EDSGN 100
Design Project #2
Preliminary Design Review

ALCOA Aluminum Redesign
Introduction to Engineering Design
EDSGN 100 Sec 024

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ALCOA Aluminum Redesign

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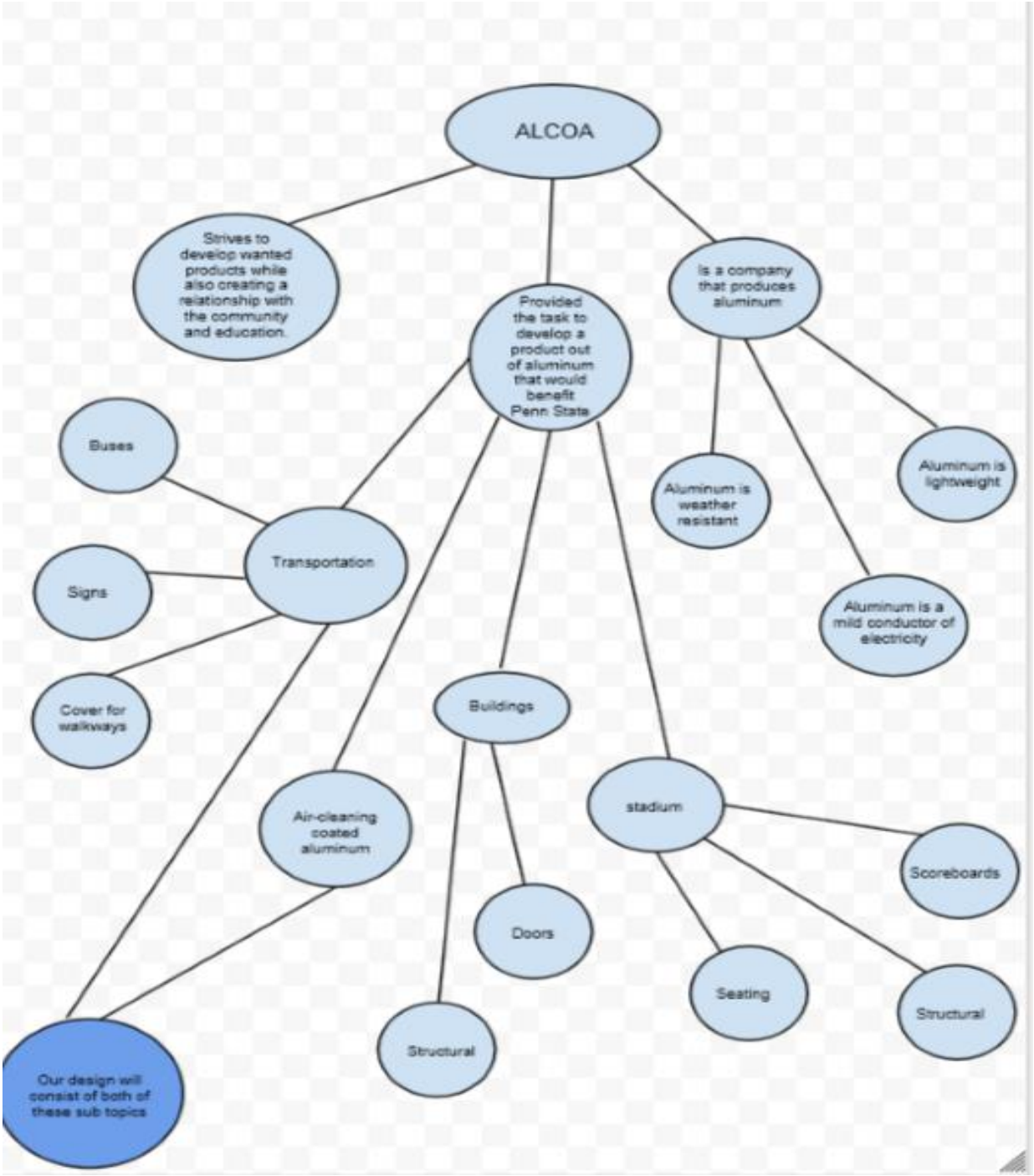
1.0 Introduction

The focus of the redesign is to apply aluminum to a current feature of Penn State University Park campus in way that makes the selected feature more environmentally friendly in a way that is valuable to Penn State. The redesign will involve an evaluation of the current market situation to determine factors that will determine the success of the redesigned product and applying that knowledge to the generation of new concepts and, eventually, the selection of an appropriate alternative to the current product. The following sections will explain the path to choosing an applicable and relevant substitute for the current product on campus.

1.1 Project Focus

In order to narrow the scope of possibilities Alcoa presented with such an open-ended task, a concept map was generated to assist in brainstorming a focus to the project. The concept map (appear below) looked at various components of Alcoa as a whole and created branches that eventually turned into concept ideas.



After the idea map was generated, main concepts were chosen and split into categories that define what the main concept is composed of.

Broad Concepts:

1. Clean Air
    a. Exhaust pipe lining
        i. Cleans bus emissions
    b. Reynobond™ aluminum siding
        i. Cleans surrounding vehicle emissions
2. Transportation
    a. Buses
        i. CATA bus
    b. Signs
    c. Cover for walkways
3. Buildings
    a. Doors
    b. Structural
4. Stadium
    a. structural
    b. seating
    c. scoreboard

Out of the four main concepts, it was decided that the CATA bus affects the college campus through transportation but also through air emissions. These emissions can be reduced through the use of Alcoa's recently developed Reynobond Aluminum, which clean the air in its vicinity. The possibility to combine both the transportation and clean air concepts through the redesign of the CATA busses makes the busses the clear favorite for the focus of the project.

1.2 Mission Statement

During a recent project launch, Alcoa tasked teams with using aluminum in an innovative fashion to improve the impact a system at Penn State University Park has on the environment. To reduce the amount of air pollution on campus and the quantity of gas consumed, the CATA Buses will be targeted in the redesign, with aluminum being used to clean the air and reduce the overall vehicular weight.

2.0 Customer Needs Statement

To provide a basis for brainstorming redesign concepts, an online survey was created at the beginning of the project that asked consumers their thoughts on what can be improved on campus with aluminum. This survey was largely unsuccessful, mainly due to a lack of response and knowledge on the topic. Following this failure, an idea to redesign the CATA buses was generated, providing a new source for customer needs: CATA.

Since the mission of the redesign project is to convince Alcoa, Penn State, and the manufacturer, in this case CATA, to implement the redesign, it was fitting that the customer needs should come from these three entities. An examination of the Alcoa website provided insight to Alcoa's mission to "[partner] to create innovative and sustainable solutions that move the world forward," ("Vision and Values" 2013). Alcoa approaches their mission statement through the development of lightweight alloys, such as aluminum, and the application of these alloys in such a way that it promotes sustainability. Penn State and CATA were found to be looking for ways to increase sustainability in the CATA buses, thus saving both money in the long run, as well as a way to decrease emissions on and around campus.

From the examination of these three entities, it was determined that emissions, gas usage, cost, and safety are the four most important components of the buses to the entities, therefore providing the main parts of the customer needs.

2.1 Revised Mission Statement

In order to incorporate aluminum on the Penn State University Park campus, the CATA Buses can be redesigned to decrease the amount of emissions produced by the buses and the surrounding cars, as well as the gas usage can be decrease through the decrease in weight between aluminum and steel.

3.0 External Search

Following the customer needs assessment, an external search was performed to compare the aspects of current products on the market. This information was important to the redesign because it provided insight on the current position of products on the market, as well as allowed an exploration on current patents so that none would be violated in the creation of the redesign.

3.1 Literature Review

Literature on the web was utilized to examine companies and products throughout the redesign process, providing a database of information that conclusions could be drawn from.

"About CATA." *CATA*. CATA, 2009. Web. 15 Nov. 2013. <http://www.catabus.com/AboutCATA/index.html>.

"Capital Area Transportation Authority." *Wikipedia*. Wikimedia Foundation, 11 Feb. 2013. Web. 17 Nov. 2013. <http://en.wikipedia.org/wiki/Capital_Area_Transportation_Authority>.

"Cost: Facing the Challenge." *WorldAutoSteel*. World Steel Association, n.d. Web. 17 Nov. 2013. <http://www.worldautosteel.org/why-steel/cost/>.

"Homepage." *Environmental and Energy Study Institute*. EESI, n.d. Web. 17 Nov. 2013. <http://www.eesi.org/>.

"Vision & Values." *Alcoa -- About: Vision & Values*. Alcoa, 2013. Web. 15 Nov. 2013. <http://www.alcoa.com/global/en/about_alcoa/vision_and_values.asp>.

“Welcome to New Flyer!” New Flyer, n.d. Web. 17 Nov. 2013. <http://www.newflyer.com/>.

3.2 Patent Search

A patent search was then conducted to examine the main components of a CATA Bus.. From this process, the four main components of the bus were determined and their functions explored as well.

Function		Art		
	Aluminum alloy wheels for minibus Airbus	Aluminum coating on exhaust piping for automobiles	Hollow frame member of aluminum alloy of vehicle body frame	Aluminum alloy bracket for vehicle seats
Wheels	CN202965795 U			
Exhaust Pipe		EP0705914 A1		
Vehicle Frame			EP1398247 B1	
Seats				CN201371828 Y

3.3 Benchmarking

In order to consider possible redesigns, the specifications of current CATA busses must be taken into account. After comparing the relative performances of the current fleet of CATA busses, including busses of multiple fuel types and producers, the current bus types were found to be relatively equal although some busses slightly stood out. After full analysis of their performances, it was found that the New Flyer C40LF was the best model to work off of as an example due to low relative price with competitive specifications.

Bus	Emissions g/mi	Safety Rating	Weight (lbs)	Gas Usage	Fuel Type	Cost
Orion V	4	3	4	2	CNG	3
New Flyer XN40 Xcelsior	2	3	3	2	CNG	2
New Flyer C40LF	3	3	3	3	CNG	4
ElDorado National EZ Rider II	1	3	1	4	Diesel	3

Bus	Emissions g/mi co2, co, thc, nmhc, nox	Safety Rating	Weight (lbs)	Gas Usage	Fuel Type
Orion V	2050, 6.8, .4, .023, .43	Safe at 45 mph	26,350	.7mi/lb (3.962 mpge)	CNG
New Flyer XN40 Xcelsior	2207, 39.2, .04, .033, .497	Safe at 45 mph	28,500	.64 mi/lb (3.6224 mpge)	CNG
New Flyer C40LF	2072, 8.3, .44, .033, .633	Safe at 45 mph	28,360	.76 mi/lb (4.3016 mpge)	CNG
ElDorado National EZ Rider II	N/A	Safe at 45 mph	35,000	5.27 mpg	Diesel

3.4 Global Considerations

Although this project is to be implemented on just the Penn State University Park campus, the technology created has the potential to be utilized around the world. Developing countries could use the buses' Reynobond™ aluminum siding to filter their air since they typically don't have many eco-friendly options for creating power in their countries. On other campuses, it could be used in a similar manner to Penn State, filtering the emissions of other cars, while also using less gas themselves, saving the universities' money in the long run.

3.5 Product Dissection

While it was unfeasible to dissect an actual CATA bus for redesign, it was feasible to think through the general design of a bus and identify the main components that make it inefficient. From this examination, it was decided that there are three main components of the buses: siding, frame, and mechanical parts. While all of these components need to be functioning properly for the bus to work, they have a generally low level of interconnectivity, demonstrated by the fact that if one part is changed, it doesn't directly affect another component. For example, if the siding of the bus is changed to a lighter material than it currently is, neither the siding nor mechanical parts will have to drastically change to allow the bus to continue functioning in the same manner. The only slight impact of the lighter material would be that there is less stress on the engine since the bus would be lighter as a whole and, therefore, easier to propel.

The product dissection also determined that there were very few, if any, non-essential parts on the bus. Since the bus is already meant to be a cheap way for college students to travel around campus and the surrounding area, the bus companies seem to have already cut the unnecessary amenities that are normally in buses. This makes it easier to identify the exact places in the bus to redesign since there are no other distractions while evaluating the impact of each component.

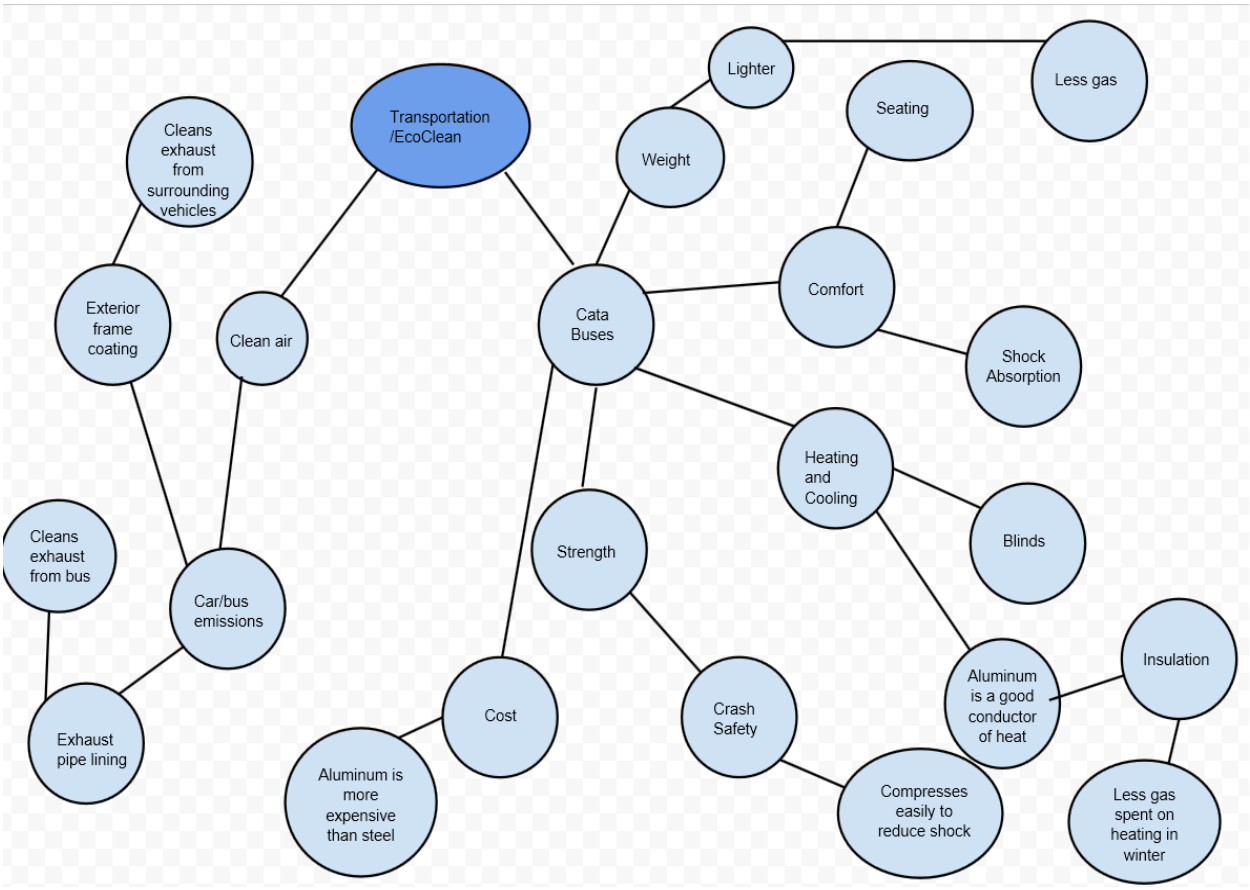
4.0 Internal Search

After finding information about bus companies and the vehicles used through external search, an internal search must be led in order to determine how to generate the best

product. This allows the ability to pick out factors that will suit best for the bus companies and also determine factors that would not be favorable in the companies' eyes.

4.1 Concept Generation

Following the external search, a new idea map was generated in order to organize the conclusions drawn from the previous processes. It divides the redesign into two phases: the clean air initiative and the CATA bus efficiency. From there, concepts were generated on how to maximize the success of these two main phases, thus creating multiple branches that represent potential new concepts. The idea tree is as follows:



The key components of the concept map are listed below and comprise the list of possible concepts to include in the redesigned CATA Bus.

1. “Clean Air” Aluminum
    a. Exhaust pipe lining
        i. Cleans bus emissions
    b. Reynobond™ aluminum siding
        i. Cleans surrounding vehicle emissions
2. Strength
    a. Crash safety (weaker than steel) (Aluminum infrastructure)
        i. Compression to absorb shock
3. Heating and Cooling
    a. Aluminum insulation
        i. conductor of heat
        ii. less energy used on heating in winter
    b. Cooling blinds
        i. less energy used on air conditioning in summer
4. Weight
    a. Aluminum = low weight
        i. less fuel used/ emitted
        ii.

These concepts were chosen in concept generation since they seem to have the highest level of impact on either the quality of air on campus or on the efficiency of the busses on campus. Choosing these concepts and applying them to the CATA busses will make them more environmentally friendly, thus fulfilling the mission statement.

4.2 Concept Selection

The ideas formulated in concept generation were then organized and developed into concepts for concept selection. The ideas were each assigned a letter and placed in a key, creating an organized view of all the potential redesign components of the bus. The key can be seen in Figure 4.1.

Figure 4.1: Redesign Components Key

KEY
A = Exhaust Pipe Lining
B = Reynobond Aluminum Siding
C = Regular Aluminum Siding
D = Aluminum Infrastructure
E = Steel Infrastructure
F = Aluminum Insulation (Interior)
G = Cooling Blinds
Emissions Effective = AB
Gas Efficient = CDFG
Gas Efficient 2 = BDFG
Cost Effective = DFG
Environmentally Friendly = ABDFG
Original CATA Bus = E

Following the creation of the key, a concept matrix was created to evaluate each design. The designs were created by generating combinations of the components from the key, each with a specific purpose in mind that is accomplished with the components. For example, concept AB (Exhaust pipe lining and Reynobond aluminum siding) was introduced in an attempt to create an emission-efficient bus. Five concepts were constructed in this fashion, with a sixth being the current CATA bus, thus serving as the benchmark for the rest of the concept matrix.

After the concepts were constructed, they were evaluated in four different categories: cost, safety, gas usage, and emissions. Each individual category was then weighted, providing more power in the concept selection to the more important categories. Gas usage and emissions were clearly the most relevant categories to the mission statement of making CATA busses more environmentally friendly, causing them to receive 35% weightings, while cost received a 25% weighting and safety a 5% weighting. Cost was rated above safety since the targeted entities were interested in creating a sustainable and eco-friendly bus system that is also cost efficient.

Each concept was graded on a scale from 1-5, with 1 being the worst and 5 the best. The ratings were based off of what concept ‘E’ received, since it served at the current CATA bus benchmark. After each concept was rated, it was determined that concept ABDFG was the best option. No combinations were considered because the concepts were already so closely related that any combinations would have resulted in an overlap in ideas.

Figure 4.2: Concept Selection Matrix

		Concepts															
		AB		CDFG		BDFG		DFG		ABDFG		E		x		x	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Crash Safety	5%	3	0.15	2	0.1	2	0.1	3	0.15	2	0.1	5	0.25		0		0
Cost	25%	3	0.75	2	0.5	1	0.25	2	0.5	1	0.25	4	1		0		0
Gas Usage	35%	2	0.7	5	1.75	5	1.75	5	1.75	5	1.75	2	0.7		0		0
Emissions	35%	5	1.75	3	1.05	4	1.4	3	1.05	5	1.75	2	0.7		0		0
			0		0		0		0		0		0		0		0
			0		0		0		0		0		0		0		0
			0		0		0		0		0		0		0		0
			0		0		0		0		0		0		0		0
			0		0		0		0		0		0		0		0
			0		0		0		0		0		0		0		0
	Total Score	3.35		3.40		3.50		3.45		3.85		2.65		0.00		0.00	
	Rank																
	Continue?	No		No		No		No		Yes		No		x		x	