University of Toronto
Faculty of Applied Science and Engineering
Final Examination, December 07, 2012
Duration: 2.5 hours
APS111H1 F and APS113Y1 Y - Engineering Strategies & Practice 1

Calculator Type: 4 (No electronic or mechanical devices permitted)
Exam Type: A (Closed book, no aids permitted)
Course Coordinator: Prof. J. Bazylak
Communication Coordinator: Dr. P. Weiss
Module B Coordinator: Prof. J. O'Brien

Instructions:
This is a closed book exam; no calculators or aids are permitted, except for a translation-only dictionary, i.e., direct word-to-word translations but no definitions. There are two parts of the exam: multiple-choice questions, and a writing component. Read each question carefully.

For the multiple-choice portion, provide the most correct answer to each question on the answer sheet. **Only one answer is to be given for each question**. Be sure to fill out the answer sheet clearly with no overlaps, using a pencil. Erase any errors completely. There are a total of 33 multiple-choice questions, each of which is worth about 1.8 marks, for a total of 60 marks worth 60% of the exam.

The second part of the exam is a writing component worth 40% of the exam. Answer this part in the exam booklet carefully following the instructions.

Part 1: Multiple-choice questions (60%)

1. Which of the leadership styles presented in lecture tend to focus on team dynamics?
   a. Analyticals.
   b. Drivers.
   c. Empaths.
   d. Amiables.

2. Legislation that requires certification or action by a professional engineer is known as:
   a. Job creation legislation.
   b. Supply-side legislation.
   c. Demand-side legislation.
   d. Professional Engineers Act.

3. Students at Lehigh University estimated how much it would cost to build a "Death Star" based on dimensions they collected from George Lucas's "Star Wars". The students relied on data about steel used in modern day aircraft carriers. By doing this, the students used which of the following approaches to estimate the cost of the steel:
   a. Supplier information.
   b. Rule of thumb.
   c. Analogy.
   d. Industry standard.

4. Bioaccumulation means that a pollutant:
   a. Is carcinogenic.
   b. Can be used to kill agricultural pests.
   c. Builds up in the fatty tissues of animals.
   d. Is biodegradable.

5. Your company needs to upgrade its transportation fleet and is considering different fuel alternatives. As the design engineer responsible for evaluating the alternatives, you have prepared a business case that compares vehicles powered using conventional fuel to propane and hybrid vehicles. The data in your business case in Table 1 shows:
   a. The capital cost for the hybrid alternative is too low.
   b. It costs less for the propane alternative because there are more propane refuelling stations than there are for the hybrid alternative.
   c. The payback period for the hybrid is shorter than the propane alternative.
   d. Nothing, because there is not enough information to make any conclusions.

Table 1

Alternative	Capital Cost ($)	Annual Operating Savings ($/year)
Propane	$2,000	$500
Hybrid	$8,000	$4,000

6. In Figure 1, the area marked A represents:
   a. Total costs.
   b. Net revenue.
   c. Surplus.
   d. Losses.

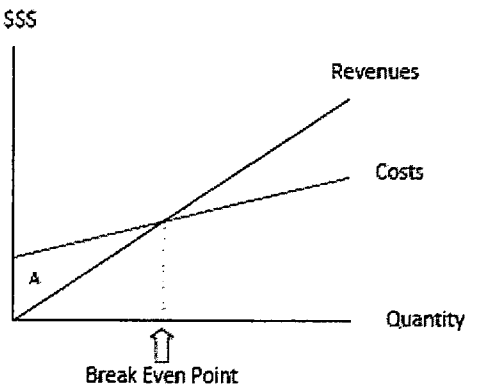

Figure 1 - Expenditure versus quantity plot

7. The value of money changes over time, and this is an important consideration in engineering projects, especially those that have a very long service life. The cost of money, inflation, and risk all affect the time value of money; of the three:
   a. Inflation is not relevant to infrastructure projects because these types of projects are not consumed.
   b. Risk refers to the availability of government grants that can be used to finance large infrastructure projects.
   c. None has an impact on whether or not a project will proceed.
   d. The cost of money can be predicted based on the interest rate.

8. Pollution control is often described as an "end of pipe" approach to managing emissions to the environment after the emissions have been created. An example of pollution control applied to municipal wastewater is:
   a. Disinfection of wastewater effluent as the final step in the treatment process before the effluent is discharged to the environment.
   b. Enforcement of sewer use by-laws, which set limits on the quantity and type of pollutants that industries connected to the municipal wastewater collection system are allowed to discharge to it.
   c. A requirement for homeowners to install rain barrels to collect stormwater on their properties and prevent it from entering the municipal wastewater collection system.
   d. Providing rebates to consumers who buy and install "low flush" toilets thereby reducing the amount of wastewater that must be treated at the wastewater treatment plant.

9. Regarding the human tech ladder, colour can be part of which rung(s)?
   a. Physical.
   b. Political.
   c. Ergonomics.
   d. Physical and Psychological.

10. The use of the 3Rs (reduce, reuse, recycle) is an effective strategy for conserving resources. Which of the following statements about the 3Rs is **TRUE**?
    a. The most effective of the 3Rs is reuse because it encourages companies to use raw materials, products, and by-products more than once.
    b. Recycling is the least effective of the 3Rs from an environmental perspective because it is applied to waste residuals that have already been produced and transforming the residuals into something else can involve additional use of energy.
    c. Banning plastic bags in the City of Toronto is not a sustainable solution to environmental management because the ban means residents will not be able to buy plastic garbage bags.
    d. Industries that practice the 3Rs can claim tax credits for the quantity of raw materials they replace with recyclable materials.

11. Kimberly-Clark conducted life cycle assessments (LCAs) of toilet paper made from new ("virgin") and used ("post-consumer") materials. Kimberly-Clark wanted to know which type of material was environmentally preferable. The LCAs followed ISO 14040 and ISO 14044 and were comprehensive. Kimberly-Clark collected information about resource availability, air and water emissions, solid waste generation, chemicals used, packaging, and energy requirements for each type of toilet paper. The results of the LCAs indicated that neither new nor used materials were environmentally preferable. This means the LCAs:
    a. Were a waste of time.
    b. Will have to be re-done so that Kimberly-Clark can find environmental savings.
    c. Provided valuable information about current processes, and can serve as baselines when Kimberly-Clark conducts LCAs in the future.
    d. Were conducted incorrectly, because Kimberly-Clark did not follow a recognized and acceptable procedure.

12. Industrial ecology is sometimes referred to as "cradle-to-cradle" environmental management. The goal of industrial ecology is for man-made systems to emulate efficient, sustainable natural systems by seeking to optimize the total materials and residuals cycle taking into consideration resources, energy, and costs. The community of Kalundborg in Denmark is a practical example of industrial ecology. In Kalundborg:
    a. The participants (companies, the municipality, and individuals) realized that waste and residuals from one process could be used as inputs to another process.
    b. The companies benefited from a rebate program offered by the Danish government, which paid them to use municipal solid waste as a source of energy.
    c. The City Council decided to ban plastic bags, so the companies needed to change their production processes to make paper bags.
    d. Recycling was not popular, so farmers were encouraged to join the community to further reduce wastes.

13. Life Cycle Assessment (LCA) is a 4-step process that can be used to evaluate the environmental aspects and potential impacts of a product, process, or system. Step 1 is to identify the scope of the LCA. It is important to have a well defined and manageable scope because:
    a. The LCA will take much less time to complete.
    b. It is virtually impossible to identify all the processes, inputs, and outputs that would be needed to conduct a fully comprehensive LCA.
    c. The cost of the data management software used for the LCA will be lower.
    d. Sometimes it is not possible to obtain information from suppliers because the information is proprietary.

14. "Triple Bottom Line" is a phrase first used in 1997 by John Elkington to define a:
    a. Philosophy of maximizing profits at the expense of society and the environment.
    b. Framework for measuring and reporting performance against economic, social, and environmental parameters.
    c. Method for resource extraction companies to file improper financial statements with the Securities and Exchange Commission.
    d. Scheme whereby economists inflate the value of goods on company balance sheets

15. In 1798, Thomas Maltus wrote "An Essay on the Principle of Population". Almost two centuries later, The Club of Rome published a report titled "The Limits to Growth". What these two treatises have in common is that they both identified:
    a. The steam engine as a major contributor to the industrial revolution.
    b. That there are more than enough resources on earth to serve all our needs.
    c. Pollution prevention is not sufficient to alleviate environmental degradation.
    d. An environmental limit to ever expanding human needs.

16. Sustainability is often depicted as the nexus of economy, environment, and society, as shown in Figure **2**. The intersections of the individual components of sustainability, shown by A, B, and C also represent practices, and these practices are:
    a. A = infrastructure, B = labour, C = safety.
    b. A = problematic, B = business-oriented, C = waste of resources.
    c. A = beneficial, B = equitable, C = viable.
    d. A = hardship, B = poverty, C = degradation.

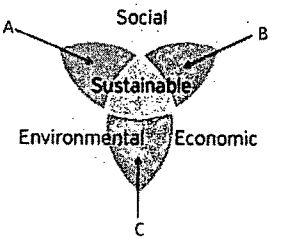

Figure 2.

17. The arrow diagram shown in Figure **3** was developed for a design project to develop, test, calibrate, and finalize a computer model to predict pollutant loadings discharged from combined sewers to receiving watercourses during rainfall events. How many different paths does the arrow diagram show?

a. 3.
b. 4.
c. 5.
d. 6.

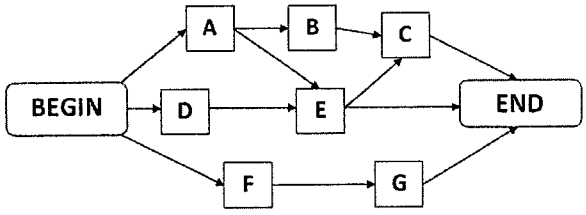

Figure 3

18. Table 2 shows the amount of time in days needed to complete each of the tasks in the computer model design project shown in the arrow diagram in Figure **3**. Based on the times shown in Table 2, the critical path has the following number of days:

a. 23.
b. 34.
c. 35.
d. 46.

Table 2

Task Number	Task Start	End Task	Duration (days)
1	Begin	A	6
2	A	B	11
3	B	C	8
4	C	End	7
5	Begin	D	9
6	D	E	14
7	E	End	12
8	A	E	5
9	E	C	16
10	Begin	F	4
11	F	G	3
12	G	End	18

19. The Ontario Professional Engineers Act (PEA) sets out the responsibilities of Professional Engineers Ontario (PEO), the organization that regulates the practice of engineering in Ontario. Two of these key responsibilities are to:

a. Collect licensing fees and publish a bi-monthly magazine.
b. Set standards for licensing Professional Engineers & ensure compliance with PEA.
c. Encourage engineering students to join PEO's Student Program and offer reduced rates for licensing when the students graduate.
d. Inspect large infrastructure to ensure designs comply with applicable codes and regulations, and prosecute Professional Engineers who fail to follow best practices.

20. Engineering in Canada is a self-regulated profession. This means that the government has enacted legislation so that Professional Engineers:
    a. Can claim their annual license fee as a taxable credit on their income tax return.
    b. Do not need to worry about legal liability.
    c. Have the authority to determine the appropriate standard of professional competence and ethics required for protection of the public.
    d. No longer need to seal documents and drawings as a sign of accepting responsibility for the contents.

21. You are a design engineer working for a gold mining company. The company has just been awarded the mineral rights to a property in Papua New Guinea. The property is remote, and currently without road access. You have been asked to work on the mine development plan. Your assignment is to identify and evaluate all the steps required to access the mine site, extract the gold, and transport the gold to the coast for shipping to processing facilities in Australia. As part of your assignment, one of the first steps you should take is to:
    a. Assume Canadian design practices can be applied.
    b. Ensure your company pays for the residents to be relocated to the nearest city.
    c. Contact equipment suppliers to find the most current technology for treating tailings pond waste.
    d. Consult with local residents to determine ways to mitigate potential negative environmental impacts resulting from the mine and its operation.

22. A business case and a response to a request for proposal (RFP) contain similar information, but differ in the following way:
    a. Business cases are used by internal clients, and RFPs are used by external clients.
    b. Business cases contain cost information, but RFP responses do not.
    c. RFPs specify the timetable for the project, but business cases do not.
    d. Business cases are only for private companies; RFPs are only for governments.

23. A fundamental difference between a Gantt chart and the Critical Path Method (CPM) as project management tools is that:
    a. CPM does not rely on a graphical depiction of the project, but a Gantt chart does.
    b. CPM is used for complex projects and Gantt charts are used for simple projects.
    c. CPM can be used to show project expenditures, but Gantt charts cannot.
    d. CPM acknowledges the relationships between tasks, but a Gantt chart does not.

24. Cutting and pasting sentences from a website as a practice is:
    a. Good as long as you include a number in square brackets and a reference.
    b. Good because that may the best way of expressing the idea.
    c. Bad because your purpose for the information may not be the same as the source.
    d. Bad because any use of exact wording is plagiarism and will result in a penalty.

Questions 25-27 relate to Case Study #1: Giardia Lamblia Water Contamination

25. Environmental Assessment (EA) is a planning process for infrastructure projects, such as roads, water treatment plants, and landfill sites. As the design engineer for the Small City water treatment plant upgrade you find a key feature of the EA process is that it:
    a. Specifies the number of water treatment plant designs that you must examine.
    b. Sets time limit to identify a preferred design to upgrade the water treatment plant.
    c. Does not apply to your project because you are not designing a new one.
    d. Encourages public consultation.

26. The Safe Drinking Water Act and regulations specify minimum acceptable standards for drinking water treatment. The Provincial Government is considering changes to the Act and has posted a policy document explaining the new, more stringent standards. As the design engineer working on the upgrade to Small City's new water treatment plant, you would:
    a. Demonstrate due diligence by incorporating the new, more stringent standards in your design.
    b. Ignore the proposed changes to the Safe Drinking Water Act and rely strictly on Small City's design guidelines.
    c. Advise your client that you will need to increase your fee to design the water treatment plant to meet the new standards.
    d. Contact the Provincial Government to find out why they are changing the standards.

27. Table 3 shows the value of losses caused by the epidemic. As the engineer responsible for designing upgrades to the water treatment plant, you have calculated an annualized cost of $4 million per year over a 20-year period to upgrade the water treatment plant to prevent giardia cysts from contaminating the drinking water. Assuming you have complied with applicable legislative and regulatory requirements, and that you have accounted for the time value of money, your preliminary estimate would lead you to recommend that Small City should:
    a. Give you more time to investigate alternative upgrade designs.
    b. Proceed with the water treatment plant upgrade based on your preliminary design and cost estimate.
    c. Set aside funds to cover a future epidemic because it is too costly to upgrade the water treatment plant.
    d. Relocate the beavers that caused the epidemic to the local zoo.

Questions 28-30 relate to Case Study #2: Safe Wireless Power through Invisibility

28. A potential negative environmental impact of a space solar power system would be:
    a. Emissions from the manufacture of solar panels.
    b. Reduction of insolation on the earth from the shading of the panels in orbit.
    c. Use of non-biodegradable materials in the construction of the in-orbit systems.
    d. Propagation of fears of being "microwaved" reducing air travel.

29. Suzuki of the Japan Aerospace Exploration Agency (JAXA) said, "We're aiming to produce stable, cheap electricity at the target price of 5 cents per kilowatt-hour." If the standard price of electricity in Japan is 10 cents per kilowatt-hour and the $10 billion system would generate 10 million kilowatt-hours per year, what is the Payback period if this target is achieved?
    a. There is not enough information supplied to answer the question.
    b. $10,000,000,000.
    c. 20 years.
    d. 20,000 years.

30. If you were a member of the Risk Management team for the Japan Aerospace Exploration Agency (JAXA), the agency responsible for the proposed space solar power system, one of your first tasks would be to:
    a. Hold public consultation meetings to discuss the potential health risks of the project.
    b. Compare the theoretical power of the transmission beam to health regulations.
    c. Attempt to redesign the system to use a less dangerous wavelength of radiation.
    d. Have the designs reviewed by an occupational health and safety inspector.

Questions 31-33 relate to Case Study #3: Problem Statement

31. Which of the following is a correct stakeholder and their interest?
    a. NASA – wants opportunities to increase profit
    b. Airline industry – interested in maximizing revenue
    c. Ontario Power Generation – fears lost revenue due to design
    d. Environmental NGOs – want design to solve problems of global warming

32. The website cited for this problem statement has the following warning:

    "This article has multiple issues. Help improve it or discuss these issues on the talk page.
    - The neutrality of this article is disputed. (June 2012)
    - Parts of this article (those related to article) are outdated. (January 2011)
    - This article contains weasel words: vague phrasing that often accompanies biased or unverifiable information. (June 2012)"

    The student using it should therefore have:
    a. Revised the article and resubmitted it to Wikipedia.
    b. Used other sources as well as Wikipedia.
    c. Gone to the Talk Page and joined the discussion.
    d. Avoided using Wikipedia because it is a bad source.

33. In the second paragraph, which is based on the Wikipedia source, the student team:
    a. Maintained the bias of the article because of value-laden language
    b. Overcame the bias of the article by using value-laden language
    c. Increased the quality of the writing by using dramatic value-laden language
    d. Achieved excellent engineering writing due to lack of grammar errors

Part 2: Long Answer Question (40%)

INSTRUCTIONS: This question requires two written answers. Use an exam booklet, and write in your name, student number, course, and date of examination on the booklet's cover page. You may use as many pages as you need for your preliminary work, but the final answers must be no more than four (4) pages single-spaced or eight (8) pages double spaced. Clearly indicate the final copy to be graded by writing "Final Copy" at the start of it. Use headings, subheadings, paragraphs, and bullet lists where appropriate.

1. Based on the case given below and using a bullet list (20%):
    a. Identify the key stakeholders and their interests.
    b. Identify functions, objectives, and/or constraints that arise from their interests.
    c. Indicate how particular functions, objectives or constraints are related to human factors, economic or environmental concerns.
2. Based on the case given below, in paragraph form (one or more paragraphs) write a concise Problem Statement **in your own words**. DO NOT COPY SENTENCES WORD-FOR-WORD FROM THE CASE STUDY IN YOUR PROBLEM STATEMENT. YOU WILL RECEIVE NO MARKS FOR MATERIAL COPIED WORD-FOR-WORD FROM THE CASE STUDY. (20%)

3D Design Solution for Sports Television

Entertainment Evolution Enterprises (3E) wants to be on the ground floor for the next stage in 3D television. Twenty-four million people bought 3D televisions in 2011 and almost twice that number purchased them the following year [1]. The 2010 FIFA World Cup was broadcast everywhere in the entire earth and was watched by 3.2 billion people – 46.4% of the world's population [2]. As exciting as it was in 2D, imagine what it would be like in 3D.

Since the dawn of the Olympics in Ancient Greece, sports have been an important tool for international communication and can be an instrument in developing world peace. Watching through the window of a television set, sports seem somewhat distant, but 3D breaks down the barrier. The viewer in the middle of the action. How much more powerful a weapon for peace would televised sports be in they were in 3D? Imagine FIFA 2014: it is the 13th of July and you are right on the field of the refurbished Estadio Jornalista Mario Filho – or as the Maricana, as it is better known [3] – the game is underway, the football is coming right at YOU! This is the 3D illusion!

It's not so easy, though, especially in real time – 2D sports broadcast and 3D sports broadcast are very different, and despite great advancements, 3D challenges have by no means been met. The 2D monitor space is flat, like a painting or a photograph. The viewer is outside of it, looking in. Movement or changes inside the picture do not affect the viewers' perceptions of their own position in space. In 3D, on the other hand, the viewer feels like she or he is INSIDE the picture. A change, especially a sudden change, can make the viewer feel as if he or she has suddenly been catapulted to a different place or is whirling around. These changes, along with any other visual mistakes that occur, can be more than confusing. The two lenses on which the 3D effect relies may be misaligned, causing painful

eye strain. Mismatched depth cues, on the other hand, can actually cause nausea. Viewers suffering physical distress tend to be unforgiving and litigious. [1]

There are two problems the proposed system has to solve, and a challenge in size and cost. The first problem that has to be solved has to do with the "frame" that 2D sports broadcast employs at the boundary of the picture. That "frame" contains computer generated augmentation of the viewing experience: not just the game clock, halves, score and, most importantly, a "branding" bug – the logo of the broadcaster and/or major advertisers. This information just sits on the border of a 2-dimensional space, and does not disturb the viewer, but in 3D, it seems to float in mid-air and get in the way of objects moving toward it. The use of semi-transparency for this frame, as is done in frequently in 2D, destroys the illusion of 3-dimensionality and that illusion must NEVER be destroyed or the whole 3D project becomes pointless. [1]

Secondly, differences between information from the two lenses required for 3D will also harm the 3D illusion but are far more difficult to compensate for electronically. The system cannot use the information from one lens to correct the other because 3D depends on the slight difference in position (and hence difference in information) between the lenses in order to establish its 3D effect. While this positional difference must be maintained, other sorts of information must be identical, including colour and focus. Obviously, collecting and correcting information on time, camera, lenses, relative vertical positions, relative rotations and colour will require massive amounts of metadata. Broadcasting live sports in 3D requires many thousand times more computations than 2D – on the order of teraflops rather than gigaflops. [1]

Finally, all of this has to be accomplished in a system that weighs less and costs less than the current 15 kg and approximately $100K USD. Current weight and cost is down considerably from these values a few years ago [1], but we would like to see a system that weights no more than 5 kg and costs no more than $25K USD by 2014, so that on June 12, 2014 at 17:00 the kick-off in Sao Paulo [3] will move right out of video screens causing viewers to duck all across the planet!

[1] H. Postley. (2012) "Sports: 3-D TV's Toughest Challenge." *IEEE Spectrum* [Online] http://spectrum.ieee.org/consumer-electronics/audiovideo/sports-3d-tvs-toughest-challenge Accessed: 2012 November 19
[2] Fédération Internationale de Football Association (11 July 2011) Almost half the world tuned in at home to watch 2010 FIFA World Cup South Africa™ [Online] http://www.fifa.com/worldcup/archive/southafrica2010/organisation/media/newsid=1473143/index.html Accessed: 2012 November 20
[3] Fédération Internationale de Football Association (1994-2012) Destination: Estadio do Maracana – Rio De Janeiro [Online] http://www.fifa.com/worldcup/destination/stadiums/stadium=214/index.html Accessed 2012 November 29

You may remove this page in order to use it when answering questions 25-27.

Case Study #1: *Giardia Lamblia* Water Contamination

An epidemic of giardiasis occurred in 1992 in Small City. The outbreak was caused by contamination of the municipal water system with *Giardia lamblia*, making it unsafe to drink. The municipality of Small City owned and operated a water treatment plant, but the type of treatment provided did not prevent *Giardia lamblia* from contaminating the drinking water. Before the cause of the epidemic could be identified, 6,000 people became ill and required medical attention. Boil water advisories lasting up to nine months were issued to 80,000 people and to 40 industries. Beavers resident in the Burbling Brook Reservoir were identified as the immediate source of Giardia cysts in the water supply. These animals carried the infection from upstream tributaries to the reservoir, which was the water source for area residents and businesses. A malfunctioning wastewater treatment plant and a number of improperly constructed septic systems were also located on these tributaries.

A study was conducted to estimate the value of losses caused by the epidemic, and these are shown in Table **3**:

Table 3

Cost Category	Estimated Cost
Loss due to illness	$27,300,000
Providing water to residents during period of boil water advisories	$40,700,000
Providing water to industry during period of boil water advisories	$14,700,000
Total	$82,700,000
Cost per capita	$1,033.75

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Case Study #2: RFP - Safe Wireless Power through Invisibility

Client: One Ring Enterprises

In his 1941 science fiction short story, "Reason", Issac Asimov proposed a space solar power system (SSPS) coupled with microwave-beamed power as a method for wireless transmission. Since that time, this idea has moved from fiction to reality; the United States, Japan, European Union, and India are pursuing the dream of nearly limitless, clean, renewable power [1-4]. One obstacle facing these initiatives is the concern for public safety. Non Governmental Organizations are concerned about the health risks of a focused beam of microwave radiation transmitting 1 GW of power, especially if a 747 were to enter the beam.

Since 2006, David Schurig and David Smith of Duke University have done more than their share to move science fiction into science fact. Using their theory of "Transformation Optics" they have developed an invisibility cloak. This cloak is currently limited to only working on microwave radiation and from a single direction [5-6], which may disappoint Harry Potter fans, but our organization sees true potential in using this technology to alleviate safety concerns associated with the wireless transmission of power from SSPSs.

We are interested in how this technology could make any or all or the following safer:

- Commercial Aircraft
- Private Aircraft (including small airplanes, lighter-than-air crafts, and ultralights)
- Ground-based bystanders living around the microwave reception sites

The design must:

- Be affordable.
- Prevent human casualties.
- Not have significant negative environmental impacts (compared to the positive environmental impacts)
- Function for power transmissions rates that proposed SSPS are capable of generating.
- Be easy to retrofit into existing systems (ie., no requiring new 747's).
- Be easy to maintain.
- Have a life expectancy comparable to the technology on which it is retrofitted.

[1] T. Hornyak (2008, Jul), "Farming solar energy in space," Scientific America [Online]. Accessed December 03, 2012. Available: http://www.scientificamerican.com/article.cfm?id=farming-solar-energy-in-space
[2] P.E. Glasser et al. (1974), "Feasibility study of a satellite solar power station," NASA [Online]. Accessed Dec 03, 2012. Available: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19750015611_1975015611.pdf
[3] L. Edwards (2010, Jan), "European space company wants solar power plant in space," Phys.org [Online]. Accessed Dec 03, 2012. Available: http://phys.org/news183278937.html
[4] National Space Society (n.d.), "National Space Society Announces the Kalam-NSS Energy Initiative," National Space Society Blog [Online]. Accessed Dec 03, 2012. Available: http://blog.nss.org/?p=2214
[5] J.B. Pendry, D. Schurig, & D.R. Smith (2006, Jun), "Controlling electromagnetic fields," Science [Online]. Accessed December 01, 2012. Available: http://www.sciencemag.org/content/312/5781/1780.abstract
[6] N.Landy(2012),"Full-parameter unidirectional metamaterial cloak for microwaves," Nature Materials [Online]. Accessed Dec-01-2012. Available: http://www.nature.com/nmat/journal/vaop/ncurrent/abs/nmat3476.html

You may remove this page in order to use it when answering questions 31-33.

Case Study #3: Problem Statement (Written by a student team based on Case Study #2)

Our client, One Ring Enterprises, is looking for a new safety system that will enable power to be beamed by microwave from a solar power system in space. While the functional basis of the overall system would be transmission of power, the specific design the client is seeking from our team would be to secure mass, specifically to shield aircraft and humans on the ground near the microwave reception sites from the effects of microwaves transmitting beams of up to 1 GW of power from space to the earth.

The design will fill a much needed gap on earth. Due to global warming and over-use of fossil fuels for energy, the earth is rapidly running out of power and heading toward economic destruction. Renewable sources for electricity are needed urgently in order to avoid catastrophe [1].

Our team is committed to a design that is:

- Reasonably economical considering the technologies involved
- Safe for humans, aircraft, buildings and the environment
- Functional at the levels of transmission foreseen for SSPS
- Compatible with current systems (i.e. aircraft) requiring no major modifications
- Ergonomic and intuitive to maintain

[1] Wikipedia contributors. (28 Nov 2012) "World energy consumption." *Wikipedia, The Free Encyclopedia.* [Online] http://en.wikipedia.org/w/index.php?title=World_energy_consumption&oldid=525387684. Accessed: 2 Dec 2012