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COMPUTER-AIDED DESIGN AND FABRICATION: AN OVERVIEW

The engineers, craftsmen, and clerical personnel of the Engineering and Fabrication Branch have long comprised a highly creative element in the programs of the Applied Physics Laboratory. These skilled people have a tradition in design and fabrication that dates to APL's early work in fuzes, missiles, and radars and that now spans a range of applications as broad as the work of the Laboratory itself. The skills of our staff have been applied from submarine detection in the oceans to spacecraft systems in vacuum, from small biomedical implants to large shuttle telescopes, from measurements of photons on earth to measurements of particles around Jupiter, from radar systems on surface ships to navigation systems on satellites, from measurements in the hot exhaust plume of a ramjet to those at cryogenic temperatures in low-temperature devices.

When the Technical Services Department was formed in 1982, a commitment was made to revitalize the facilities and laboratories required to support future technical activities. This was required because technological change occurring outside of APL was advancing rapidly on all fronts, ranging from dense, fast, microelectronic circuits to more precise cutting and machining tools. In order to continue developing innovative hardware that would stay abreast of these changes, we too had to leap into that future. To implement the changes, the Engineering and Fabrication Branch has under way several endeavors that, when completed, will make it possible to provide the essential services of the future:

- Computer-aided design/computer-aided engineering (CAD/CAE)
- Computer-aided manufacturing (CAM)
- Very large scale integrated (VLSI) circuits
- Materials Laboratory
- Quality assurance

The following articles provide a snapshot of the progress made and highlight some of the exciting capabilities now available.

The distinction between CAE and CAD is not always well defined because of the overlap in capabilities. CAE provides the engineer with a powerful, computer-based tool that allows design, simulation, and testing to be performed efficiently. CAD enhances the designer's ability to do detailed design layout and drafting in preparation

for fabrication. The CAE tools help designers throughout APL to create and conceptualize designs. The CAD tools help designers, primarily in the Engineering and Fabrication Branch, to develop imaginative detailing and packaging schemes for the implementation of the CAE designs. The article by West et al. describes both the CAD facility, where mechanical and electrical design drafting is performed in preparation for fabrication, and a CAE network that is now in operation. The article by Schachtner and Ahlbrand presents a variety of hardware developments that have been performed using CAD. Finally, the article by Rothman and Ecker highlights some of the capabilities that the CAE network provides to mechanical engineers.

Computer-aided tools do not stop with engineering and drafting. Rather, with the development of numerically controlled machines and suitable computer interfaces, the CAD output can serve as the input to CAM and computer-aided test and inspection. The articles by Hagler and by Strider and Wagner describe some of the capabilities numerically controlled machines have introduced into mechanical and electrical fabrication and provide some examples of the work that has been done using these tools.

The progress in VLSI microcircuits has afforded many opportunities to insert the technology innovatively into the wide range of APL systems. Toward that goal, work has been focused on the design, acquisition, packaging, and testing of VLSI systems. The article by Charles et al. provides an overview of those activities.

Associated with the VLSI technology is a major change in packaging schemes needed to provide a high number of input/output connections. Packages called chip carriers—hermetic devices with input/output connections at the periphery—provide reduced size and weight over previous packaging schemes. As a result, 55 percent of the integrated circuits manufactured worldwide in 1990 are projected to be packaged in chip carriers, compared to 11 percent in 1985. The article by Clatterbaugh and Charles describes thermomechanical modeling of the package. The modeling provides design guidelines for making reliable attachments that will survive stringent environmental conditions and operational scenarios. Once the package is selected, the VLSI technology requires high-density interconnection at the

electrical board level between the packages. The development of a processing laboratory capable of providing multilayer ceramic boards for chip-carrier packages is described in the article by Romenesko et al.

The importance of the selection of materials and the rapid emergence of high-performance composite materials will change the types of structures used in the future. A Materials Laboratory has been established to provide support in the fields of chemical analysis, metallurgical engineering, mechanical properties determination, materials engineering, and composite structures development. The article by Jamison et al. provides a case study of the advantages that composites would provide over metals in a typical spacecraft application.

While all this technological change is occurring, we cannot lose sight of the fact that the machines by themselves are only tools to assist creative people. It is important that people know how to use machines correctly and that the machines assist them in doing their work. The result has to be a quality product, appropriate to the customer's needs. Since responsibility for quality is shared by everyone, inputs regarding how to maintain and improve quality are needed from everyone. A Quality Teams Program encourages the staff to provide the inputs. The article by McHenry et al. describes the objectives of the program and some of our experiences with it to date.

Finally, a significant aspect of the revitalization effort is APL's planned replacement of the outdated Butler Buildings that now house the engineering and fabrication activities. A new permanent structure will result in its largest and most versatile laboratory and office facility. A model of the proposed building developed by James Goldstein and Partners is shown in Fig. 1. Its five

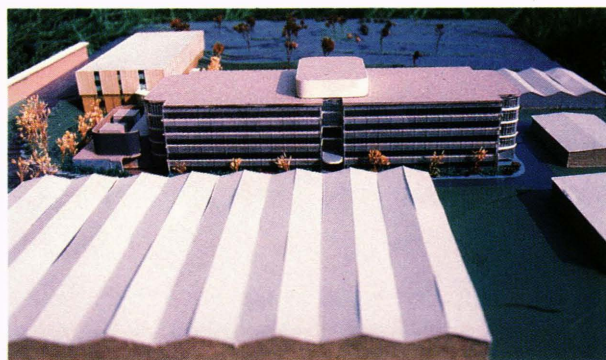
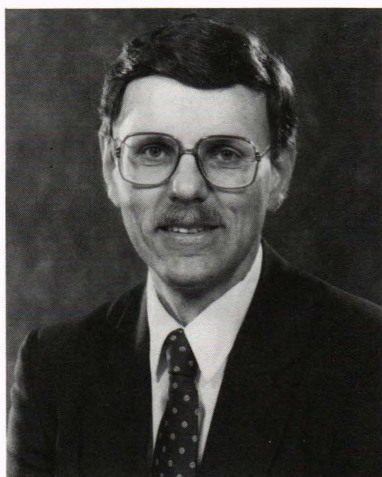


Figure 1—The architectural model of the planned new high-technology facility at APL. The model provides a westward-looking view of the proposed new five-story building in relation to the East Annex Butler Building (foreground), the Microelectronics Laboratory and the Paint Shop (right), and the main Laboratory buildings (left). While increasing site density with 176,500 gross square feet of floor space, a counterbalancing environmental tactic is being used that widens the separation between buildings and enlarges or creates "green spaces."

stories will connect to several adjacent existing and future buildings, and its location will permit an intensification of land use near the centroid of existing operations. The new building will provide a major increase in the quality of space for high-technology laboratories (including cleanrooms) and offices. Ground-breaking for the new building is scheduled for the spring of 1987, with initial occupancy of the upper floor offices occurring in late 1988 and of the lower floor laboratories in early 1989.

It is with great excitement and enthusiasm that the engineering and fabrication activities move into the future.

THE AUTHOR



KENNETH A. POTOCKI is supervisor of APL's Engineering and Fabrication Branch and assistant head of the Technical Services Department. Born in Chicago in 1940, he received his Ph.D. in high-energy nuclear physics in 1968 from Indiana University. Since joining APL in 1970, he has conducted oceanographic tests using acoustic and infrared technologies for the Submarine Technology Division and has managed the Navigation Group in the Strategic Systems Department. As a member of the Space Department, he was program manager for the HILAT satellite and was engineering manager of the Hopkins Ultraviolet Telescope Program with the Center for Astrophysical Sciences at The Johns Hopkins University. In his current assignment, Dr. Potocki chairs the Independent Research and Development activities in VLSI and in microwave/millimeter wave monolithic integrated circuits. He is an instructor in the G.W.C. Whiting School of Engineering Part-Time Engineering Program at APL and is a past member of the APL Advisory Board.