

(WITH APOLLO GUIDANCE/NAVIGATION ADVANCE)

The Instrumentation Laboratory of the Massachusetts Institute of Technology plays an important role in undergraduate and graduate educational programs offered by the Institute.

The Laboratory provides an environment where graduate students, working under the close personal supervision of highly skilled faculty, engineers and scientists, are able to carry out thesis research leading to advanced degrees. In addition, research performed by Laboratory's faculty and professional staff generates new technology and knowledge for courses that are quickly incorporated into the regular Institute curriculum.

The Laboratory designs and develops guidance, navigation and control systems for missiles, airplanes, helicopters, satellites, ships, submarines and spacecraft -- all under research contracts from such various branches of the federal government as the Army, Navy, Air Force, Federal Aviation Administration and the National Aeronautics and Space Administration.

The research work itself, of course, is at all times the responsibility of the Laboratory's own staff of scientists and engineers, headed by Professor Charles Stark Draper, and the vast bulk of research performed at the Laboratory is done by this staff. Nevertheless, the availability of the Laboratory and its skilled staff provides M.I.T. with an educational facility of great value.

An illustration of how the Laboratory's work program is closely linked to the Institute's educational program is the fact that Dr. Draper himself was for many years both Head of the Department of Aeronautics and Astronautics as well as Director of the Laboratory. Scores of his students from the Department have performed their thesis research under his

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supervision at the Laboratory and have gone on to occupy positions of major responsibility in national defense and space programs. Dr. Draper was succeeded as Head of the Department last July 1 by Dr. Raymond Bisplinghoff, Deputy Head of the Department who had been on leave of absence since 1962 while serving first as Associate Administrator of NASA and later as Special Assistant to the NASA Administrator. Dr. Bisplinghoff has been on the M.I.T. faculty since 1946.

M.I.T. receives no fees or profits for the work the Laboratory does. Sponsoring agencies simply reimburse the Institute for the costs incurred in operating the Laboratory. As a national resource of talent and skill built up over the years at the request of sponsoring federal agencies, M.I.T. makes the Laboratory available to help to the extent that it can in the achievement of national goals. But the benefits that accrue to M.I.T. itself are the educational contributions the Laboratory makes to the Institute as a whole.

One of the Laboratory's largest undertakings has been the design and development of the guidance and navigation system that three U.S. astronauts will use to steer their Project APOLLO spacecraft to the moon and back -- a system that will soon be given its first flight test during a suborbital unmanned mission from Cape Kennedy, Fla., to the mid Pacific Ocean.

Over the five years that the Laboratory has been designing the APOLLO guidance and navigation system, for example, 45 theses have been completed or are underway based on APOLLO research. These are theses that lead to doctor of science, engineer, master of science, and bachelor of science degrees. Since some theses are done jointly by more than one student, the total student participation under APOLLO alone has been 56.

APOLLO is by no means the only project in which the Laboratory is involved. Others include such defense projects as POLARIS, POSEIDON, TITAN and SABRE. All make similar contributions toward the education of young engineers and scientists.

In the academic year 1964-65, for example, there were 79 advanced degrees

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awarded based on research carried out by student research assistants at the Laboratory, including 10 doctoral degrees, four engineer degrees, 64 master of science degrees, and one bachelor of science degree. The number of advanced degrees based on research performed at the Laboratory has been averaging about 60 a year for the past 10 years.

Although the Laboratory itself is a part of the Department of Aeronautics and Astronautics, not all degree candidates working on Laboratory projects are from this one department. Others represented are the Departments of Electrical Engineering, Mechanical Engineering, Physics and Mathematics.

Five NASA astronauts hold advanced degrees which they earned while working at the Laboratory prior to being selected for astronaut training. They are Lt. Col. David R. Scott, Maj. Edwin E. Aldrin, Jr., Russell L. Schweickart, Lt. Cmdr. Edgar D. Mitchell, and Capt. Charles M. Duke, Jr. Schweickart worked at the Laboratory and later at the M.I.T. Experimental Astronomy Laboratory as a research scientist before he was picked for astronaut training. EAL itself grew out of Instrumentation Laboratory. EAL is directed by Professor Winston Markey, former Chief Scientist for the Air Force.

The Laboratory also provides an environment where graduates of military academies may receive advanced technical education. One of the most famous of the U.S. Air Academy graduates to receive an advanced degree while at the Laboratory was Capt. Brock Strom, who gained fame as the Academy's first All-American football player. He played tackle on the USAFA's undefeated once-tied Cotton Bowl team of 1958.

The Department of Aeronautics and Astronautics has been teaching classes in guidance and control developed out of Laboratory research for more than 25 years. One of the early faculty members who began teaching courses based on Laboratory research was Dr. Robert C. Seamans, Jr., who earned his own doctoral degree via thesis work at the Laboratory. Dr. Seamans today is Deputy Director of NASA.

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Professor Walter Wrigley, the Laboratory's educational director, began offering the first regular course in inertial guidance in the mid-1950's. Dr. Richard Battin, a mathematician who heads the APOLLO group that is working out computer programs for earth-moon trajectories for the various planned APOLLO missions, also teaches a course in astronomical guidance.

In all, more than 20 different courses, now offered as a regular part of the M.I.T. curriculum, have grown out of the research projects carried out at the Laboratory.

Dr. Draper is the Laboratory's founder and director and a pioneer in the development of inertial guidance, inertial navigation and inertial control systems for ships, submarines, airplanes, missiles and satellites.

Dr. Draper started the Laboratory just prior to World War II to develop lead-computing gyroscopic gunsights for Navy anti-aircraft guns. His Mark 14 gunsight was the first of its kind to reach the fleet and played an important role in naval engagements of World War II.

Toward the end of World War II, Dr. Draper and his associates developed gyro-stabilized gun-bomb-rocket sights for Air Force fighter planes and one of these saw extensive service in the Korean War aboard F-86 fighters.

Following World War II, Dr. Draper began applying knowledge of gyroscopic stabilization and feedback control to the original work done in this country on inertial navigation and guidance. Interest in this work actually originated with Dr. Wrigley's own doctoral thesis research supervised by Dr. Draper in the late 1930's.

Essentially, these are systems that have a gyro-stabilized inner member on which force-measuring accelerometers are mounted. Information from the accelerometers, isolated from the vehicle by gyro and gimbal stabilization, is then computed into information about changes in speed, position and direction of movement, all without reliance on any

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information from outside the vehicle. Navigation systems read out this information, guidance systems control the vehicle automatically and guide it to a terminal or target.

Dr. Draper made his first inertial system transcontinental test in an airplane flight from Massachusetts to Los Angeles in 1953, demonstrating feasibility of such systems. Since then from the Laboratory have come designs and design concepts for many now-operational systems. The Air Force THOR missile guidance system is based on Laboratory design concepts. The Laboratory designed and carried out engineering test of the inertial measuring unit in the Air Force TITAN missile guidance system. The Navy POLARIS missile guidance system also was designed, developed and tested by the Laboratory and the Laboratory is now at work on the guidance system for the new Navy POSEIDON. The first ship's inertial navigation system (SINS) was built, tested and demonstrated by the Laboratory. SINS are now used on nuclear submarines to enable them to navigate while remaining submerged for long periods.

Laboratory research and development on advanced inertial guidance, navigation and control systems for military vehicles is continuing. One important such project is SABRE, a new concept in missile inertial guidance that will guide a warhead all the way to its target.

In APOLLO, as in all of its programs, the Laboratory works closely with government-selected participating contractors in developing system designs, fabricating prototypes, carrying out engineering design tests and supporting operational use. System production and manufacturing, of course, is performed by industry. Of federal funds expended for design, development, test and procurement of these systems, the bulk goes to the participating industrial contractors for manufacture and fabrication, and only a small portion to support M.I.T.'s design, test and operational support efforts.