# Air Vehicle Design

## AOE 4065 – 4066

***II. Project Management Topics***

## Course Module P7

## Writing Effective Design Reports

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# AOE 4065-4066:
## Capstone Air Vehicle Design (AVD) Course Modules (CMs)

### Overview of AVD Courses

#### I. Foundational Elements

F1. Design: *An Engineering Discipline*

F2. Systems and Systems Thinking

F3. Basics of Systems Engineering

F4. Decision Making with Ethics and Integrity

#### II. Air Vehicle Design Fundamentals

A1. Purpose & Process

**Conceptual Design**

A2. Understand the Problem

A3. Solve the Problem

A4. Initial Sizing: *Takeoff Weight Estimation*

A5. Initial Sizing: *Wing Loading and Thrust Loading Estimation*

A6. Cost Considerations

A7. Concept to Configuration: *Key Considerations*

A7A. Configuration Layout: *Drawings & Loft*

**Conceptual & Preliminary Design**

A8. Trade Studies

A9. Use of Software Tools

A10. Preliminary Design: *Baseline Design Refinement & Validation*

#### III. Project Management Topics

P1. Basics of Project Management and Project Planning

P2. Project Organization

P3. Roles & Responsibilities of Team Members

P4. Project Execution: *Teamwork for Success*

P5. Project Risk Management

P6. Delivering Effective Oral Presentations

**P7. Writing Effective Design Reports**

# ***Disclaimer***

*Prof. Pradeep Raj, Aerospace and Ocean Engineering, Virginia Tech, collected and compiled the material contained herein from publicly available sources solely for educational purposes.*

*Although a good-faith attempt is made to cite all sources of material, we regret any inadvertent omissions.*

***CRUCIALLY IMPORTANT***

***CMs only introduce key topics and highlight some important concepts and ideas…but without sufficient detail.***

***We must use lots of Reference Material* to add the necessary details!***

***(*see Appendix in the Overview CM)***

# Outline

## P7. Writing Effective Design Reports

### P7.1 Writing Reports in Proposal Style

### P7.2 Report Evaluation

### P7.3 Best Practices for Design Reports

# Writing Design Project Report
## *in Proposal Style*

### Three Stages in the Life of All Reports

1. **Plan**
2. **Prepare**
3. **Deliver**

***IN THIS ORDER! Don't switch 1 and 2—PLEASE!***

***(Just like Ready, Aim, Fire: the right sequence)***

# *Stage 1. Plan* the Design Report

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

- You don't really understand your work until you try to write it up
- GOOD OUTLINE **early** can help you avoid wasted effort, and panic later on
  - putting your work together shows logic gaps, and tells you exactly what needs to be done
- With team efforts, Storyboards are very useful as brainstorming aids

  https://www.canva.com/learn/how-to-build-a-storyboard/

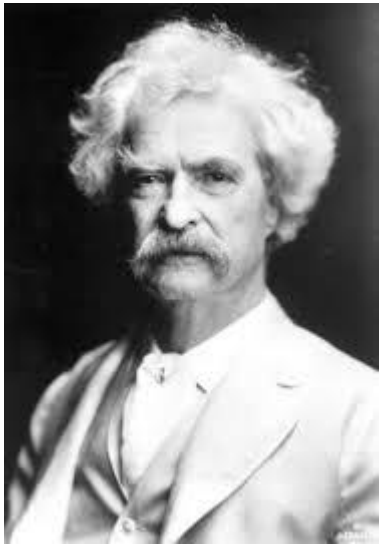
***START EARLY!***

# Why Start Early?

*Je n'ai fait celle-ci plus longue que parce que je n'ai pas eu le loisir de la faire plus courte.*

-- Blaise Pascal, Provincial Letters: Letter XVI, 1657

Translation: **I have made this longer than usual because I have not had time to make it shorter.**



Publisher's telegram to Mark Twain:

***NEED 2-PAGE SHORT STORY [IN] TWO DAYS.***

Mark Twain's reply to the publisher:

***NO CAN DO 2 PAGES TWO DAYS.***
***CAN DO 30 PAGES 2 DAYS.***
***NEED 30 DAYS TO DO 2 PAGES.***

***Proposals Are Page Limited—Being Brief While Hitting the Mark Takes Time***



*Source: Internet*

# *Stage 2. Prepare* the Design Report

## *Cardinal Rule: Be Totally Responsive to the Customer!*

- **Meet *All* Request for Proposal (RFP) Requirements**
  - General Rules and Specifications (page limits, fonts, formats, etc.)
  - Proposal and Data/Deliverables Requirements
  - Project Objective and Product Requirements
  - …
- **It's a Proposal (Response to an RFP), *Not* a Technical Report!**
  - ***Use P-R-A-J Construct for ALL Sections; it's the right 'proposal style'***
  - **Problem: *What* your understanding of the requirements is**
  - **Result: *What* you are offering that best meets requirements**
    - Use a "compliance matrix" to show that all requirements met or exceeded
    - Clearly state your conclusions; don't allow them to draw their own
  - **Approach: *How* did you generate the results/ products you are offering**
    - Describe how you used the engineering and decision-making tools
  - **Justification: *Why* your approach is the best/ most appropriate?**
    - Discuss why the customer should trust your result(s)

***Never, Never, Never Patronize!***

# Example of P-R-A-J Construct

## *Choosing an Engine*

- **Problem: *What* your understanding of the requirements is**
  - We need to select a turbofan engine to meet *X* $lb_f$ of SLS thrust requirement.
  - The engine should also be low cost, low maintenance, and high fuel efficiency
- **Result: *What* you are offering that best meets the requirements**
  - Show a picture of the engine along with its supplier's name (GE or P&W or…) and the specifications or the engine including cost, weight, size, etc.
- **Approach: *How* did you generate the results/ products you are offering**
  - We selected three engines in the *X* $lb_f$ thrust class
  - We used a decision matrix to compare the specifications & characteristics of all three engines to select the best one
- **Justification: *Why* your approach is the best/ most appropriate?**
  - We used appropriate *selection criteria* such as sfc, weight, size cost, maintenance, reliability, etc., with appropriate weighting factors to select the best engine

***The P-R-A-J Construct of Design Reports in Proposal Style Differs from P-A-R-C Construct of Technical Reports!***

# *Stage 3. Deliver* Report

- **Deliver On Time. Period.**
- **Risk of Late Delivery--Unacceptable.**
- **Example: AFRL RFP excerpt**

**Proposal Due Date and Time**: 22 May 2017, 3:00 p.m. EST. **Wright-Patterson AFB, OH**. ***NOTE: Proposal receipt after the due date and time shall be governed by the provisions of FAR 52.215-1(c)(3).***

*Proposals delivered even a minute after 3:00 PM EST would be disqualified!*

# Outline

## P7. Writing Effective Design Reports

P7.1 Writing Reports in Proposal Style

**P7.2 Report Evaluation**

P7.3 Best Practices for Design Reports

# Project Report (in Proposal Style): *Evaluation Criteria (1 of 2)*

**TECHNICAL: Part I (80%)**

- **Executive Summary (15%)**
  - Is it **C**lear. **C**oncise. **C**omplete. **I**mpactful (**C$^3$I**)?
  - Does it include (a) problem summary, key features of the solution, compliance matrix, and compelling evidence to differentiate your offering from your competitors' offerings; and (b) drawings (such as 3-views, cutaways, "walk around" chart) and tables to complement text?
- **Understanding of the Problem (20%)**
  - Does the proposal demonstrate a comprehensive understanding of the problem by adequate description of (a) Requirements and Constraints; (b) Comparator Aircraft, ConOps, Key Design Drivers; (c) MoMs and Promising Technologies for innovative air vehicle; (d) Design Timeline from Authorization to Proceed (ATP) to Entry in Service (EIS); and (e) Design Strategy, Design Objectives, Mission Profile, etc.?
- **Proposed Solutions and Substantiating Technical Details (45%)**
  - Is the Preferred Solution Balanced & Integrated?
  - Does design evolution include multiple viable and feasible candidate concepts?
  - Is the Initial Sizing approach reasonable for *TOGW*, wing and thrust (power) loading estimation?
  - Is the design space (constraint plot) properly defined for *W/S-T/W* (or *W/S-P/W)* matching?
  - Are Trade Studies presented (e.g., carpet plots) that provide "complete" answers?
  - Are 3-Vu drawings legible and dimensioned?
  - Are adequate substantiating engineering analyses/ data/ results presented for various disciplines including Aerodynamics, Propulsion, Performance, S&C, Structures, Materials, Subsystems, Weights, Manufacturing, and Cost (*not necessarily in this order*)?
  - Are all assertions fully substantiated?
  - Are project risks and strategies to address them adequately described?

# Project Report (in Proposal Style): *Evaluation Criteria (2 of 2)*

## MANAGEMENT: Part II (10%)

- **Project Organization and Plans (10%)**
  - Is a team (project) organization chart included with each team member's roles and responsibilities?
  - Is a good Gantt chart presented for the entire project from RFP release to final proposal submission?

## PROPOSAL ORGANIZATION (BOTH PARTS) (10%)

- **Proposal Organization (10%)**
  - Is the Table of Contents complete and logical? Are List of Figures & List of Tables included?
  - Are **action captions** used for figures (illustrations) and tables?
  - Is the report written in English using correct grammatical construction of sentences; has no spelling mistakes; and reads like one written by a single individual?
  - Are all references cited as [n] inserted in the text, and listed in the References section at the end

**Rating Factors:**

| Exceptional | Excellent | Very Good | Good | Above Avg. | Average | Below Avg. | Marginal | Poor | Very Poor | Dismal | Missing |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.95-1.0 | 0.9-0.95 | 0.85-0.9 | 0.8-0.85 | 0.75-0.8 | 0.7-0.75 | 0.6-0.7 | 0.5-0.6 | 0.4-0.5 | 0.25-0.4 | 0.0-0.25 | 0 |

# Executive Summary—A Critical Part of ALL Design Reports in Proposal Style

**Executive Summary is NOT an abstract!** Abstract of a paper (or report) is a brief write-up that summarizes its contents and helps individuals decide whether or not to read the paper (or report). Most technical papers and reports have abstracts.

**Executive Summary is the most important part of a proposal or a report and is intended to be read by *key decision-makers*.**

- It is a short document intended to help readers grasp the **main points** of a large body of material without having to read the entire proposal (or report).
- **It is a *concise yet complete* document in miniature that may be read in place of a longer complete proposal (or report).**
- Executive Summary typically has a brief description of the problem at the start followed by highlights of the proposed solution with figures and tables if needed, and ends with main conclusions about why the solution is the best. Executive Summary is usually written last!
- **It is intended to convince the reader (or customer) that the team**
  - **(i) understands the problem;**
  - **(ii) has offered the best solution that meets all requirements; and**
  - **(iii) has provided compelling evidence why the solution is the best!**

***You want decision-makers to decide in your favor!***

# Project Report: *Key Considerations*

***Considerations:***

- The report should be *fully* responsive to customer needs and specifications.
- Evaluators should be able to easily understand why your proposed solution is the best.
- Label figures (illustrations) and tables with "*action captions*." That is, the caption should crisply highlight the "message" of the figure (or the table), not just what the figure is. For example, if you include a drag polar, do not just write "Figure x. Drag Polar." Instead use the caption to reiterate your message.
- All charts and plots must include legible scales and legends.
- Assumptions, results, and conclusions should be clearly stated so that there are no voids for readers and evaluators to fill with their own independent (yet biased) judgments or opinions.
- All assertions in the report must be fully substantiated with engineering data/ results. For example, stating that "the aircraft can takeoff from short runways" is unsubstantiated *unless* you define what is meant by "short runways" and then include a numerical value of the takeoff distance of your concept. The numerical value should be equal to or less than your definition of "short runways."
- The report must be written in English using correct grammatical construction of sentences, and with no spelling mistakes.
- The report should read as if written by one single individual. That is, inputs of all team members should be *seamlessly* integrated.

# Project Report: ***Specifications***

***Specifications:***

A. Page Limit: *The page count should never exceed the specified limit.*
   - For AOE 4065, report should be *approximately half the size* of the report to be submitted in May. Think quality over quantity! We strongly recommend that you keep the page count of the fall semester report to 50 or less (8.5”x11”) including any appendices. You may use up to four fold outs (11”x17”); each will count as one page.

B. Font: ***Use the font specified by the customer.*** If no customer specs are available, use 12 pts. double spaced Times New Roman font for text, and 10 pts for figure and table captions.

C. All references should be cited as [n] inserted in the text with a complete list in the ‘References’ section at the end of the report.

D. Upload your report (as an **Adobe PDF file**) to the shared Google drive by the posted deadline.

***Carefully Read the Documents Posted on the Course Site***

***See Course Site folder:*** **Files > Final Project Report**

# Outline

## P7. Writing Effective Design Reports

P7.1 Writing Reports in Proposal Style

P7.2 Report Evaluation

**P7.3 Best Practices for Design Reports**

# Guide to Writing an Effective Design Report

**P** **Plan**

**O** **Outline**

**W** **Write**

**E** **Edit**

**R** **Revise**

George Dieter and Linda Schmidt
*Engineering Design*

# Writing An Effective Design Report:
## *Important Considerations*

- For the capstone design project, the design team authors should write the report using techniques that make it easy for the evaluators to grade. *Organizing the report for the reader's purpose is the first technique in effective technical writing.*
- Develop a **report outline (Table of Contents)** based on a thorough understanding of the *criteria* that evaluators will use.
- Although it may be harder to write the report to such an outline, **it will be easier for the judges to grade.**
- Pay special attention to page limits, formats, specific graphs and drawings, delivery mode (electronic and/or hardcopy), etc.
- Avoid making up long introductions to major sections. A single sentence describing the topics to be covered is adequate, for example

  *The following section describes the research we performed, our design and analysis process, and our design selection process.*

***Report writing is a skill, different from informal writing – letters, notes, email. Like all skills, it needs practice to be mastered.***

*Source: Adapted from SAE AeroDesign document: "Final Design Report Guidelines"*

# Make a Report Outline—FIRST!

Two popular styles for creating an outline or "Table of Content"

A. Built around Roskam's two classes of design cycles:
   - Class I. Design using statistical methods
   - Class II. Design using analytical methods

**Table of Contents**

1. Requirements
2. Conceptual Design
3. Class I Design
4. Class II Design
5. Design Verification
6. Internal Configuration
7. Cost

- Disciplinary tasks are split as they are included in the Class I and II Design sections.
- Challenging for disciplinary experts tasked with evaluating the proposal.

B. Built around tasks and data by functional disciplinary groups supporting conceptual [and preliminary] design activities

**Table of Contents**

1. Requirements
2. Initial Concepts
3. Preferred System Concept
4. Aerodynamics
5. Propulsion
6. Stability & Control
7. Weights & Balance
8. Subsystems
9. Performance
10. Cost

- Disciplinary tasks are consolidated in their respective sections.
- It mimics "real-world" major design proposals where specific discipline sections are evaluated by teams of disciplinary experts.

# Best Practices for a Good Design Report

## *A. Approach & Process*

### Allocate Pages

- Allocate pages to the sections of the outline and make sure that the total number of pages meets any specified page-count constraint. The allocations should reflect the emphasis areas of the team's design.
- Do this before writing begins, and adjust after reviewing the first draft.
- For each page of the report, define the topic to be discussed and *the messages to be delivered*.

### Create the Figures

- Most evaluators will be engineers, and engineers are graphically inclined - they can understand a concept more easily when looking at a picture. Therefore, build each page around at least one figure.
- Create the figures first, and review them before starting to write.
- Each figure needs a message which should be summarized in the figure title. (This is also known as '***action caption.***')
- Make the figures data-rich, but legible (9-point font is a minimum size).
- You may use the same figures for the oral presentation!

*Source: Adapted from SAE AeroDesign document: "Final Design Report Guidelines"*

# Best Practices for a Good Design Report:

## *A. Approach & Process (contd.)*

### Draft the Text

- Use text to highlight, explain, or further develop the major points of the figure.

### Edit the Text and Figures

- Take the time to edit the document at least twice.
- Perform one edit cycle based on a group review of the draft document (called a Red Team). Have the Red Team members read the document as evaluators, supplying them with the scoring criteria and a copy of the rules.

### Create the Final Document

- Although several persons may contribute to the writing process, ***one team member should make the final version*****.** This person works to achieve a consistent style to the text and to make the messages consistent.

### Schedule the Effort

- A good report takes more than a week! ***One month is a guideline*** for the duration of the writing effort. Create a schedule of the [report] tasks and status it regularly.

***An efficient method is to establish the outline, page allocations, and figures early in the project, so the team can generate the necessary data as the design progresses. This reduces both the last-minute cram and the amount of unused documentation.***



*Source: Adapted from SAE AeroDesign document: "Final Design Report Guidelines"*

# The Art of Writing a Good Design Report

## *B. Writing Clearly and Succinctly*

### Use Active, not Passive, Voice

- Simple examples:

  *The team calculated the drag of the aircraft.* (Active)

  *The drag of the aircraft was calculated by the team.* (Passive)

- Using active voice makes the writing lively – the reader sees an action being performed and knows who is doing it.
- A design report example illustrates this point – the highlighted verbs are passive voice:

  *Part of the initial design steps, after choosing the airfoil and getting its resulting $C_l$, included choosing a range of desired aircraft weights. Using these estimated ranges, a range of wing areas **was determined** that could satisfy the requirements. The operating ranges **were then narrowed** down and iterated until workable values **were obtained**. Once the required wing area **was known**, along with the taper ratio, the chord dimensions **were chosen**.*

  Edited using active voice verbs (highlighted)

  *After selecting the airfoil, the **design team established** a desired weight range for the aircraft. Using these weights and the $C_l$ value of our airfoil, **we calculated** wing areas that provided the lift needed to achieve the takeoff requirement. **We iterated** this analysis and selected a wing area. The **team then selected** a taper ratio and established the chord dimensions.*

- Passive voice can be used occasionally to alter the sentence flow. A suggested ratio is one passive voice sentence for every two active voice sentences.

*Source: Adapted from SAE AeroDesign document: "Final Design Report Guidelines"*

# The Art of Writing a Good Design Report

## *B. Writing Clearly and Succinctly (contd.)*

### Eliminate Unnecessary Words and Phrases

- Casual conversation uses many introductory phrases and colloquialisms. Using these extra words in a technical document dilutes the meaning of a sentence. In a page limited document, these words also reduce the space available for additional material.
- Examples of unnecessary words:

| | | |
|---|---|---|
| *now that* | *from the start* | *to go about this* |
| *simply* | *the next step* | *from this* |

- "*In order to* is almost always out of order." Just use "*To*" instead.
- A before/after example illustrates how many words can be eliminated without removing content – unnecessary words are highlighted:

  ***Now that** the type of wing **that was going to be built** was selected, **the next step** was to select the airfoil **that would be used**. **To go about this**, research was conducted on **different types** of airfoils through **various** airfoil databases. **During the search** a program called Profili was discovered.*

  After – edited to contain only necessary words:

  *With the wing configuration selected, we then evaluated airfoil options. We researched airfoil databases and found a program called Profili.*

- Eliminate phrase duplication, for example,

  *Additionally, fuel burn **has little effect on** the center of gravity as well **(less than a quarter of an inch shift).***

  After - with duplications removed:

  *Fuel burn shifted the center of gravity less than 0.25-in.*

*Source: Adapted from SAE AeroDesign document: "Final Design Report Guidelines"*

# The Art of Writing a Good Design Report

## *B. Writing Clearly and Succinctly (contd.)*

### Talk Technical

- Do not use adjectives to quantify a topic, use data. Here are examples of expressions that should <u>not</u> be used in a technical report:

  *large amount/quantity/effect several*
  *significant increase/decrease some*
  *extensive range a few*
  *Low/high level of many*
  *excellent agreement/levels*

- State a value or range of values, an order of magnitude, or a percentage. This provides the reader with a clear understanding of the magnitude of the data comparison.

### Explain Symbols

- Introduce symbols and acronyms in the text to spare the reader from constantly referring to the List of Symbols and Acronyms.
- The first time a symbol is used, provide the definition (in parentheses is adequate).
- For an acronym, spell out the words of the acronym then follow with the acronym in parentheses.

### Cite References in Text

- Wherever appropriate in the report, <u>*cite the reference*</u>!
- If the references are numbered in the list of references, each should be cited using words within parentheses (*see Reference X)* or a number within brackets [X].

*Source: Adapted from SAE AeroDesign document: "Final Design Report Guidelines"*

# The Art of Writing a Good Design Report

## *B. Writing Clearly and Succinctly (contd.)*

### Use *due to* Correctly

- Since technical reports often describe cause-effect relationships, the phrase *due to* is often (over)used. Use it correctly!
  - *Due to* is a substitute for *caused by*. It is **not** a substitute for *because of*.

### Keep Tenses Simple

- A technical report usually combines a history of work performed with a description of the result. Confusing tense structure can be avoided by using the following guidelines:
  - When describing the design development process, write in the past tense. The work was done in the past. The obvious exception is description of follow-on work or work being performed as the report is written. For these cases, use the future or present tense respectively.
  - When describing the features of the design, or results of the design process, use present tense (e.g. *the data show*, not *the data showed*). The features, once established, are independent of time. An exception is when describing a feature that was subsequently changed, past tense is appropriate.
- Limit using past perfect, present perfect, and conditional tenses, as they add words. Examples:

| *Instead of* - | *Use* - |
|---|---|
| has been, have been | was |
| would be | is |

*Source: Adapted from SAE AeroDesign document: "Final Design Report Guidelines"*

# The Art of Writing a Good Design Report

## *B. Writing Clearly and Succinctly (contd.)*

### Always Complete the Comparison

Something is *easier (*or *more* or *better)* than *what*?

- 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.

### Be Concrete (Specific)

- *Vague sentence:* This option is better than the previous one.
- *Concrete sentence:* Option 3 weighs 10% less than Option 2.
- "the surest way to arouse and hold the attention of the reader is by being specific, definite, and concrete." – *Strunk and White*

### Adopt AIAA Style Guide: Provides rules for

- Capitalization, parentheses, plurals, possessives, punctuation and spacing, etc.
- Properly referencing papers, conference proceedings, reports, books, electronic publications, computer software, patents, private communication, websites, etc.

# Sample Compliance Matrix for Final Report (in Proposal Style)

## 1.2 COMPLIANCE MATRIX

*Table 1: Matrix of RFP and External Requirements*

| Design Parameter | Requirement | Capability | Page |
|---|---|---|---|
| **RFP General Requirements** | | | |
| Crew | 2 | 2 | 20 |
| Passengers | 175 (1 Class) | 175 | 20 |
| Seating | Pitch 32", Width 17.2" | 32", 17.2" or 19" | 20 |
| Cabin Width | > 12.5 ft | 12.5 ft | 18 |
| Cabin Height | > 7.25 ft | 8ft | 18 |
| Cargo | 1240 $ft^3$ | 2,400 $ft^3$ | 49 |
| Takeoff Distance | 8,200 ft | 8,200 ft | 64 |
| Landing Speed | < 140 KCAS | 140 KCAS | 64 |
| Maximum Landing Weight | Defined as max. zero fuel weight plus fuel reserves for max. range | 123,000 lb | 44 |
| Cruise Speed | Mach 0.8 | Mach 0.8 | 62 |
| Maximum Operating Speed | Mach 0.83 / 340 KCAS | Mach 0.83 | 62 |
| Initial Cruise Altitude | 35,000 ft | 35,000 ft -> 37,000 ft | 67 |
| Maximum Cruise Altitude | 41,000 ft | 41,000 ft | 62 |
| Nominal Range | 1,200 nm | 1,200 nm | 62 |
| Maximum Range | 3,500 nm | 3,500 nm | 62 |
| Payload Capacity | 37,000 lb | 37,000 lb | 44 |
| Alternative Fuels | Biofuels, Drop-in Replacement | Algae & others | 74 |
| **RFP Background & Objectives** | | | |
| Entry Service Date | 2020 | 2020 | 13 |
| Aircraft Replacement | 737NG/A320 Replacement | > B737 & A320 | 2, 41, 70 |
| L/D | 25% Improvement in Lift-to-Drag Ratio | 28% | 62 |
| Adv. Operating Procedures | Reduce fuel consumption | ADSB, CDA | 71 |
| Adv. Technologies | Laminar Flow | Hybrid laminar flow | 32 |
| | Active Controls | Dynamic stability | 53 |
| | High Bypass Ratio Engines | RB3011 open rotor | 58 |
| | Adv. Materials / Structure | Adv. Al / composites | 41 |
| | Navigation Equipment | Adv. flight deck | 86 |
| Enhance Aircraft & Engine Efficiencies | Minimize Fuel Burn | 65 lb/seat nominal | 70 |
| | Minimize Noise | ICAO Level 4-12dB | 79 |

*Source: 2010 AIAA Undergrad Team Competition Winner, CalPoly, SLO*