Review: Engineering Design Approach

- evaluate (or define) the requirements
  - customers/regulations, constraints/performance goals
  - ask the customer “Why?” - Communicate
- understand current approaches (what’s done now?)
- think of some possible solutions (creativity)
- identify a variety of possible concepts (concept generation)
- concept evaluation (analysis)
- select a preferred concept for development (make a decision)
- do the detail design and make a prototype (analysis)
- test and evaluate-scrutinize
- continually refine the design until it’s a viable product

Many of these steps are repeated, it’s an iterative process

Design Reviews, Writing and Proposal Writing

W.H. Mason
(w/ Chris Cotting)
AOE 4065-4066
Aircraft Design
The man who can think
and does not know how to express what he thinks
is at the level of the man who cannot think.

Pericles (almost)

used by Prof. Robert Jones, ESM, Virginia Tech
in the ESM Senior Project Course

or more simply: *out of a job*  (Mason)

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**Form vs. Substance**

- Only 1 Lecture on Form
- Your work is worthless, unless you can effectively communicate your work
  - Clear
  - Precise
  - Concise

Some “new grads” think that the Presentations Department will do this for you, *they may help*, but it’s up to you.

- The effective communicators become the bosses
Outline

- Comments on responding to an RFP* (again)
- Basis for Judging: AIAA
- Reports
  - Organization
  - Format
  - Comments on Text
  - Example Figures
- Design Reviews
- Some References

* RFP - Request for Proposal

RFPs: Typical Competitive Procurement

- Know your customer
  - find out about upcoming jobs
- Respond to CBD* Sources Sought
  - You get one visit before SOW** goes to Procurement
  - Get on bidder’s list to receive RFP
- Be ready when the RFP “Hits the Street”
- After you submit - Be Prepared for questions
  - at this stage it’s a formal procedure

* CBD - Commerce Business Daily, previously a newspaper, now on the web
** SOW - Statement of Work
How to Win?

Rule #1, 2, ... Be Totally Responsive!

Make sure you meet all RFP Requirements:
- RFP - Section III - Requirements and Constraints
- RFP Section IV - Data Requirements

Let the reader know
- Tell him you meet all the requirements
- Tell him *how* you will meet the requirements
- Show him with a reference chart

**RFP Cross Reference Chart**

- Good for the team
- Good for the reader
- Often inside front cover (or foldout)

Note: SOW on the next page refers to the key section of the RFP: the *statement of work*
Response Index: Cross-Reference Proposal and RFP Sections
Proposal for the Study of Advanced Applications of the PCB Testability Design and Rating System

The following cross-reference index facilitates evaluation of this proposal by identifying where technical responses to the RFP and SOW requirements may be found:

<table>
<thead>
<tr>
<th>RFP Section L 39</th>
<th>Subject</th>
<th>Response Section/ Subsection</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Experience and background</td>
<td>5</td>
</tr>
<tr>
<td>b</td>
<td>Available facilities</td>
<td>6</td>
</tr>
<tr>
<td>d</td>
<td>Resumes of key personnel</td>
<td>7</td>
</tr>
</tbody>
</table>

SOW

4.1.1 Survey of recent systems 4.1.1
4.1.1.1 Intermediate level maintenance assessment
4.1.1.2 Organizational level maintenance assessment

Note that the SOW and Proposal section numbering is the same.

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Basis for Judging

Real Life

- Technically Acceptable or Not?
- Lowest Cost of Technically Acceptable

AIAA

Technical Content 35%
Organization and Presentation 20%
Originality 20%
Practical Application and Feasibility 25%

But Quality of Presentation Influences Judging of Every Other Category!

See example from last year for level of quality expected.
Overall Organization
Brainstorming

and the

Storyboard

Make your Report/Proposal ACCESSIBLE
- same story for presentations
  - Judges get a huge pile to evaluate
  - Help them!
    - Good Summary up front
    - Good 3-view and inboard profile of final design
    - Good, Clear Configuration Description
  - Make all figures tell a story
    - Summary, Conclusions, Introduction - IMPORTANT -
      start now, rework, finish last
The Approach

P  Plan
O  Outline
W  Write
E  Edit
R  Revise

from Dieter, Engineering Design

Proposal/Report/Presentation
Outline Is Crucial

• Think of the story you want to tell
• Make an outline, including figures

Start early
• You don’t really understand your work until you try to write it up
• Early GOOD outline can help you avoid wasted effort, and panic
  - putting your work together shows logic gaps, and tells you exactly what needs to be done
• With groups efforts, Storyboards are useful as brainstorming aids
Overall Arrangement

Presentations, reports and proposals:
- start with an introduction
- progress logically
- emphasize the basis for design decisions!
- have a conclusion
Format Comments

Reports:
- Margins!
- Figure Quality, including margins
- All outside material cited
- All pages count in page count limit
- Use AIAA Style Guide (especially for references, equations, figures, and tables, symbols and units)

Figures:
- Titles on top in presentations
- Titles are captions in proposals/reports (bottom)
- DO NOT Use large lettering in report figs!
- DO use big enough letters in presentations

Proposal Text

Use a proposal style:
- write with enthusiasm
- write authoritatively (specifics)
- write in present and future tense
  - supporting work past tense
- be honest

Save your text (and graphics) for future use
The Elements of Style by Strunk and White

Rules - Strunk and White, Section I.
14. Use the Active Voice
15. Put Statements in Positive Form
16. Use Definite, Specific, Concrete Language
17. Omit Needless Words
   “In order to” is almost always out of order (Roskam)
   – don’t overuse

Section V. 8. Avoid the use of qualifiers
   “Very, little, pretty—these are the leeches that infest the pond of prose, sucking the blood of words.”

Modern Style
• Use Bullet Charts, Comparison Tables

Typical Examples of Problems from AOE 4065 Fall Reports

Poor Wording
- “in which the above”
- “the above described”
- “a reasonable range”
- “it is anticipated that”
- “one can see”

And:

Figures and reference callouts must be integrated into the text!
Always Complete the Comparison

more
Something is easier than what?
better

- You can’t say: “The dashed curve is higher”
- You must say:
  “The dashed curve is higher than the solid curve.”
- Be explicit and precise (no mystery comparisons)
- Always fill in the blank for a comparison.

And:

Be Concrete

- Vague:
  This option is better than the previous one.
- Concrete:
  This option (3) weighs 10% less than option two.

Students often write sentences that read smoothly, but provide absolutely no information content!
Don’t do this.

Once again from Strunk and White:
“the surest way to arouse and hold the attention of the reader is by being specific, definite, and concrete.”
How to avoid looking like an amateur

- No straight quotes
- Don’t use double returns for paragraphs
- Don’t use two spaces after punctuation
- No gray boxes behind text
- Don’t use borders around everything
- No half-inch indents
- Don’t use hyphens for bullets
- Don’t underline - supposed to be italic
- Avoid ALL CAPS

Also, The PC Is Not a Typewriter

Mathematics: Symbols in text are usually in italics, i.e., $C_L$

Figures are precious - make each one tell a story

Coordinate with text
- the message you want the reader to get must be stated in the text
  - describe the figure as if you were explaining it to a blind man
- every figure must be called out in the text before it appears
- proper citation if you didn’t originate figure (this is plagiarism)

Mechanics
- portrait, not landscape
- good, high quality: all lettering neat, legible
- maintain margins
Examples

The next charts contain examples of an effective table and several effective figures, they:

- tell a story by themselves
- illustrate that good hand drawn charts can be effective
  - poor hand drawn charts are completely unacceptable
- they do not use obscure legends
  - or confusing, hard to see symbols and line types
  - or use color on the screen which is impossible to understand in black & white

I’ve included two figures each by Paul Bavitz, Rudy Meyer, Joe Landfield, and Bob Englert. They are all masters, and all colleagues from the Grumman days.

From a Grumman presentation to the Air Force, December, 1981
Example of a good table for a complicated story

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>FIGHTER ROLE</th>
<th>PENETRATOR ROLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAKEOFF GROSS WEIGHT, LB</td>
<td>34,990</td>
<td>42,505</td>
</tr>
<tr>
<td>PAYLOAD, LB</td>
<td>4 x 215</td>
<td>2 x 2000</td>
</tr>
<tr>
<td>MACH NUMBER</td>
<td>0.8/1.6</td>
<td>0.8/2.0</td>
</tr>
<tr>
<td>RANGE, NM</td>
<td>100/250</td>
<td>360/250</td>
</tr>
<tr>
<td>ALTITUDE, FT</td>
<td>55/65/65</td>
<td>49/56/65</td>
</tr>
<tr>
<td>LIFTOFF MASS (LBS)</td>
<td>12,070</td>
<td>12,070</td>
</tr>
<tr>
<td>RANGE FACTOR (MILE)</td>
<td>6.0/9.2</td>
<td>10/10/10</td>
</tr>
<tr>
<td>SUSTAINED ACCEL, MBS TO MBS, 36K FT</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>TAKEOFF GROUND ROLL, FT</td>
<td>410</td>
<td>875</td>
</tr>
<tr>
<td>LANDING GROUND ROLL, FT</td>
<td>900</td>
<td>1100</td>
</tr>
</tbody>
</table>

*Subsonic/supersonic cruise legs

Exploded view example: (key features summarized)

- Mission Adaptive Wing
  - Programmed Variable Camber Twist
  - Shaped Tragic Plume

- Structural/Material Integration
  - Advanced metallic, composite, & smart materials
  - Tailor configuration architecture

- Integral Weapon Carriage
  - Multirole Capability
  - Optimized load weighing

- Two-Dimensional Nozzle
  - Airframe-compatible shaping
  - Thrust vectoring & reversing
  - Engine signature shielding

- Low Profile Crew Station
  - Enhanced Area Progression
  - High Acceleration Cockpit

- Choke Coupled Canard
  - Relax Static Stability
  - Advanced Flight Control System

- Conical Inlet
  - Short Dash Length
  - Supersonic Flow
  - Nozzle and exhaust system

- Inlet
  - Modular propulsion system
  - Fixed to the geometry of the jet engine
Rudy Meyer puts the whole story on a single figure/viewgraph.

**Tail Sizing and A/C balance**

Another chart by Rudy Meyer, Grumman

**Canard Sizing and Aircraft Balance**

Example of a figure telling a story
Joe Landfield constructs easy to read chart showing conditions, requirements and system performance - reader doesn’t have to work too hard.

Thrust Vectoring for Direct Lift Control


Sketch shows config and sign convention

Nosewheel liftoff speed was high on the X-20

Another chart by Joe Landfield, “Thrust Vectoring Technology,” Grumman, Jan. 1985
Labeled so reader knows what to look for: EA-6B

REDUCED APPROACH SPEED

By Bob Englert, Grumman, from an undated EA-6B program briefing. The point comes across clearly. For this airplane, carrier based, approach speed is critical.

excellent hand written text didn’t scan well, simulated here

Spelling out improvements in flying qualities

EFFECT OF MANEUVER IMPROVEMENT MODS

LATERAL-DIRECTIONAL STABILITY (BODY - AXIES)

Another chart by Bob Englert from an undated EA-6B program briefing - easy to get the point -
Why most legends are lousy and other tips

Legends: Hard to connect legend symbols to lines on plot.
Here: Each line clearly labeled, plot is very easy to read.

- Points show location of data. Lines must go through points.
- For multiple charts, use same scales so they can be compared.
- Consistent use of symbols throughout presentation (and color too)

Other examples

Numerous good and bad examples are available from past reports:
- A/C Size Comparison
  - always valuable to be able to see
- Structural Design Example, Niu’s book
- A Similar Example from KU
  - it can be done by students!
- Example of Fuel System Layout
  - shows how system fits into the plane
- Cutaway
  - 1997 winning proposal had one

Many past reports and presentations are on the class web page
From a Cal Poly Winner

More from Cal Poly
But, from VT:
Evan Neblett, Team Lemming, Spr. 2003

Mid Term Design Review

• Review the RFP or problem statement
• Discuss the key issues/problem drivers for this project
  – How do existing designs relate to your problem?
• Explain the decisions made/to be made - and process
• Discuss your initial concepts
• Identify 2 or 3 for further examination: why did you select?
  – The final preferred concept to be presented at the final fall design review
• Your plan to get to the preferred concept
  – Decisions made must be supported by physics!
• Approximately 35 minute presentation, 5-10 minute Q&A
References

The AIAA Style Guide (online)

Goodman, Michael, *Write to the Point*, Prentice-Hall, 1984


Williams, Robin, *The MAC(orPC) is not a Typewriter*, Peachpit Press, 1990
- this is one students really need to read, and it’s short!

Planning now can payoff later!

Remember the 7 P’s:
Prior Proper Planning Prevents Pitifully Poor Performance
or
Plan Your Work and Work Your Plan!

Remember, in real life, there are no points for 2nd place.

Good Luck!