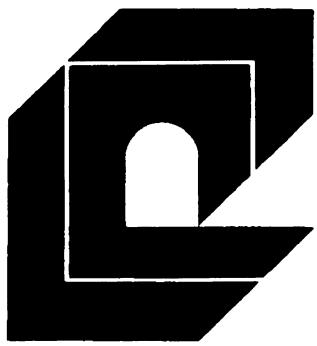

COLLEGE OF ENGINEERING
THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

INTELLECTUAL INVENTORY

February 1984

COLLEGE OF ENGINEERING: INTELLECTUAL ACTIVITIES

A Survey

The intellectual activities of the College of Engineering can be grouped under ten major engineering disciplines, or departments.

1. AEROSPACE ENGINEERING (AERO)
2. ATMOSPHERIC & OCEANIC SCIENCE (A&O)
3. CHEMICAL ENGINEERING (ChE)
4. CIVIL ENGINEERING (CIVIL)
5. ELECTRICAL ENGINEERING & COMPUTER SCIENCE (EE&CS)
6. INDUSTRIAL & OPERATIONS ENGINEERING (IOE)
7. MATERIALS & METALLURGICAL ENGINEERING (M&M)
8. MECHANICAL ENGINEERING & APPLIED MECHANICS (ME&AM)
9. NAVAL ARCHITECTURE & MARINE ENGINEERING (NA&ME)
10. NUCLEAR ENGINEERING (NUCLEAR)

In addition to research in these areas, there is also interdisciplinary research. The major research centers in the College of Engineering or the University of Michigan involving interaction among engineering disciplines or among both engineering and non-engineering disciplines are:

CENTER FOR ROBOTICS & INTEGRATED MANUFACTURING (CRIM)

Based in the College of Engineering, CRIM was formed by consolidating the relevant resources of six College departments (ECE, ME&AM, IOE, M&M, AERO, & NA&ME) as well as the Department of Computer and Communications Sciences in the College of Literature, Science, and Arts.

SPACE PHYSICS RESEARCH LABORATORY

Based in the College of Engineering, this laboratory conducts projects requiring the collaboration of people from Engineering (Atmospheric & Oceanic Science, Aerospace, Electrical & Computer Engineering), as well other disciplines, mainly Chemistry, and Physics.

CENTER FOR CATALYSIS AND SURFACE SCIENCE

Based in the University of Michigan, the Center provides interaction among researchers drawn from the disciplines of chemistry, physics, biophysics, and chemical engineering.

MACROMOLECULAR RESEARCH CENTER

Based in the University of Michigan, the Center includes among its researchers faculty from Chemical

Engineering, Materials & Metallurgical Engineering, and Nuclear Engineering.

OFFICE FOR THE STUDY OF AUTOMOTIVE TRANSPORTATION

Based in the Transportation Studies Institute, the Center stimulates and coordinates interdisciplinary activities related to automotive transportation, with major emphasis on policy and economic issues.

REHABILITATION ENGINEERING CENTER

Based in the College of Engineering, this center does work which requires collaboration among researchers drawn mainly from Mechanical Engineering, the Medical School's Department of Physical Medicine and Rehabilitation, and the U-M Transportation Research Institute.

CENTER FOR ERGONOMICS

Based in the College of Engineering, the Center's core faculty are drawn mainly from Industrial & Operations Engineering. Other faculty include members of the School of Public Health, and the Medical School.

PH.D. PROGRAM IN URBAN, TECHNOLOGICAL, AND ENVIRONMENTAL PLANNING

Based in the Rackham Graduate School, the program sponsors research involving the collaboration of researchers from Engineering, Law, Economics, Architecture, Public Health, and other disciplines. The current director of the program is a professor of electrical and computer engineering.

COMPUTING RESEARCH LABORATORY

Based in the College of Engineering, this is an interdepartmental laboratory whose members are drawn mainly from the Department of Electrical and Computer Engineering and the Computer and Communication Sciences Department of the College of Literature, Science, and the arts. It is devoted to collaborative experimental research in computer science and computer engineering.

TRANSPORTATION STUDIES INSTITUTE (UMTRI)

Based in the University of Michigan, the Institute conducts research concerned with transportation involving members of the engineering faculty draw from mechanical, electrical, industrial, bioengineering, civil, aerospace, and marine engineering, as well as faculty from the disciplines of physics, computer science, psychology, medicine, surgery, statistics, and

antropology. The current director of the Institute is a professor of mechanical engineering.

GREAT LAKES AND MARINE WATERS CENTER

Based in the University of Michigan, the Center coordinates several programs, including the Great Lakes Research Division and the Michigan Sea Grant Program. The disciplines represented by its research staff include microbiology, limnology, biological oceanography, aquatic ecology, aquatic zoology, geology, geochemistry, botony, and civil engineering. Its current director is a professor of atmospheric and oceanic science in the College of Engineering.

Other research centers and institutes under development include:

CENTER FOR APPLIED OPTICS

CENTER FOR SCIENTIFIC COMPUTATION

CENTER FOR CONSTRUCTION ENGINEERING AND MANAGEMENT

SURVEY OF ENGINEERING RESEARCH BY DEPARTMENTS

The following is an inventory of College research activities by disciplines or departments. Research under each discipline is grouped under major sub-disciplines.

AEROSPACE ENGINEERING

Major areas of research are:

FLIGHT DYNAMICS, GUIDANCE, AND CONTROL

STRUCTURAL MECHANICS AND AEROELASTICITY

GAS DYNAMICS

FLIGHT DYNAMICS, GUIDANCE, AND CONTROL

This area covers the motion (flight path and attitude dynamics) of flight vehicles in the atmosphere and of spacecraft in orbital and interplanetary flight and re-entry. These studies form the basis for the design of autopilots (control) and trajectories for space vehicles and homing missiles (guidance).

RESEARCH includes optimal re-entry trajectories, optimal orbital transfer, attitude control of space craft and dynamics of large space structures, fuel-efficient cruise of aircraft; simulation of vehicle motion.

APPLICATIONS include control of orbiting space stations, orbital transfer vehicles, and training simulators.

GAS DYNAMICS

Gas dynamics is an overall term which includes aerodynamics, fluid mechanics in general, propulsion, and combustion; as such it includes the motion of fluids and their interaction with solid bodies.

RESEARCH includes subsonic, transonic, and supersonic flows; turbulence; viscous flows; turbulent combustion of sprays and dusts; explosions; kinetic theory of gases, and plasma physics.

APPLICATIONS include improved design of airplanes, spacecraft, helicopters, automobiles, building aerodynamics, jet propulsion engines, recriprocating engines; etc.; prevention of explosions (in grain elevators, coal mines); decreased pollution (from engines and coal combustion); and controlled thermonuclear fusion.

STRUCTURAL MECHANICS AND AEROELASTICITY

This area is concerned with the proper design of aerospace structures, which must be both lightweight and able to withstand unusual loads, are made of exotic materials, and tend to be more flexible than other structures. A foremost design consideration is possible failure due to excessive stress or vibration, or buckling.

RESEARCH includes optimal design for least weight; optimal design for dynamic characteristics (vibration and flutter); plastic flow during manufacturing processes; finite element methods; and nonlinear vibration.

APPLICATIONS include aircraft and spacecraft design and construction; response of aircraft to gusts; and spin-off applications to other vehicles such as automobiles, trucks, and ships.

ATMOSPHERIC & OCEANIC SCIENCE

Major areas of reasearch are:

WATER SCIENCE AND ENGINEERING

CLIMATOLOGY

AIR AND WATER QUALITY

AERONOMY

PLANETARY SCIENCE

WATER SCIENCE AND ENGINEERING

This area covers the physical, chemical, geological,a nd biological processes in inland waters and the oceans, and their application for the benefit of mankind.

RESEARCH and APPLICATIONS: Near-shore hydrodynamic studies of storm-generated waves provide surf predictions for beach erosion, shipping, and public safety. Analysis of ocean sediments yields information on organic matter and black shale formation that helps us understand the origin of petroleum. Remote sensing of the oceans provides navigation chart updating, wave prediction, and the mapping of large-scale ocean currents.

CLIMATOLOGY

Climatologists study the earth's weather averaged over a long period of time.

RESEARCH and APPLICATIONS: From solar radiation measurements, the cloud from the El Chichon volcano in Mexico can be located, and its effect on the surface temperature determined. Data are also used in agriculture, biometereology, and building design. Analysis of radiation measurements from satellites tell us how the ozone is chaning because of its interaction with man-produced gases. Computer models of wave instabilities in the equatorial ocean demonstrate why the Pacific waters off the Peruvian coast are sometimes warm and detrimental to the fishing industry. Computer models of air and surface temperature predict temperature changes that will occur because of increasing amounts of carbon dioxide due to burning of fossil fuels.

AIR AND WATER QUALITY

Of interest in this are are gases and particles in the air and water that affect biological systems.

RESEARCH and APPLICATIONS: Monitoring of water quality in the

Saline Valley provides assistance to landowners in apply conservation practices. Determination of the environmental changes that will occur if an anti-salinity barrage and dam are built on the Gambia River in Africa. Computer models are used to determine the locations of pollutants ultimately responsible for acid rain in eastern North America; similar studies are being made to determine the movement of toxaphene by the winds. Instrumentation developed to measure trace gases and parameters such as photolysis rates reveal keys to understanding phenomena such as acid rain and stratospheric chemical balances; similar instrumentation allows remote monitoring of vehicle emissions.

AERONOMY

Of interest to aeronomists are the physics and chemistry of the atmosphere extending from 10 km to outer space.

RESEARCH and APPLICATIONS: Analysis of satellite measurements help us ascertain the origin of the electrons that produce the northern lights. Instrumentation developed and flown on rockets provide data on the chemical reactions that occur in airglow. Measurements of the cross sections of gas molecules help us understand the chemical reactions that occur in the atmosphere. Satellite data are used to infer winds and temperature from one hundred to several hundred kilometers above the surface.

PLANETARY SCIENCE

Of interest is the metecrology of the planets and moons in the solary system, including photochemistry, high energy charged particle precipitation, and the evolution of the atmospheres.

RESEARCH and APPLICATIONS: Analysis of data collected by planetary spacecraft and satellites, along with computer generated theoretical models, help us understand the composition, temperature, turbulence, auroral activity, energy budget, and early history of the atmospheres of Jupiter, Saturn, Uranus, Neptune, Titan, Mars, and Venus. The development of payloads and their components for nation and international spacecraft advances mass spectrometry and electronic design technology.

CHEMICAL ENGINEERING

Major areas of research are:

SURFACE AND COLLOID SCIENCE

FLOW THROUGH POROUS MEDIA

COAL LIQUEFACTION

POLYMERS

BIOENGINEERING

BIOTECHNOLOGY

SURFACE AND COLLOID SCIENCE

A colloid is a mixture of two or more substances in which one is very finely dispersed in the other. Two examples of colloids are fog and mayonnaise. The study of how particles adhere to surfaces to form colloids and other mixtures have many industrial applications.

RESEARCH includes dissolution of silicate minerals by hydrofluoric acid; permeability reduction in water-sensitive sandstones; emulsion stability; kinetics of electroless copper plating; the study of hydrogen bonding in solution; surfactant association; catalysis and catalyst characterization, using state-of-the-art spectroscopy.

APPLICATIONS include oil, gas, and mineral recovery; methanol synthesis; emulsion formation; and many other processes, including home washing. Medical applications include research on cholesterol gallstone dissolution.

FLOW THROUGH POROUS MEDIA

Flow through porous media refers to the flow of a fluid through the void spaces in a solid porous matrix (e.g., sandstones) and its interaction with the matrix.

RESEARCH includes core flood experiments using microemulsions, acids, and salt solutions of different concentrations; the effects of various chemical and physical parameters on the release of clay particles from pore walls, and their subsequent migration to pore constrictions where particle plugging occurs.

APPLICATIONS include the characterization of sandstones, leading to enhanced secondary oil recovery; stimulation of oil and gas wells by controlled acidization of the porous rock.

COAL LIQUEFACTION

Coal liquefaction refers to the dissolution and conversion of coal in a coal-derived recycle solvent to liquid products.

RESEARCH includes the role of heating rate, temperature, solvent characteristics and agitation on the dissolution of a Kentucky No. 9 coal. Research includes also the removal of mineral solids and unreacted coal from liquefied coal by critical solvent deashing.

APPLICATIONS: This research will serve as a guide in specifying the operating conditions in the design and operation of commercial coal liquefaction processes.

POLYMERS

Polymers are present as very large molecules in many natural substances (resins, rubber, quartz, living tissues, etc.) and in all synthetic plastics.

RESEARCH includes the effect of polymer processing on polymer properties. Recently we have initiated an approach in which long fibers are used to strengthen composite materials. APPLICATIONS include parts for automotive bodies where light weight and high strength of materials are highly desirable.

BIOENGINEERING

Research in this area is focused on the application of chemical engineering principles to the life sciences, primarily in work on medical devices.

RESEARCH includes the testing and modification of polymers as materials for devices used in contact with blood, to prevent clotting on the surface of such devices (they include artificial blood vessels, kidneys, and heart). Work is also being done on the development of optical sensors for measuring metabolites in blood and tissues. These sensors use single optical fibers and thus can be miniaturized and implanted.

APPLICATIONS include development of new devices for the health industry (examples are artificial arteries for arteriosclerosis and a glucose detector for diabetes), and methods for the continuous infusion of nutrients.

BIOTECHNOLOGY

Work in this area is concerned with the application of engineering principles in the processing of biological materials for products and services.

RESEARCH includes biological screening, biosensor development, novel bioreactor design, membrane processing, affinity absorption, controlled release technology, and computer control.

APPLICATIONS include discovery of new microbial-based drugs; design and scale-up of new biological processes such as recombinant DNA systems and cell cultures; control monitoring and systems for biological processes; and new separation techniques for biochemical products.

CIVIL ENGINEERING

Major areas of research are:

STRUCTURAL ENGINEERING

GEOTECHNICAL ENGINEERING

ENVIRONMENTAL ENGINEERING

HYDRAULICS AND HYDROLOGY

CONSTRUCTION ENGINEERING AND MANAGEMENT

TRANSPORTATION

STRUCTURAL ENGINEERING

This area deals with the analysis and design of structural systems (highways, buildings, nuclear power plants, bridges, dams, towers, and others) and structural components (walls, columns, domes, shells, etc.)

The University of Michigan has been a major center for earthquake engineering for twenty years. Much of the research in structural engineering has been motivated by the concern with earthquakes.

RESEARCH includes inelastic dynamic response of structural systems; inelastic behavior of steel and reinforced concrete members and structures; behavior of special structures (tall reinforced concrete chimneys, among others) under forces of wind and earthquakes; earthquake hazard analysis; retrofit and design of structures to resist earthquakes; study of earthquake resistance of reinforced concrete buildings in Japan; fracture analysis; matrix and finite element methods in design and analysis.

APPLICATIONS include improved design and construction of buildings, highways, bridges, dams, and other structures. Improved building codes.

GEOTECHNICAL ENGINEERING

Geotechnical engineering deals with the strength and deformation of soils as influenced by gravity forces, dynamic loadings, loads from structures, and chemical changes.

RESEARCH includes mechanics of natural and reinforced earth; response of soil masses and foundations to dynamic loads; behavior of structural foundation systems; and physical and chemical methods for stabilizing soils.

APPLICATIONS include design and construction of foundation

systems and earthen embankments; design of reinforced earth retaining structures; improvements to earthquake-resistant foundations; and use of marginal land for construction sites.

ENVIRONMENTAL ENGINEERING

Major concerns in this area are: measurements of contaminants in the air, water, and soil; mathematical modeling of transformations of contaminants in the natural environment and in air and water treatment systems; cost-effective treatment and disposal of waste so as to minimize their impacts on human health and natural biological processes; and management of water resources to insure maximum benefit from their use.

RESEARCH includes analysis of adsorption processes for the removal of organic contaminants from water supplies and wastewaters; modeling of the impacts of nutrients in wastewaters on algal biomass and dissolved oxygen in surface waters; estimation of the costs and power consumption of large-scale diversions of freshwater from the Great Lakes; comparison of fluidized, expanded, and packed beds for biological wastewater treatment.

APPLICATIONS include improved design and operation of water and wastewatewr treatment systems and air pollution control devices; development of cost-effective strategies for the control of nuisance algae in lakes and ponds; new techniques for dealing with hazardous and solid wastes; and increased understanding of the behavior and fate of pollutants in the environment.

HYDRAULICS AND HYDROLOGY

RESEARCH includes coastal engineering, surface and groundwater hydrology; jet mixing and turbulent diffusion; steady and unsteady open channel flows; unsteady liquid and gas flow in pipelines; multidimensional unsteady flow; and wave propagation in soils.

APPLICATIONS include breakwater design and harbor protection in the Great Lakes; groundwater supply and subsurface contaminant movement; surface water hydrology including flood flows and drought predictions; water distribution in canals and pipelines; natural gas and other fluid flows; pollutant discharges into rivers and lakes.

CONSTRUCTION ENGINEERING AND MANAGEMENT

This area covers the planning, estimation, scheduling, and management aspects of construction (of buildings, dams, power plants, highways, bridges, ports, refineries, and other structural systems).

RESEARCH includes simulation of construction processes and projects; motivation of construction workers; scheduling of linear projects; computer-aided design; integrated databases; site layout; resource aloocation; competitive bidding analysis; temporary support of masonry walls; cost reduction by substituting fly ash and sulphur for asphalt in pavement construction; aging effects of asphalt in pavements; cracking of concrete; fibre reinforced concrete in construction.

APPLICATIONS include improvement of work training, safety and productivity; better management and control of construction processes; lower construction costs, improved construction quality, improved construction materials, and increase in contractor's profits.

TRANSPORTATION

This area is concerned mainly with improving the planning, design, and operations of transporattion systems. Of special interest are roads, public transit, safety, terminals, control, and demand determination.

RESEARCH includes highway safety related to the facility; advanced multivariate analysis techniques; improvement in estimation procedures for person travel-demand; improvement in standards for the geometric design of roads and streets.

APPLICATIONS include better investment decisions in highway and short-range transit planning.

ELECTRICAL ENGINEERING & COMPUTER SCIENCE

Major areas of research are:

SOLID STATE ELECTRONICS

COMMUNICATIONS & SIGNAL PROCESSING

OPTICS & ELECTROMAGNETICS

POWERS SYSTEMS & ENERGY CONVERSION

TECHNOLOGY PLANNING & ASSESSMENT

BIOELECTRICAL SCIENCES

ROBOTICS

COMPUTER SCIENCE

COMPUTER ENGINEERING

SOLID-STATE ELECTRONICS

RESEARCH in this area covers a broad spectrom of topics in solid-state and quantum electronics. It includes solid-state materials and microstructures; microwave, millimeter-wave, and submillimeter-wave devices and circuits; monolithic solid-state sensors; custom integrated circuits; modeling and simulation; and VLSI system development.

APPLICATIONS of this research: Integrated circuits and microchips appear in new products everyday. The many applications of research in this area include computers, intrusion alarms, smoke detectors, pollution control devices, television sets, video recorders, telephone systems, instrument landing systems, radar, and communication systems.

COMMUNICATIONS AND SIGNAL PROCESSING

RESEARCH includes communications, signal and image processing, and instrumentation; probability, statistics, and stochastic processes; information and coding theory; data transmission; modulation and detection theory; interference test signals for use in satellite performance evaluation; spread-spectrum communications; use of remote transceivers for position-locating communication signals; color facilities for complex information displays; extraction of information from vast amounts of data; extension of the theory of signal processing in uncertain noise spectra; low-noise, charge-sensitive preamplifiers; and pulse propagation on wire grid spark chambers.

APPLICATIONS include the design of communication systems for

satellites, telephone networks, computer networks, aiding trapped miners, underwater telemetry, and the study of the atmosphere of other planets. Appplications in medicine include patient monitoring and computerized tomography. Still other applications are in computerized voice recognition, storage, and synthesis; and the study of ocean circulation.

OPTICS AND ELECTROMAGNETICS

RESEARCH includes coherent optics; holography; optical data processing; interferometry; integrated optics; and the radiation, propagation, scattering, and reception of electromagnetic energy.

APPLICATIONS include three-dimensional photography; the study of interference caused by terrain and man-made objects on antennas (in television reception, communication systems); the performance of antennas for communication systems, such as radio, television, and air control; optical information storage; fiber optics for communications and other applications; holographic lenses; and nondestructive testing of materials.

POWER SYSTEMS AND ENERGY CONVERSION

RESEARCH includes static and dynamic simulations of power systems, power electronics, rotating machines, computer relaying, and gaseous plasma phenomena.

APPLICATIONS include batteries for electric vehicles, alternate sources of electrical energy, thermonuclear fusion, and electrical power distribution to homes and factories.

TECHNOLOGY PLANNING AND ASSESSMENT

This area is concerned with the interrelations between society and technology.

RESEARCH includes forecasting and assessment of the impact of a technology on various social areas; planning and policymaking for technology; and development of new techniques for technology assessment and technology planning.

APPLICATIONS include the assessment of the impact of technology and its implications; the assessment of a specific technology on jobs, society, and the environment. Three recent projects were concerned with the increased usage of coal for heating and energy, electric vehicles, and an analysis of the deciding factors for high-technology companies to remain in the Ann Arbor area.

BIOELECTRICAL SCIENCES

This area is concerned with applying engineering theory and practice to various aspects of medicine, physiology, biochemistry, and other biological sciences.

RESEARCH includes electrical biophysics, bioinstrumentation, biological systems analysis, and biological signal processing.

APPLICATIONS include the study of information transmission in the hearing, touch, visual and balance systems; the study of the dynamics of posture; analysis of speech pathology; development of microprocessing instrumentation systems to measure and analyze eye movements, cardiac potentials, and body motion parameters; use of solid-state fabrication techniques to develop a multichannel neural probe for recording brain potentials over extended periods (this is part of a national effort to develop prosthetic devices for the handicapped.)

ROBOTICS

RESEARCH includes the theory of dynamical systems, optimal and adaptive robot control, and computational aspects of robot control; development of integrated sensors; sensor-controlled robots; special-purpose computer architectures for robotics; machine vision; robot languages; and interfacing computer-aided design with robots.

APPLICATIONS include design of computers, the management of large computer databases; and the development of robots with artificial intelligence and vision to assist in manufacturing processes and as aids to the handicapped.

COMPUTER SCIENCE AND ENGINEERING

RESEARCH includes database management, logic and system design, arithmetic switching and automata theory, fault-tolerant computers, artificial intelligence, computer graphics, and high-speed computation

APPLICATIONS computer design, software research and development, and the management of large computer databases.

INDUSTRIAL AND OPERATIONS ENGINEERING

Major areas of research are:

OPERATIONS RESEARCH

MANUFACTURING SYSTEMS ENGINEERING

MANAGEMENT ENGINEERING

ENGINEERING ECONOMY AND CAPITAL BUDGETING

ERGONOMICS

INFORMATION SYSTEM DEVELOPMENT

DATA MANAGEMENT

OPERATIONS RESEARCH

Work in this area is focused on the modeling of and optimal decision-making in deterministic and probabilistic systems that originate in real life.

RESEARCH includes linear, nonlinear, integer, and dynamic programming; network flows; queuing theory; decision analysis; mathematical modeling of large-scale systems; and stochastic processes.

APPLICATIONS include production scheduling; capacity expansion; equipment reliability, replacement and maintenance; interactive routing and scheduling; bidding; public patrol allocation; risk assessment; multi-criteria decision-making.

MANUFACTURING SYSTEMS ENGINEERING

Research is focused on the analysis, modeling, and optimal control of production facilities, and material flows among manufacturing and warehouse facilities.

RESEARCH and APPLICATIONS include capacity and location of plants and warehouses; design of new production facilities; layout in existing facilities; material handling systems, plant flow analysis; automation of manufacturing processes; computer control of manufacturing systems; forecasting; production scheduling; inventory control; manufacturing information systems; quality control; process routing; equipment replacement and maintenance; material requirements planning.

MANAGEMENT ENGINEERING

Concerns in this area include the design of organizational

structures to deal with technical change; incorporation of organizational and interpersonal issues in the design of technical and management systems; and increasing productivity through improved management systems.

RESEARCH includes management of technical change; effect of employee involvement in technical decision-making; quality of work life; methods of productivity improvement.

APPLICATIONS include manufacturing industries undergoing technical change (e.g., in automotive assembly plants with increased automation and statistical control processes); quality circles; nurse staffing; scheduling of inpatient and operating procedures in hospitals.

ENGINEERING ECONOMY AND CAPITAL BUDGETING

This area is concerned with evaluating and developing methodologies and procedures for making economic decisions.

RESEARCH includes decision procedures for capital investment decisions for projects with risk and uncertainty; equipment replacement decisions, including effects of inflation, technological change, and uncertainty; simulation of large economic systems and decision-making within such systems.

APPLICATIONS include allocation of financial resources among projects; asset replacement or expansion; analysis of unstructured economic problems.

ERGONOMICS

Ergonomics is concerned with the design of machines, vehicles, tools, procedures, and the general work environment, as they relate to human needs, capabilities, health, and safety.

RESEARCH includes work physiology; biomechanics; occupational health; occupational safety; psychomotor capabilities; work measurement; transportational and recreational vehicles; robotics, job analysis; methods engineering; vocational assessment; occupational rehabilitation; and tool design.

APPLICATIONS include study of effects of worker exposure to toxic substances; improvement of workplace layout and work methods; human-robot interface design; vehicle design; division of labor between man and machine; work accommodations for the physically handicapped; computer-aided design of man-machine systems.

INFORMATION SYSTEM DEVELOPMENT

Information system development is concerned with the analysis, design, construction, operation, and maintenance of information

processing systems.

RESEARCH includes systems analysis and design, problem statement languages and analyzers, software engineering, system construction with programming languages such as Ada and CHILL, fourth generation languages, user applications programming, and software support environments.

APPLICATIONS include management information systems, distributed systems, decision support systems; embedded, realtime command and control systems, and manufacturing systems.

DATA MANAGEMENT

Data management is concerned with the design and maintenance of data bases.

RESEARCH includes data modeling; user view analysis; database management, system design and performance evaluation; analysis of data models, including hierarchical, network, and relational.

APPLICATIONS include database management systems, distributed database systems, data dictionary development and use.

MATERIALS AND METALLURGICAL ENGINEERING

Major areas of research:

CERAMICS

POLYMERS

METALS: SHEET FORMABILITY

METALS: CAD (Computer-Aided Design) for Castings

METALS: STEELMAKING

METALS: CREEP, FATIGUE, AND FRACTURE

CERAMICS

Ceramics are solid articles produced by treating non-metallic inorganic materials at high temperatures. They are distinguished by their hardness, strength, and resistance to corrosion and heat.

RESEARCH includes structures and properties of high-temperatures crystalline and glassy metal oxides, nitrides, and carbides.

APPLICATIONS include ceramic structural parts for high-temperature engines, cutting tools, and sensors for temperature and gas composition measurements (e.g., for auto exhaust systems and furnace atmospheres).

POLYMERS

Polymers are substances composed of very long chain molecules, each made up of thousands of identical small molecules. All living things are made almost entirely of polymers. Natural polymers include proteins, cellulose, chromosomes, and DNA. Also among natural polymers are natural rubber, wood, cotton, wool, silk, and glues. Synthetic polymers include synthetic rubber, polyesters, nylon, acrylics, vinyls, and Teflon.

RESEARCH includes structure and properties of the glassy state; equations-of-state of polymers; control of physical aging by control of processing variables; blood-protein polymer interaction mechanisms.

APPLICATIONS include (in construction) plumbing, siding, protective coatings, floor and wall coverings; (in clothing) fibers, shoes; (in packaging) plastic bags, containers, lightweight packing; (in autos) bodies, fenders, wheels, tires, upholstery; (in medicine) artificial body parts, including limbs, heart valves, blood vessels, catheters, dialysis membranes.

METALS: SHEET FORMABILITY

APPLICATIONS: Products made from formed sheets range from automobile bodies, aircraft panels, appliances, sinks, and canoes to flashlights, flashlight batteries, and fuse caps. In the stamping or deep-drawing of all such parts, if the deformation is too severe, failure may occur by splitting or by wrinkling. These problems are particularly severe in the auto industry because of increased usage of aluminum and high-strength steels for weight-saving.

RESEARCH includes theoretical and experimental studies of wrinkling and splitting, especially the effects of material properties such as work-hardening, anisotropy, strain-rate sensitivity, and strength/modulus ratio, and the underlying mechanics.

METALS: CAD FOR CASTINGS

Computer-aided Design (CAD) is utilized to determine the optimum gating and rigging for producing castings of highest quality.

RESEARCH includes geometric modeling of castings; computer simulation of solidification; development of database, including thermal properties, heat transfer characteristics, fluid flow in mold filling and mold-metal interactions.

APPLICATIONS include production of castings of high integrity with maximum metal yield and efficiency. Central Foundry Division of General Motors is the world's largest casting producer and the auto industry is our major casting user.

METALS: STEELMAKING

Steelmaking involves the refining of steel for production of sheet, strip, structural bar, and rod products.

RESEARCH includes slag-metal reactions, gas-metal reactions, mass transport, kinetics and equilibria at high temperatures.

APPLICATIONS include inmprovement in productivity and control of steelmaking operations; and development of more competitive technologies for steel production.

METALS: CREEP, FATIGUE, AND FRACTURE

The focus of this area is how alloys respond to high temperature and cyclic or static stresses.

RESEARCH includes microstructural instability during long-time creep; environmental effects on creep-crack growth; load

interaction effects during fatigue crack propagation.

APPLICATIONS include successful prediction of useable and safew service life for components operating at elevated temperatures (e.g., turbine components in jet engines and steam lines in power plants); improved resistance of materials to fatigue and catastrophic failure.

MECHANICAL ENGINEERING AND APPLIED MECHANICS

Major research areas are:

FLUID MECHANICS

HEAT TRANSFER

THERMODYNAMICS

MATERIALS AND MANUFACTURING

SOLID MECHANICS AND DYNAMICS

SYSTEM DYNAMICS, CONTROL, AND INSTRUMENTATION

FLUID MECHANICS

Fluid mechanics deals with the flow of liquids and gases in every possible environment, under a wide variety of conditions.

RESEARCH includes analytical, computational, and experimental studies of the flow of fluids.

APPLICATIONS include modeling of fluid systems (such as ink jet printers for computers) to understand their behavior and to improve their design; decreased pollution (from oil spills); assessment of damage due to erosion of materials by droplet impact (as in helicopter wings and cockpit canopies) and cavitation; understanding of the behavior of stratified flows and geophysical flows.

HEAT TRANSFER

Heat transfer refers to the flow of energy from a hot object to a cooler one, due to a temperature difference.

RESEARCH includes studies of basic heat-transfer mechanisms, among them radiation, boiling, condensation; heat transfer in crevices of steam-generators in nuclear power plants; long-term energy storage from solar collectors; heat-transfer processes in biological systems.

APPLICATIONS: Heat transfer is manifested in all aspects of life - the body is a thermodynamic engine whose temperature must be carefully regulated by heat transfer, either automatically (as in shivering, perspiration), or by external aids such as clothing, heating, and air-conditining. The functioning of all devices that assist human/animal muscle-power depends on heat transfer and heat engines, as in electric power plants, gas turbines, internal combustion engines, hydroelectric plants, and solar energy devices .

THERMODYNAMICS

Thermodynamics is the engineering science that is concerned with energy, energy transfer, energy conversion and the accompanying changes in matter that may result.

RESEARCH includes heat pump analysis; automotive engine modeling and performance evaluation; assessment ofalternate fuels and motive power for vehicular applications; evaluation of various fluids for use in heat pumps.

APPLICATIONS include developing and evaluating alternate fuels for automotive engines; optimum method for operating heat pumps to attain maximum efficiency; determining effects of various parawmeters on the performance and efficiency of automotive engines.

MATERIALS AND MANUFACTURING

The focus here is on converting designs into goods.

RESEARCH is conducted in three areas: 1) mechanics of processes (involving modeling of the machining, forming, and welding processes), and characterization of surface finishes; 2) the relationships between material properties and manufacturing processes; and 3) use of the computer to solve manufacturing problems.

Applications include achievement of the lowest manufacturing cost along with the highest reliability in a manufactured article.

SOLID MECHANICS AND DYNAMICS

Solid mechanics deals with the strength and stiffness of solid bodies under applied loads, and related problems. The area of dynamics is concerned with the motions and vibrations of both rigid and flexible bodies.

RESEARCH includes computational methods for optimal structural design; contact problems with friction (analysis and computation); engine mount study; fracture under conditions of partial closure; loss characteristics of cord rubber composites; macrostructural characteristics of normal human cornea; mechanics of pneumatic tires; operation of restraint testing program; optimal structural design and geometric programming in continuous systems; pressure loss mechanisms in pneumatic tires; rehabilitation engineering.

APPLICATIONS include improved analysis and design of structures and mechanisms such as buildings, dams, automobiles, ships, aircraft, nuclear reactors, equipment, machines; improved control of structures and mechanisms (robots, vehicles, etc.); and highway safety studies.

SYSTEM DYNAMICS, CONTROL, AND INSTRUMENTATION

This area covers the mechanical performance of machinery, vehicles, and other dynamic mechanical systems. Topics include the mathematical modeling and simulation of system time-response and methods for measuring and controlling system-performance.

RESEARCH and APPLICATIONS: In the simulation area, methods and programs have been developed which predict, in particular, the large-displacement, two- and three-dimensional dynamic response of arbitrary mechanical systems. Work is also done on vehicle- and occupant-response in studies on highway vehicle design and safety. Theoretical and experimental work is done on the control of mechanical systems such as vehicles and manufacturing machinery; other work includes optimization of engineering systems and research in orthopedics. Computers are involved in this research, which is supported by a laboratory containing computer-aided engineering equipment.

NAVAL ENGINEERING AND MARINE ARCHITECTURE

Major areas of research are:

SHIP HYDRODYNAMICS

SHIP STRENGTH AND VIBRATION

MARINE ENGINEERING

OFFSHORE ENGINEERING

SHIP PRODUCTION

MARINE COMPUTER-AIDED DESIGN

MARINE SYSTEMS MANAGEMENT

SHIP HYDRODYNAMICS

This area is concerned with the resistance (power requirements), propulsion (propellers), maneuvering, and seakeeping (motions) of ships and other marine vehicles.

RESEARCH includes interaction forces between ships passing in shallow water, the hydrodynamic forces on ships in confined waters, the prediction of ship motions, the wave amplitude in the bow region of a ship, the prediction of the viscous wake behind a ship, unsteady cavitation on a propeller, and the study of propeller induced vibration; and safety of marine towing operations.

APPLICATIONS include ship design; improvements in the efficiency and safety of marine transportation in restricted waters such as the Great Lakes system; propeller and hull design improvements to reduce propeller excited vibration; improved ship designs for operation in severe ocean environments.

SHIP STRENGTH AND VIBRATION

This area is concerned with the structural design and analysis of ships, which include man's largest mobile structures and must operate in hostile environments.

RESEARCH includes experimentatal and analytical work in the fundamental mechanisms of ship springing (wave-induced hull vibration); limit analysis of plates; dynamic stresses in propellers operating behind a ship; deflections in propeller components during icebreaking; ship structural weight and cost optimization; development of inverse perturbation techniques for marine structure redesign; development of finite-element techniques for ship structural analysis; analysis ofthe hydrodynamic added mass of vibrating ships; and added mass and

damping of vibrating propellers.

APPLICATIONS include ship design. Research contributes to the improved performance, reduced weight and cost, and more rational design synthesis of ship structures.

MARINE ENGINEERING

This area is concerned with the components and systems for propulsion, control, cargo handling, and life support onboard ships. Although the machinery used onboard ships is typically adapted from other industrial and transportation fields, the marine engineer is concerned with overall systems engineering and the many special problems of the ship application.

RESEARCH includes optimal and adaptive control of ships and onboard systems; reliability analysis of shipboard systems; finite-element analysis of elasto-hydrodynamic bearings; probabilistic analysis of marine diesel vibrations during fuel changeover; performance of propeller bearings during icebreaking operations; dynamic modeling of marine diesel engines; and the application of computer methods to marine engineering design.

APPLICATIONS include ship design. Research contributes to the use of more rational methods for the design and analysis of marine engineering systems and components.

OFFSHORE ENGINEERING

This area is concerned with the design and analysis of offshore systems. These include drilling ships, semisubmersible and tension leg platforms, concrete and steel gravity platforms, drilling and production risers, guyed towers, templates onthe ocean floor, pipelines and cables, and research and rescue submersibles.

RESEARCH includes prediction of forces on and motions of large offshore structures; koiter and large deflection postbuckling analysis of hydraulic columns, risers,and pipelines; effects of large deformations on small amplitude structural vibrations; design optimization of offshore structures; launching loads on offshore structures; windloads on offshore structures for use in safety and dynamic positioning analyses; capsizing of offshore structures during operation and towing.

APPLICATIONS include design of offshore systems. Research contributes to the improved effectiveness and safety of systems used for offshore exploration and production.

SHIP PRODUCTION

This area is concerned with ship construction methods, ship

production planning and control, ship design for improved producibility, the application of computer methods in ship design, manufacturing, production control, and long-range planning and facilities-development in shipyards.

RESEARCH includes application of group technology concepts in ship production; evaluation of designs and redesign for production efficiency; and the analysis and modeling of the hull plate bending process which uses flame heating and associated cooling.

APPLICATIONS include ship and boat production. Research contributes to the improved efficiency in the construction of ships, boats, and recreational craft.

MARINE COMPUTER-AIDED DESIGN

This area is concerned with the development of computer methods and systems for the computer-aided design (CAD) and computer-aided manufacture (CAM) of marine vehicles and offshore structures.

RESEARCH includes optimization applications in marine design, such as the optimum design of marine risers, and the determination of the optimum propeller blade skew distribution to minimize vibratory excitation; computerized pipe routing; development of portable CAD executive system software; development of graphics-based pre- and post-processors for finite-element analysis programs; development of systems for design database definition and transfer within the ship design and construction process.

APPLICATIONS include ship and offshore structure design and construction. Research contributes to the improved quality and efficiency of marine design and construction.

MARINE SYSTEMS MANAGEMENT

This area concerns the application of the analytical tools of probability, random processes, engineering economy, statistics, and operations resarch to ship design and construction decisions and the operation and management of ships and marine systems.

RESEARCH includes cost benefit, economic, and feasibility analysis in ship design, construction, and operation; the economic benefits of and technical problems associated with operating the Great Lakes system through a 12-month extended season; the feasibility of moving Western coal through a Lake Michigan transshipment point in Michigan's Upper Peninsula; the effects of improved maneuvering control on the optimum size of Great Lakes bulk cargo vessels; optimal strategies for fleet deployment.

APPLICATIONS include ship design and the operation and management of ships and other marine systems. Special emphasis has been placed on the Great Lakes system.

NUCLEAR ENGINEERING

Major areas of research are:

NUCLEAR FISSION REACTORS

PLASMAS AND CONTROLLED FUSION

NUCLEAR MATERIALS

RADIATION APPLICATIONS AND INSTRUMENTATION

NUCLEAR FISSION REACTORS

Studies are conducted in support of technologies important in present-day light-water nuclear reactors as well as in future designs, such as the fast-breeder reactor.

RESEARCH includes reactor kinetic behavior, with emphasis on reactor plant modeling, nonlinear kinetics, optimal reactor control, reactor safety, neutron transport, reactor core design, and reactor code development for coupled thermal hydraulic-neutronics calculations.

APPLICATIONS include improvement in the safety and economic performance of nuclear reactors used to generate electrical power. It is expected that 25% of the electricity generated in the United States by the year 2000 will be from nuclear power plants.

PLASMAS AND CONTROLLED FUSION

Research is aimed at furthering our understanding of the technological factors important in the development of future power plants based on nuclear fusion.

RESEARCH includes theoretical studies of the stability of plasmas in magnetically confined configurations, with emphasis on microinstabilities and turbulence; the application of fluctuation theory to the analysis of plasma properties; and the interaction of charged particles and electromagnetic radiation with plasmas. Experimental work is concentrated on laser-plasma interactions; wave-heating of plasmas confined in magnetic mirrors; generation of particle beams for inertial confinement fusion and for neutral beam heating of magnetically confined plasmas; and the design of very high power lasers.

APPLICATIONS: Efforts at producing controlled fusion energy are still in the research stage. These studies aid our understanding of the confinement and heating processes required to produce fusion energy on a commercial scale.

NUCLEAR MATERIALS

This area includes studies of matter using nuclear particles or radiation as probes, and studies of the behavior of materials under the extremes of temperature, radiation, and corrosion found in nuclear applications.

RESEARCH includes the effects of fast neutron irradiation on structural materials and the properties of solids; the use of ion beams to beneficially modify the properties of materials; nuclear reaction techniques for profiling flaws and damage in metals; the structure and behavior of gases, liquids, and crystals of various engineering materials.

APPLICATIONS include development of materials for use in nuclear fission and fusion reactors; development of improved materials through ion implantation;and improved understanding of the structure of alloys, polymers, and other conventional materials.

RADIATION APPLICATIONS AND INSTRUMENTATION

This area deals with the application of nuclear radiation in medicine and industry, and with the development of methods for the accurate measurement of radiation .

RESEARCH includes use of radiation in the study of materials, including annihilation radiation and resonance gamma ray absorption; insjtrument development for the improved spectroscopy of radiatiobn; and the application of nuclear measurement techniques in nuclear medicine and radiology.

APPLICATIONS include studies of the competing effects caused by displacement spikes and enhanced diffusion in precipitation-hardened alloys; phase determination and kinetic analysis of thermally induced reactions in alloys; and development of SPRINT, a device (now under evalutation at the University of Michigan Medical Center) for the tomographic imaging of the human brain.