MIT-Q-86-004

MIT SEA GRANT
Summer 1986

Quarterly Report

Congress Awards MIT Sea Grant $1.6 Million

Matching Funds Total $1.3 Million

With a federal grant of $1.65 million, received on July 1, 1986, MIT Sea Grant will continue its marine research, education and advisory services for its sixteenth year since 1970. The two-year grant from the National Oceanic and Atmospheric Administration (NOAA) will be supplemented by $1.3 million from MIT, foundations, industries, and other institutions.

MIT Sea Grant is nationally recognized for its research in ocean engineering. The new grant money will fund research primarily at MIT, but also at other institutions, in coastal processes, offshore facilities, technology development and management, unmanned, underwater vehicles, and living resource development. Abstracts of projects funded in each of these areas are listed below.

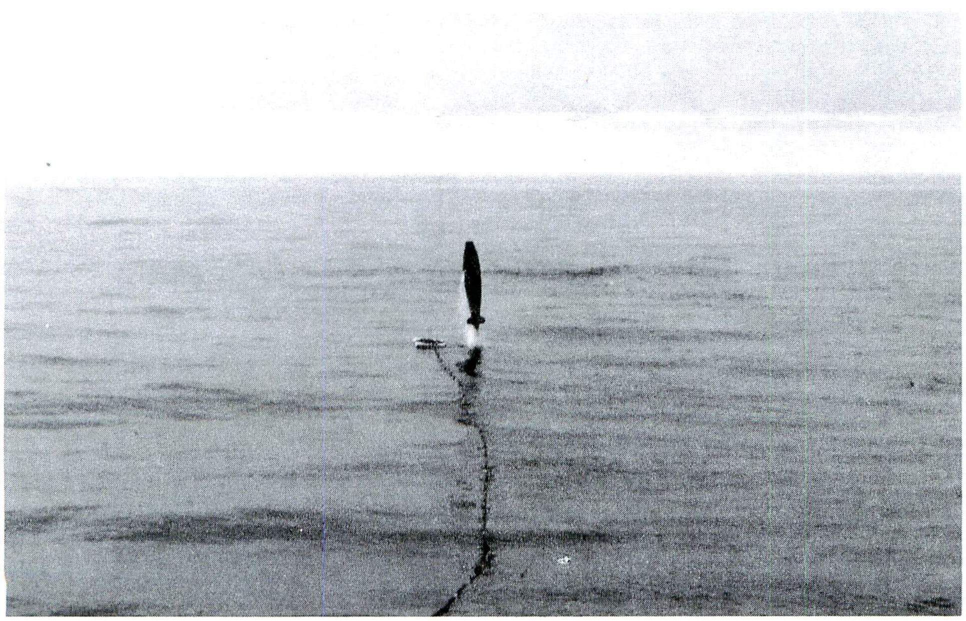
In addition to research, MIT Sea Grant's funds are used to finance advisory activities, which focus on field application of the program's research products and dissemination of research information to users. The Massachusetts Marine Liaison Service, for example, matches MIT research expertise with the needs of local marine businesses to ensure effective transfer of completed research to the field. The Communications Office publishes technical reports of Sea Grant research and operates a resource center of marine-related publications and databases of marine information.

There is also the MIT Marine Industry Collegium, a membership organization of local, national, and international marine businesses, introducing them to marine research with profitable business prospects.

In support of Massachusetts' billion-dollar fishing industry, suffering from dwindling fish stocks on one hand and skyrocketing insurance costs on the other, MIT Sea Grant sponsors jointly with the Massachusetts Maritime Academy training programs for fishermen.
At hands-on workshops and seminars, fishermen learn new fishing techniques, marine electronics, business management, and other valuable skills.

A particularly successful, fairly new program, also for fishermen, is MIT Sea Grant's Center for Fisheries Engineering Research. Using the technologically advanced circulating water channel and towing basins of the U.S. Navy's Ship Research and Development Center (NSRDC) in Bethesda, Maryland, groups of fishermen, organized by Sea Grant, experiment with different gear strategies and net configurations to see firsthand how changes affect a net's underwater performance. Through MIT Sea Grant, commercial netmakers also use the NSRDC facilities to develop new net designs.

Some of Sea Grant's new funds are allocated for MIT students to assist faculty in marine research. Both undergraduate and graduate students are supported.



New, fast, and efficient oceanographic data-gathering instrument returns to surface after successful deployment. Story page 3.

MIT Sea Grant 1986-87 Research Agenda

Coastal Processes

Response of Fine-Grained Sediments to Wave Agitation
Ole Secher Madsen
MIT Department of Civil Engineering

Investigate and quantify the response of fine-grained sediments to the agitation of water waves. The question is of considerable importance in assessing the fate of organic compounds adsorbed on fine sediment particulates released into the coastal environment through, for example, sewage outfalls.

Measurement of Natural and Waste Particles in Coastal Waters
Francois M.M. Morel
Keith D. Stolzenbach
MIT Department of Civil Engineering

Understand the processes controlling the fate of natural and waste particles in coastal waters. Involves development of analytical techniques, direct field measurements, and mathematical modeling.

In this issue

Microbial Processes Influencing Cycling of Tin and Lead in Urban Estuaries
Joseph J. Cooney
University of Massachusetts Environmental Sciences Program

Determine microbial processes contributing to the methylation and demethylation of two heavy metals, tin and lead, and to the fate and transport of these metals in an urban estuary. In urban harbors heavy metals introduced by urban run-off, air, and wastewater are a serious concern.

Modeling and Measurement of Sewage Effluents in Boston Harbor
E. Eric Adams
Philip M. Gschwend
MIT Department of Civil Engineering

Adapt and apply numerical models of circulation and transport to Boston Harbor, quantify halocarbons in Boston Harbor and sewage effluent to establish the suitability of halocarbons as tracers, and quantify volatilization rates in Boston Harbor.

A Field-Portable Probe for the Measurement of Volatile Pollutants and Biogeochemicals in the Coastal Environment
Harold F. Hemond
MIT Department of Civil Engineering

Develop a portable instrument capable of accurately measuring a large class of pollutants and naturally occurring biogeochemicals in the coastal environment.

Living Resource Utilization

Health Effects of Fish Oil
E.R. Pariser
A.B. Clifton
MIT Sea Grant Program

Investigate the availability, properties, and composition of oils obtained from locally available fish that represent a reliable, economically sound resource, and investigate technologies to prepare selected fish oils for human consumption.

Fish and Cephalopod Eye Lenses as Models for Cataract Formation
Roland Siezen
MIT Department of Physics

Use fish and cephalopods to develop new model systems to study the molecular mechanisms for cataract formation in eye lenses and the effectiveness of potential anti-cataract drugs.

Marine Biomaterials for Controlled Release and Diffusion Control
Marcus Karel
Robert S. Langer
MIT Department of Applied Biological Sciences

Using the marine biopolymers alginate, carrageenan, agarose, and chitosan, develop systems for controlled release of drugs, diffusion control in engineered foods, and stabilizing enzymes to be used in conversion of gaseous substrates at high temperatures.

Isolation of Bioactive Compounds from Sharks
Robert Langer
Dorothy Poitras
MIT Department of Applied Biological Sciences

Develop improved bioassays and purify the shark cartilage inhibitor previously found to inhibit angiogenesis, or new blood vessel growth. This is important in controlling the growth of tumors.

Biological Monitoring of Aquatic Environments by DNA Hybridization Assays for Bacteria
Renee A. Fitts
MIT Department of Applied Biological Sciences

Devise a new biological monitor for contamination of coastal water resources with bacteria commonly found in sewage.

Offshore Facilities

Behavior of Open-Ended Offshore Piles
Mohsen M. Baligh
MIT Department of Civil Engineering

Improve understanding of offshore pile-soil interaction in order to develop rational methods for predicting the behavior of open-ended friction piles in marine clay sediments.

Remote Detection of Corrosion Using SQUID Magnetometers
Margaret L.A. MacVicar
MIT Department of Physics

Investigate the feasibility of detecting and monitoring the magnetic field induced by currents flowing in electrolytic corrosion cells by utilizing the extreme sensitivity of Superconducting Quantum Interference Devices (SQUIDs) to magnetic fields.

Technology Development and Management for Ocean Uses

Marine Research Center
C. Chryssostomidis
MIT Sea Grant

Plan and conduct focused offshore research programs in collaboration with, and jointly sponsored by industry. Current Marine Center projects include Piles for Tension Leg Platforms, Mooring Dynamics, Computer Codes, and Dented Tubes.

Geometric Modeling in Computer-Aided Engineering of Marine Systems
Nicholas M. Patrikalakis
MIT Department of Ocean Engineering

Develop basic tools in geometric modeling which will allow researchers to address issues of design, analysis, simulation, production, and maintenance of marine systems in a unified computer environment.

Unmanned Underwater Work Vehicles

Effects of Tether Dynamics on the Performance of Remotely Operated Underwater Vehicles
M.S. Triantafyllou
J. Kim Vandiver
J. Burgess
MIT Department of Ocean Engineering

Quantitatively describe the forces exerted by a tether on a remote underwater vehicle and investigate the influence of the tether on the control of the vehicle.

Computer-Aided Combined Control of Remotely Operated Vehicle, Manipulator, and Camera
Thomas B. Sheridan
MIT Department of Mechanical Engineering

Refine, integrate and apply newly-developed control technologies and software to the simultaneous (combined) control of ROVs, their manipulator arms, and their video cameras.

A Laser/Sonar Ranging System for 3-D Underwater Imaging and Positioning of Remotely Operated Vehicles
Arthur B. Baggeroer
MIT Department of Ocean Engineering
MIT Department of Electrical Engineering and Computer Science
W. Eric L. Grimson
MIT Department of Electrical Engineering and Computer Science

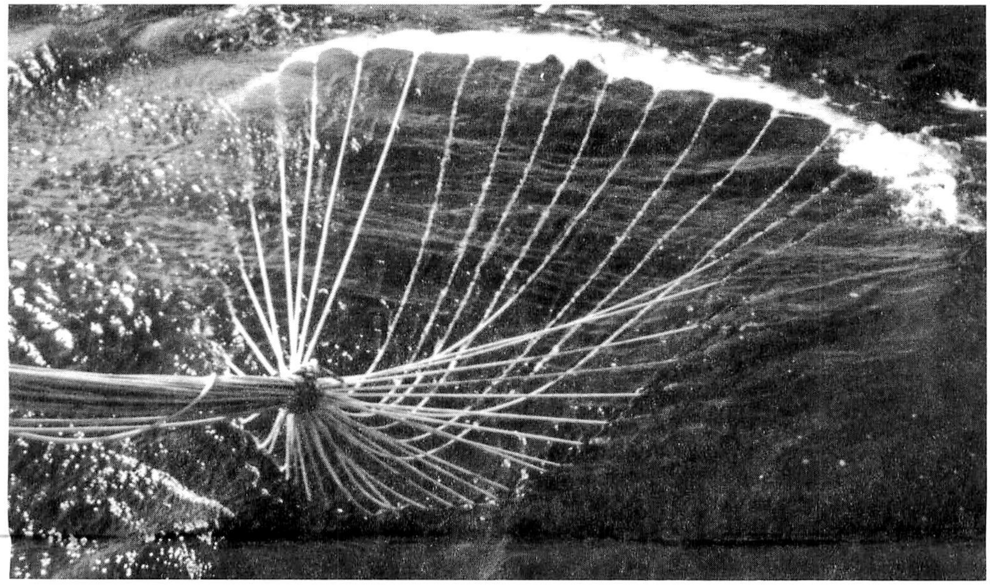
Demonstrate the concept of using range measurements from a remotely-operated vehicle to generate a three-dimensional, real-time computer model of the underwater work environment.

MOVING?

Please send us the mailing label from this *Quarterly Report*, along with your new address. Thank you.

Editor: Elizabeth T. Harding
Program Director: C. Chryssostomidis
Writers: Lynne Newman Lawson, Debbie Levey, Elizabeth T. Harding

The MIT Sea Grant *Quarterly Report* reviews the Program's marine-related research, education, and advisory service activities at the Massachusetts Institute of Technology. Funding is provided by the National Oceanic and Atmospheric Administration through the Office of Sea Grant. Free subscriptions to the *Quarterly Report* are available on request from the MIT Sea Grant College Program, Building E38-302, Cambridge, MA 02139. Telephone (617) 253-3461.



Sea anchor simulates trawl drag to measure towing power.

Student Research

Student Measures Towing Power of Fishing Vessels

Depending on what they want to catch, fishermen have to adjust their boat's towing power to the fishing circumstances. By learning more about the detailed towing characteristics of the boat, the skipper can make more informed decisions—Is a different type of propeller needed? What trawl system would make optimal use of the boat's power for different types of nets?

One way to discern the pulling force of the fishing vessel is to tie the boat to a bollard (the metal post on piers for attaching mooring lines). A line is run from the bollard to a dynanometer, which is connected to a strong part of the boat and measures tension when the boat pulls on it. Pulling force is measured for each setting of the boat engine revolution.

Unfortunately, the bollard pull measurements of towing power can be misleading. As a vessel moves through the water, the forces on the propeller are reduced. Subsequently, towing pull at trawling speeds of three or four knots is much less than what is measured when the boat is tied to a pier.

For the last year, the MIT Sea Grant Program has been conducting experiments aboard local trawlers to measure towing pull at various speeds. Most of the work has been done by ocean engineering student Alex Bocconcelli under the direction of Cliff Goudey, Sea Grant Fisheries Engineer.

In these experiments, first the bollard pull and then the free-running speed are measured over a range of engine speeds. Finally, the towline tension and speed are recorded as the boat drags a 15-foot diameter sea anchor. "The sea anchor simulates the drag of a trawl without having to set out a net," says Bocconcelli. Experiments with the sea anchor are more involved than simple bollard pull, but are much simpler than steaming out to a suitable location and taking readings while actually trawling.

The data from the boats point out the discrepancy between bollard pull and useful towing power. Bocconcelli hopes to make measurements aboard as many boats as possible to develop a better understanding of how the engine, propeller, and hull shape affect towing performance.

The researchers are building a data base to allow more accurate prediction of the pull of a fishing vessel during trawling. "If we can test enough boats, captains can know what the pull at trawling speeds is based on the bollard pull test," says Bocconcelli. Accurate estimates could even be made based on engine and propeller size and hull shape.

When Bocconcelli began this Sea Grant Undergraduate Research Opportunities (UROP) project, he brought not only his academic training but also many years of practical experience. At age 12 in his native Italy he began fishing professionally, and as a teenager he spent six strenuous summers on large boats where crew members hauled up the heavy nets by hand. After eight years in the Italian Merchant Marine and a year of fishing out of Gloucester and Boston, Massachusetts he entered the MIT ocean engineering department. Hearing that Goudey was looking for someone to help with some experiments aboard fishing vessels, he says, "I wanted to do something practical, so I jumped at the opportunity."

Speedy "Fish" Improves Oceanic Data Collection

Most sections of the world ocean remain undersampled because of the prohibitive cost of mounting a large scale ocean monitoring program. A basic limitation of the models now used to predict weather is the paucity of oceanic data to cover the model's spatial and temporal scales. The Fast Profiler being developed by Joshua Hoyt, a recent graduate of the Woods Hole/MIT joint doctoral program, is intended to break this cost bottleneck by radically increasing sampling speeds and making the data-gathering process much cheaper and easier.

An autonomous, streamlined, gravity driven vehicle, the Fast Profiler is capable of high speed (14 knots) vertical excursions to depths of 6000 m and can guide itself back to an acoustic beacon at the surface. Phase difference measurements made at four hydrophones mounted in the nose of the body are used to actuate control surfaces to correct vehicle attitude and steer the vehicle toward the surface beacon. The oceanographic sensor package is initially intended to measure conductivity and temperature as a function of depth. From the difference in density one can reconstruct the relative motion of the ocean's currents.

The traditional method of measuring temperature and conductivity consists of lowering small collection bottles to sample the water column at specific locations. Even though the electronics revolution has spawned a wide range of instruments that measure and transmit or record data at high speed, cost (research ships alone can cost $10,000/day) and logistics continue to prevent people from doing large ocean-basin scale hydrography.

The Fast Profiler is intended to make large-scale hydrographic experiments more feasible. Because it is a small, free-fall vehicle driven by expendable weights, a large ship with a deep sea winch is not needed to send it off. Instead of the typical four hours to deploy a cable-lowered device, the Fast Profiler will make a round trip to 6000 m in a half hour for a time savings of a factor of eight. Self-diagnostics and internal calibration also cut down on the maintenance costs. Data is downloaded and batteries recharged without having to open the pressure case, thereby shortening the turn-around time. It homes acoustically to a fixture near the ship to reduce the recovery time. Because the various measurements are more closely spaced in time than a conventional current meter, the resulting picture yields a better overview of what the ocean is doing, affirms Hoyt.

Extensive use of microprocessors within the instrument makes the obvious complexity transparent to the operator in the field. Programs within the instrument allow the user to ask the computer to do a self-test. If it responds, "I have a problem," another program isolates that problem so that the operator or field engineer can attempt to make repairs on the spot.

Even though it reaches speeds of 14 mph and shoots spectacularly out of the water, the Fast Profiler is completely gravity driven. A 100-lb weight propels it to the bottom, and after it drops ballast it becomes buoyant. Once on the surface it can no longer propel itself. "We have to work very hard to make it go so fast and still be a practical instrument," says Hoyt. Batteries take and store the data, and run the servomotors which steer the bright orange fish toward the beacon on the surface. Since it will profile in scientific missions perhaps once every 50 miles, in between dives the operators have ample time to add a new weight and recharge the batteries.

During one deployment the fish missed the beacon by 6 inches out of a total trip of 700 ft. "That level of accuracy proves that we can make a small-based interferometer to steer a vehicle toward an acoustic beacon," says Hoyt. The vehicle is designed to go up to 10 degrees off the vertical, so its glide angle is relatively small. "We know not only where it's going to come up, which is near the beacon, but also when it will emerge. It emits a ping once a second so that we can get a slant range on from the ship."

People who work on autonomous vehicles typically try to get around three crucial problems, says Hoyt. First, it is necessary to supply enough power to the instrument. Without a cable it needs an internal power source. Second is navigation: how does the vehicle know where it is? Third is communication, since there are severe bandwidth limitations in communicating acoustically through water.

Hoyt's approach was to back off from trying to solve those generic problems, and to try to mate the Fast Profiler to a mission which could use existing technology. "We don't have a high power requirement because we use a weight instead of thrusters, and the vehicle's trajectory is largely vertical. If we wanted a large horizontal excursion we would have needed thrusters." The problem of communication through the water typically inv[illegible]n sonar and video pictur[illegible]ofiler, communication h[illegible]d to one bit of information say[illegible]s working" or "System's not working."

Hoyt solved the issue of navigation "because the fish neither knows nor cares where it is or where the beacon is in three-dimensional space. Its two bearings say, 'The beacon is over there somewhere, and as long as I'm still moving through the water, I'll try to go in that direction.' So we were able in some sense to circumvent here the three cru[illegible]oblems that people are trying to so[illegible]nous vehicles."

While Hoyt [illegible]d the fundamental ca[illegible]trument, others at Wo[illegible] to improve the fish. In July 1986 a redesigned version will be taken out on a cruise for further testing.

Hoyt discussed his work, which is funded by the National Science Foundation, at a meeting of MIT Marine Industry Collegium members on June 18, 1986. The meeting, at the Woods Hole Oceanographic Institution, explored oceanographic instruments. For further details about the meeting or the Collegium, contact Norman Doelling, MIT Sea Grant Office, E38-302, Cambridge, MA 02139 (617) 253-7042.

Undersea Teleoperators and Intelligent Autonomous Undersea Vehicles

A two-day conference sponsored by the MIT Sea Grant Program and the MIT Department of Ocean Engineering will be held October 22–23, 1986 at the Massachusetts Institute of Technology. Four sessions will cover: *extending the reach of human operators; teleoperation for marine biology and oceanography research; mobile robots in unstructured environments; emerging manipulator technology.* Tours of the Department of Mechanical Engineering Man-Machine Systems Lab and several Artificial Intelligence labs will be included.

For more information contact Elizabeth Harding, MIT Sea Grant, Building E38-368, Cambridge, MA 02139. (617) 253-7041.

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Abstracts

☐ Public Waste Management and the Ocean Choice

Keith D. Stolzenbach
Judith T. Kildow
Elizabeth T. Harding, eds.
MITSG 85-36 280pp $15

Although extensive documentation indicates that the oceans can assimilate large volumes of sewage, sludge, and dredge spoils, there is also evidence that in a few cases environmental thresholds have been reached. Today, the public demands greater assurance that the oceans and coastal waters are not seriously degraded by future waste disposal.

This volume examines these issues and places ocean disposal within the context of other waste management options. Theory is blended with practice drawing upon scientists and public and private sector interests. Experience and planning in Philadelphia, Chicago, and New York illustrate the technical, economic and institutional aspects that communities face in disposing of their wastes.

The papers were presented at a symposium, "Ocean Disposal of Public Wastes: Technology and Policy for the Future," in April, 1985 at the MIT Sea Grant College Program Annual Sea Grant Lecture and Seminar Series.

☐ Waste-Heat-Driven Refrigeration Plants for Freezer Trawlers Center for Fisheries Engineering Research Report No. 12

Andrew David Kellen
MITSG 86-9 52pp No charge

Recent Sea Grant research has investigated how a high efficiency, gas turbine engine could be designed to provide optimal fishing vessel power. An attractive feature of such an engine would be its ability to provide other shipboard services such as refrigeration. This thesis in the Department of Mechanical Engineering describes design criteria and analyzes several options for an on-board refrigeration plant. The capability of being able to preserve fish for longer times could reduce the number of trips fishermen make, thus saving them fuel and manpower costs.

☐ Design Considerations for the Use of Ropes and Cables in the Marine Environment: Opportunity Brief #42

MIT Marine Industry Collegium
MITSG 86-12 20pp $4

Mooring systems have always played an important role in offshore engineering. Engineers currently do not have the tools to study dynamic loads in cables, so they design cables for static load conditions. Ropes sometimes reveal the first signs of damage when they snap. These major problems of ropes and cables, along with future research topics, are discussed by a panel of MIT investigators.

☐ Biotechnology and the Sea: Recent Advances and Applications Opportunity Brief #43

MIT Marine Industry Collegium
MITSG 86-13 22pp $4

Derivatives from seaweed, shark, crustaceans and other marine biomaterials are finding their way into the food and pharmaceutical industries. Research projects summarized in this report include the isolation of a tumor growth inhibitor from shark cartilage, a DNA-hybridization probe to detect microorganisms in seawater, use of marine biopolymers for controlled release of pharmaceuticals and food preservatives, and prospects for commercial production and applications of chitins and chitosans.

☐ Capacity of Offshore Friction Piles in Clay: Opportunity Brief #44

MIT Marine Industry Collegium
MITSG 86-14 21pp $4

Tension leg platforms represent the transition in offshore structures from depending on compression members to relying on tension members. Over the past decade a major geotechnical study at MIT has probed the interaction between friction piles used to support offshore structures and their underlying soils. Large scale load tests have verified the MIT approach which combines analytical methods with measurements obtained by the new Piezo-Lateral Stress cell to analyze and predict the behavior of friction piles.

☐ Oceanographic *Instrumentation* at Woods Hole Oceanographic Institution: Opportunity Brief #45

MIT Marine Industry Collegium
MITSG 86-15 20pp $4

Six new instruments for gathering data faster, more conveniently and more accurately are discussed. The POPUP profiler releases a series of probes to track vertical current profiles, while the Fast Profiler collects CTD data and returns to its support ship. A tiny digital recording voltmeter measures sediment temperature from within the walls of a hydraulic piston corer. Sea Duct performs *in situ* sediment transport experiments. A custom data acquisition system monitors fixed and drifting hydrophone arrays in the Arctic, and an Arctic Remote Autonomous Measurement Platform serves as a semi-permanent data station to collect and transmit or store information.

☐ Stochastic FEM in Settlement Predictions

Gregory B. Baecher
Thomas S. Ingra
MITSG 85-2J 14pp No charge

Foundation design requires predictions of total and differential settlement. However, as soil strata are spatially variable and exploration effort limited, these predictions cannot be made with certainty. This paper reports the results of two-dimensional second-moment settlement analyses using finite element methods and compares these results with one-dimensional uncertainty analyses already in the literature. Reprinted from Journal of the Geotechnical Engineering Division, April 1981, pp. 449-463.

☐ Compliant Riser Analysis

C. Chryssostomidis
N.M. Patrikalikis
MITSG 85-23J 9pp No charge

This paper presents a general mathematical model which describes the global behavior of a compliant riser idealized as a slender, non-rotationally uniform rod with bending, extensional and torsional degrees of freedom in three dimensions. In addition the embedding technique used to solve the two-dimensional static problem is developed. The researchers explain the selection of the initial approximation needed to start the solution process which makes the algorithm very efficient.

☐ Denting Analysis of Tubes Under Combined Loadings

Tomasz Wierzbicki
Myung Sung Suh
MITSG 86-5 105pp $5

Tubular members of offshore platforms and pipes which transport oil and gas from production fields are vulnerable to human damage from supply boats, dropped objects or launch mishandling and to natural causes such as ice scouring in the Arctic. In the case of platforms, distortion of shape or loss of axial and bending strength and stiffness could lead to catastrophic collapse. For purposes of design it is important to be able to predict loading and behavior of tubes. This report presents insights into the mechanisms of plastic tube deformation undergoing large shape distortion and sectional collapse. The understanding of these processes is a prerequisite for solving the whole class of boundary value problems in using tubes for industrial applications.

☐ A Tactical Decision Algorithm for the Optimal Dispatching of Oil Spill Cleanup Equipment

Harilaos N. Psaraftis
Babis O. Ziogas
MITSG 86-8J 16pp No charge

This paper develops an optimization procedure for assisting decisionmakers in allocating resources for cleaning up a specific oil spill. The inputs include information about oil outflow, the availability and performance of cleanup equipment as well as equipment transport and operational costs. To give the reader insights into the problem's structure, the model is applied to the ARGO MERCHANT spill. Finally, the authors discuss possible uses within existing operations and policy. Reprinted from *Management Science*, Vol. 31, No. 12, December 1985.

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