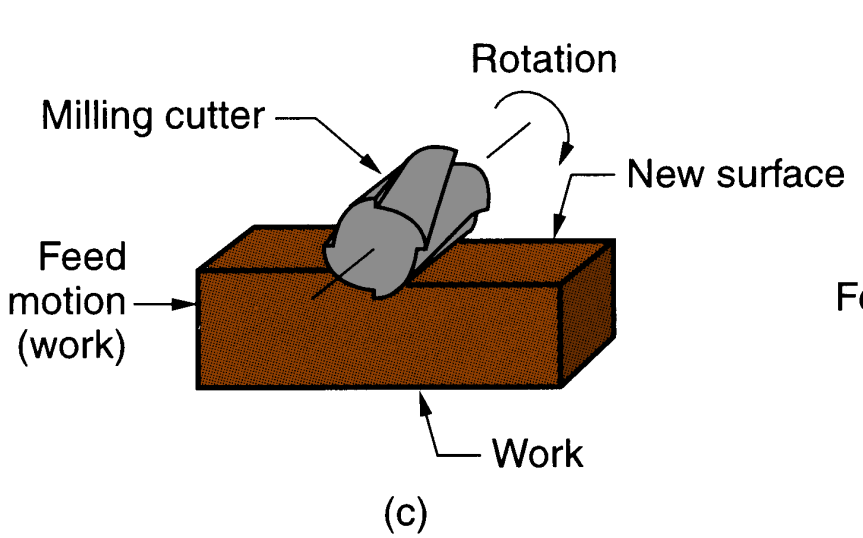
Drilling: create round holes and drill bit had two or more cutting surfaces. Tool moves parallel to its axis.



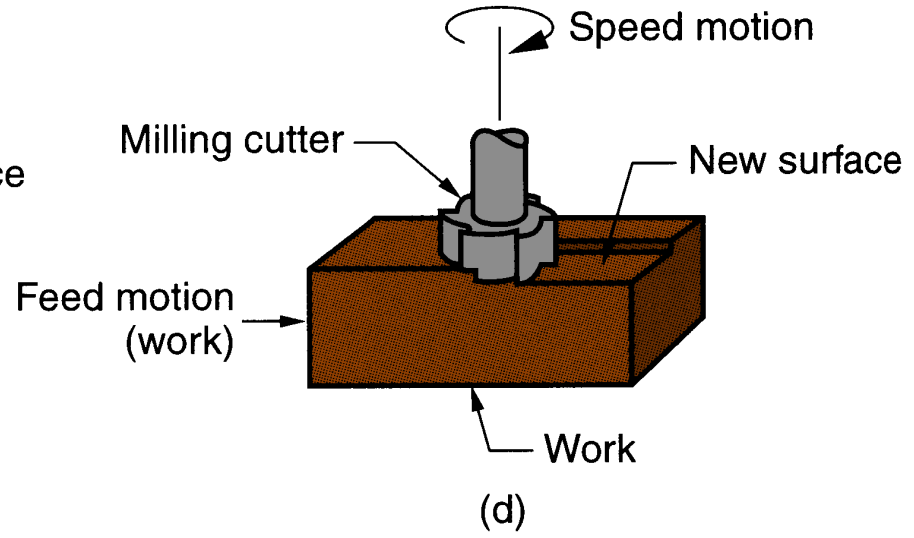
(a)

Turning: cutting tool has one edge and reduces diameter of a spinning work piece. Tool moves perpendicular to the work piece axis and feed is parallel to axis

Machining Operations: Milling



Peripheral milling



Face milling

Milling: rotating tools have multiple cutting edges is moved along surface of the work piece to give a flat surface. If tool spins on axis parallel to work surface it is called peripheral milling. If the tool rotates on axis perpendicular to the work surface it is called face milling.

Additive Manufacturing

WHERE MATERIAL IS ADDED LAYER BY LAYER

Additive Manufacturing

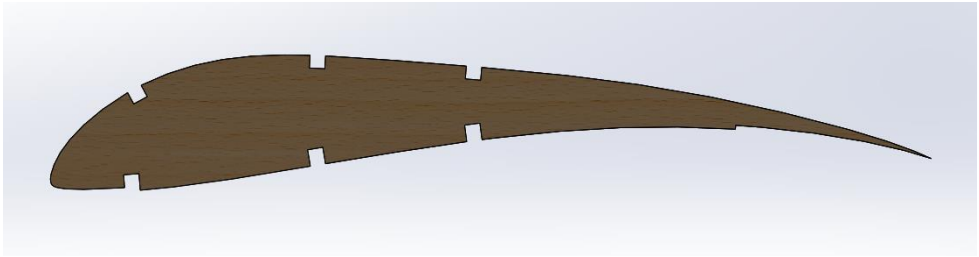
- MakerBot Replicators
  - 9.9 L x 7.8 W x 5.9 H
- ABS vs. PLA Filaments
  - ABS- Stronger, works only with MakerBot Replicator 2X
  - PLA- Better for sharp edges, works with all MakerBots
- Tolerances/Restrictions
  - 0.02” tolerance for tight fits
  - 0.04” tolerance for loose fits
  - 45° angle maximum for any sort of slopes

Automated Manufacturing

WHERE THE MACHINE DOES EVERYTHING FOR YOU

Automated Manufacturing

- CNC Machining (Computer Numerical Controlled)
  - Uses multiple traditional machining techniques
  - Combines CAD & CAM software to machine parts
- Laser Cutting- Should be utilized as often as possible
  - Up to 3/8” thick balsa
  - Up to 1/2” MDF
  - Up to 1/8” Sheet Steel
  - No Aluminum (reflectivity)
  - No plastics (melting)



Designing for Manufacturability

NO MATTER HOW GREAT YOUR DESIGN IS, IF YOU CAN'T MAKE IT YOU'VE ACCOMPLISHED NOTHING GREATER THAN DRAWING A PRETTY PICTURE

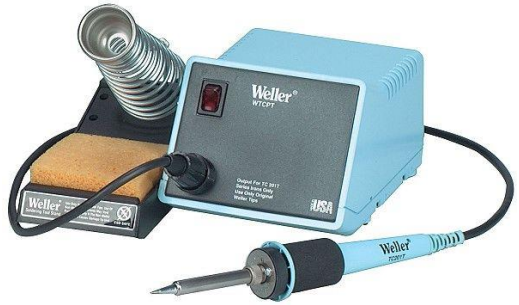
Jigging and Ease of Assembly

- **Jigging:** supports the aircraft components so that we can piece it together
- **To increase the ease of assembly:**
  1. Reduce the amount of handwork involved with laying everything up
  2. Utilize as much automated manufacturing as possible because machines are better than humans
  3. 3D print anything that would be impossible to build out of balsa or metal
  4. Increase the amount of mechanical joints
  5. Decrease the need for epoxy joining

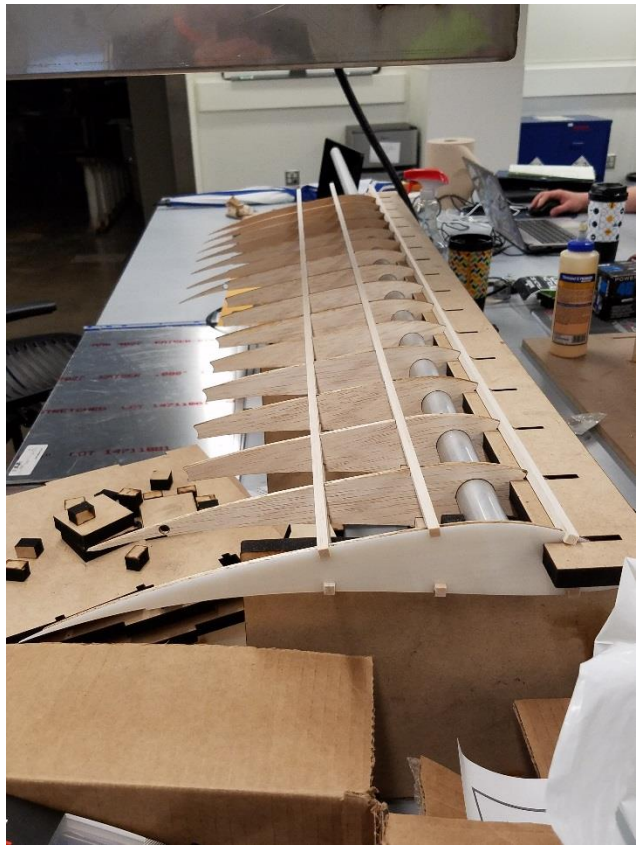
Manufacturing Capabilities

Pitt Aero Lab

- Jig-Saw
- Drill Set
- Cutting Tools
- Shaving Tools
- Wire cutters
- Soldering Kit
- Digital Multi-Meter
- Clamps
- Sandpaper
- Adhesives
- Calipers
- Miter-Saw
- And More



- What we do in the lab
  - Plane Assembly
  - Testing
  - Storage
  - Prep for Machining



Swanson Center for Product Innovation

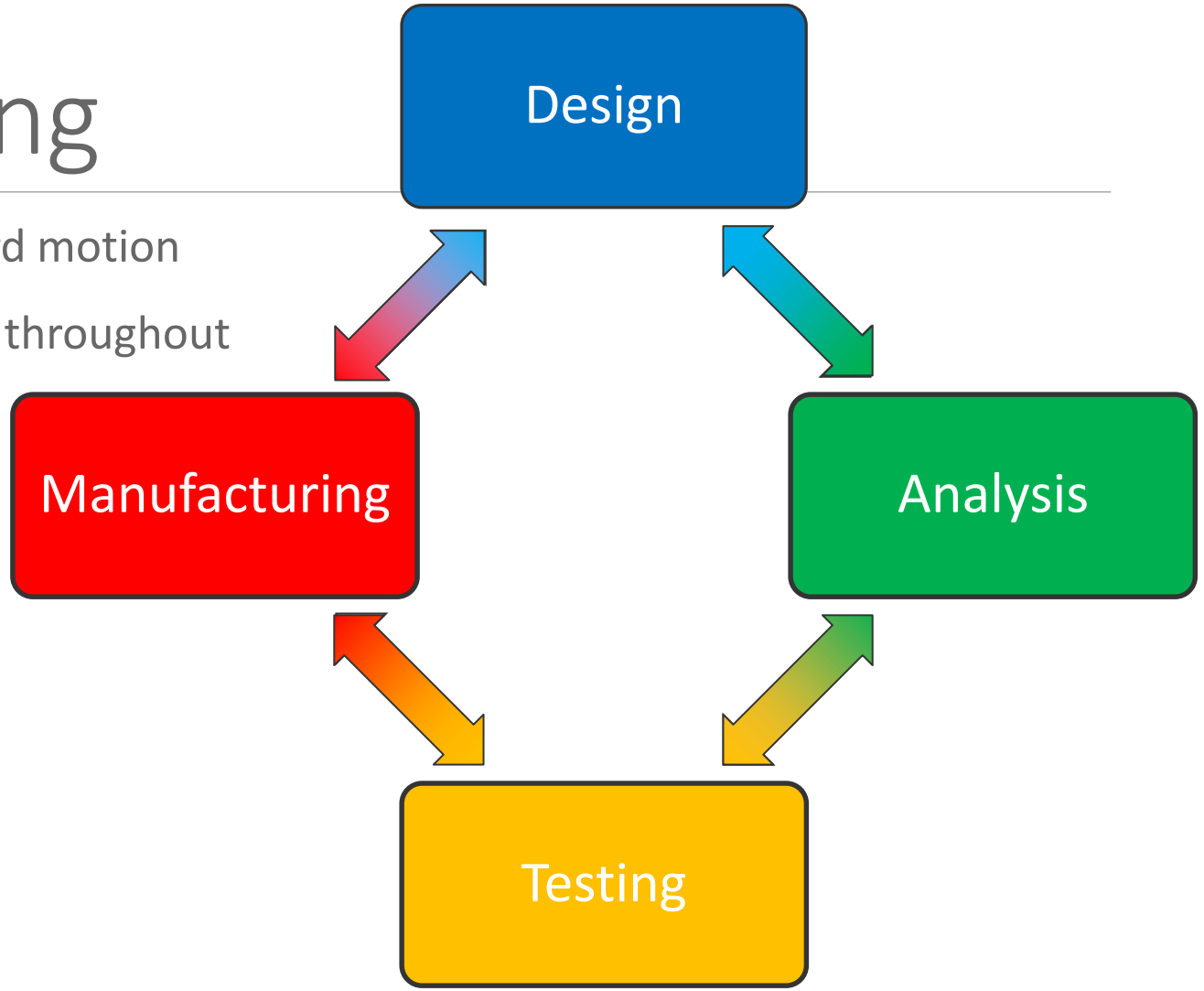
- Machine shop in the Ground floor of Benedum Hall (past the elevators)
- Main contact: Andy Holmes (jholmes@pitt.edu)
- Must take a 66 multiple-choice safety test in order to utilize any of the machines in there (PDF in Drive)
- Capabilities:
  - CNC
  - Lathe
  - Mill
  - Laser cutter
  - various 3D printers
  - Vertical band saw
  - Horizontal band saw
  - Drill press
  - Sheet bender
  - Hand tools
- Andy & his staff will help you learn on any of these machines if given enough notice
- **DO NOT** go to the SCPI to ask for help without letting your Chief Engineer know

Team Building Exercise

REVIEW OF AERODYNAMICS & THE DESIGN PROCESS

Holistic Engineering

- Engineering does not happen in a forward motion
- All four of these areas must be balanced throughout



Looking Forward

- Join Sub-team Channels on Slack
  - Make sure you notification settings are switched to “All” instead of the default “only when mentioned”
- Be on lookout for When2Meet posts in Slack
  - Both for sub-team meetings and Chemical Hygiene Certificate for Pitt Aero Lab swipe access
- Read SAE Aero Design 2017 Rules (Regular Class only)
  http://students.sae.org/cds/aerodesign/rules/
- Explore resources available to you in our Google Drive (Download Solidworks)
- Special Projects for this year:
  - Wind Tunnel
  - Current Limiter & PID card
- Don’t be afraid to ask questions!