How Did KAIST Invent, Design, Develop, Fund, and Implement Two Internationally Recognized, Highly Innovative, Large Engineered Systems – OLEV and MH – in Two Years?

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Abstract
KAIST, a research university in Korea, has developed and installed two major engineered systems (OLEV and MH) in two years. These projects are unique in many respects:

- highly complex engineered systems innovated and implemented by a research university to solve major problems society and humanity are facing;
- internationally recognized as being most innovative; implemented (i.e., installed) in two years after the basic idea was conceived and the project was funded;
- secured major funding (close to a total of about $90 million for two projects);
- filed more than 200 international and Korean patent applications for each project;
- created a new academic field of “Green” transportation.

OLEV (O-Line Electric Vehicle) is a transport vehicle -- car, bus, train, etc. -- that receives electric power (more than 10 Kw at 85% efficiency) wirelessly, while in motion, from an underground power supply system. It has a small battery on board for autonomous operation even on roads without the underground power supply system. It was conceived to eliminate internal combustion engines that emit CO₂. It satisfies all the standards for safety, reliability, and cost for commercial operation. OLEV buses are commercially operating (at profit) at the Seoul Grand Park. They took passengers around at the 2012 Yeosu World Expo, and will be providing clean transportation for general public in Gumi City in Korea in July 2013. Several cities in many countries, including the United States, are considering the adoption of OLEV. The World Economic Forum at Davos selected OLEV as one of the Ten Emerging Technologies (ET) in 2013 and as one of the major inventions of 2010 by the Time magazine.

MH (Mobile Harbor) eliminates the need for large harbors that are environmentally unacceptable, cost billions dollars to build, become targets for terrorist attacks, and are not adoptable in many countries with complicated terrains. It eliminates the need to dig the seabed or the riverbed to accommodate large container ships going into harbors. Ships
are basically designed to move in deep waters at high speed with least resistance, i.e., the functions associated with deep water mobility are coupled with the function requirements of moving into harbors at low speeds and turning with small arcs. These ships are not designed to come into crowded, shallow harbors, at low speeds. MH goes out to large container ships moored in deep open waters about 10 to 50 miles away from the shore to transport containers from the ship to the final destination on land. MH does not need deep waters or large harbor facilities to operate. A 1:3 model MH (about 20 meters high) was built and tested in open sea with waves and wind, in addition to simulation and testing in a water basin built at KAIST. This system may be installed in the United States to alleviate many problems that a large harbor would entail, including being environmentally unacceptable. MH was chosen as one of the most promising emerging technologies. MH is a “Green” technology.

There are many issues with all current transportation systems because they consume too much energy, pollute the air, environmentally unacceptable, and cost too much to install. Conventional transportation systems that have been refined for decades do not satisfy the requirement of being “green”. KAIST has established a new graduate school to deal with all of these issues with ground, sea, and air transportation. The KAIST CCS Graduate School for Green Transportation offers masters and doctorate degrees.

The fact that these projects – OLEV and MH – was completed in two-years, from concept to implementation, at a fraction of cost that would have been incurred in major corporations for similar projects, is a lesson that major corporations may wish to emulate in developing new products. At the same time, universities have not done well in teaching the design of complex systems, although students in many disciplines, including economics and political science, must learn the synthesis, design, and operation of large systems. They must learn how to identify the problem to be solved, design large systems, and execute the design and implement to minimize the time needed for the creation of large systems. They should incorporate axiomatic design and system design in their courses.

In this presentation, the history of the OLEV and MH projects (including the genesis of the projects, invention of key concepts, securing the funding for the projects, design and construction, etc.) will be reviewed.

The underlying ideas behind these two projects were invented based on the systematic methodology of Axiomatic Design. The detailed design and execution of these complex systems, ranging from design to actual operation, in such a short period of time was possible because of Axiomatic Design. We developed many other innovative products and processes at MIT using AD such as Mixalloy, microcellular plastics, laminated plastics, USM high pressure molding, electrostatic charge decay NDE technique, and others.