Early in 1965, Governor Brown of California initiated a series of pioneering efforts to investigate the applicability of the systems approach to special social-economic problems. Areojet was selected to conduct the study of waste management. Among other assignments, we were required in the study to evaluate current technology as it relates to pollution and waste control.

However, before I discuss this subject in detail, I would like to define the term "systems approach." It is simply the name for a technique of evaluating all the factors involved in a complex problem and determining possible optimum approaches. "Optimum" is a flexible term, but in general it means the best answer consistent with the results desired, the current state of technology, the expenditure required, and the time available. This approach, initially developed by the telephone companies, has been further refined by the aerospace industry, whose member companies have almost continuously addressed themselves to major problems of defense and space technology which are characterized by great complexity and by financial, technological, managerial, and time constraints.

Let me hasten to state that the systems approach is by no means a magical solution to our technical problems or a substitute for management experience. It is simply an efficient technique for data gathering and analysis which permits us to examine and evaluate huge amounts of complex and interrelated data and to direct intricate research, development, and production tasks in the most economical way. In this role, it can help us do the following:

1. Define the problem in terms of the requirements, i.e., input, output, conditions of use, reliability, and constraints.
2. Identity functions which must be performed to satisfy requirements.
3. Define the interrelationships of the functions, feasible trade-offs, and the interfaces between subsystems.
4. Optimize functions.
5. Formulate plans to achieve the desired output within the constraints.
6. Define the development activities needed to produce the final operating system, or intermediate data.
7. Design the final operating system based on previous input.

Aerojet-General has successfully used the systems approach in many large programs; in defense, space exploration, nuclear energy, water desalination, material handling, and the life sicences. Some of our well-known systems programs include those for the development of liquid, solid, and nuclear rocket engines, such as the Polaris, Titan, Minuteman, Nerva, and Apollo. In addition, Von Karman Center, which I represent, is currently applying systems engineering techniques in a number of other areas, including:

Development and production of Mark 46 torpedoes for the U.S. Navy.

Development and manufacture of space payloads for the Air Force.

Design and development of the SNAP-835-kilowatt space power supply for NASA.

Various programs in the life sciences, including the toxicology laboratory for the Air Force at Wright-Patterson Air Force Base.

Research and development for the Office of Saline Water on reverse osmosis—one of the more recently developed methods of desalting sea water and purifying polluted water.

These and other development areas occupy the attention of a staff of approximately 4,400 people, including some 1,700 engineers and scientists with a broad range of specialities and capabilities.

I'd like to begin my discussion of the adequacy of technology for pollution abatement with a brief review of the principal conclusions of the California Waste Management Study. I believe that they bear directly on the question and that they apply not only to California, but to the Nation as a whole.

1. Pollution is the most obvious result of a larger problem—that of our present failure to satisfactorily manage liquid, solid, and gaseous wastes.
2. Continued, substantial degradation of the environment will occur if present waste-handling practices are perpetuated.
3. Research and development are urgently required to achieve the following objectives:

The establishment of correlations between characteristics and quantities of effluents and the degree of environmental pollution.

The development of the economics of pollution; i.e., the financial penalties attributable to pollution compared with the costs of control.

The establishment of meaningful and environmental standards, which in turn define what our systems must be able to do.