FIRST ANNUAL SEA GRANT LECTURE

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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First Annual Sea Grant Lecture

BOUNTIFUL GRANTS OF THE SEA

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This is a great pleasure for me to be back at M.I.T. It was 40 years ago almost to the day when I entered M.I.T. as a graduate student. I came from Liverpool direct to Boston and, with my bags in hand, walked from Atlantic Pier to M.I.T. The Dean of Admissions had not heard of the University of Cape Town where I had done by undergraduate work. However, as I had come so far, he admitted me on probation to graduate work in course 16—Aeronautics.

My whole career in the United States started at M.I.T. My interest in the ocean started when I was 16 years old, and worked as a ship's engineer during vacation from college at Cape Town on voyages such as around Africa to Hamburg and back and to Lourenco Marques Madagascar, Ceylon, Calcutta and Burma and back. But after taking a degree in aeronautical engineering, I went upstairs where the brand new meteorology department had been started by Carl Rossby and it was there that I was introduced to the science of oceans and atmosphere.

Stark Draper, who was both my teacher and roommate, interested me in instruments. This, with Rossby's interest in ocean dynamics, led me to combine the two into what was, I suppose, a start in ocean engineering. My little contribution in ocean engineering—the bathythermograph—I first built in a bootleg fashion in a small shop in the basement of the Aero building and tested at Woods Hole.

At the same time, Rossby had me working on the motion of jet streams in a rotating tank. I built a huge 6-foot diameter flat rotating pan—the only space available to put this monstrous dishpan was in a seldom used men's room in the basement of Mechanical Engineering!

It was in 1963 that I conceived the idea of the Sea Grant colleges. And in October 1966, President Johnson signed it into law. By coincidence that same year I was put on the Board of the National Science Foundation and was present when the very first applications for Sea Grant awards came before the Foundation. I was delighted to see that one of these was from MIT.

I like to think that the fact that MIT received the very first Sea Grant award under the new program, the fact that I happened to be on the Science Board at the time, and the fact that I had brainstormed the Sea Grant Program were not entirely unrelated.

MIT's well-deserved institutional status in the National Sea Grant program, to my mind, strengthens the whole program; it implies that the tremendous intellectual and practical resources of this great institution will be committed even more fully to better uses of the sea.

That MIT should be a leader in ocean engineering, of course, to us quite natural. It rests on the great foundation of its distinguished department of naval architecture and marine engineering and relates to all strengths of the areas of the Institute. MIT also has a magnificent history of dedication, not only to good science, but also to the use of good science and engineering for people's needs. That is just what the Sea Grant program is all about.

This is the right time for MIT to turn more to the sea. We are seeing a burgeoning of aspiration and concern of people with regard to the quality of their environment. Such aspirations and concern are excellent. But what is not excellent is some of these people's over-simple attacks on industry and technology, attacks often without alternative positive proposals. What is not excellent is the uninformed concern leading to unrealistically stringent controls, often with impossibly short time scales of accomplishment. These, I believe, can inhibit the very industry, technology and productivity that we need to use to give us the quality environment to which we aspire. What is bad is that this has resulted in a body of uninformed vocal opinion which one might characterize as supporting non-engineering or even anti-engineering.

Engineering's job is to apply not only our scientific knowledge, but also our arts to supply people with the things they need. Non-engineering takes place when protests and action, sometimes in the name of conservation and environment, stop us providing for people's needs. What is bad is controls without incentives—attacks without proposals, actions that result in non-action that leads to profound social consequences—social consequences that lack adequate, positive social and engineering planning.

Doom forecasts are mostly based on what will happen if we don't do some things differently. (By differently, hopefully better.) But what's new about that? We always do something differently. We see the problems and as engineers we tackle them. We do, indeed, need to do some things differently and on a very large scale in regard to our environmental problems.

An engineer's analysis of the future should start from where we are and predict what must be done in business and industry to arrive where we would like to be to achieve desirable results. An engineer should not merely sit back and predict the inevitable result of carrying on present practices. He should design the future—not just let it happen.

Our people, on the average, I believe, are living in the most bountiful age—healthier, cleaner, better educated, better nourished, better than they have ever lived before. In fact, so good is the living that they can now afford these newer aspirations. There is nothing wrong with these aspirations. They're great. But there is a real danger that political and public manipulation of them can destroy the very productivity we need to achieve them.

These aspirations deal, on the one hand, with an increasing protective attitude to people, and on the other hand, with the over-concern for an over-clean environment. In both of these worthwhile objectives, there lurks the danger of ignorant, overemphasis to the extent of inhibiting national productiveness.

On the other hand, if we plan properly and imaginatively to move toward these new aspirations, we can both stimulate productiveness and initiate new kinds of industries to supply the new "commodities," if you like, of cleanliness and safety for people.

But we cannot do this with naively overstated goals of "zero risk" which may stifle inventiveness, initiative and the production of new things for people's health, mobility, improved shelter and food. Some people are already inhibiting innovations by naive over-statements of possible side effects and risks that these might present.

No one argues that the proper assessment of the side-effects of new chemicals, new drugs, new materials, new modes of transportation is an essential part of good engineering and industry. But few among the public recognize the danger to our overall national productivity if this protective assessment is overdone—as often it is today.

Similarly, the naively overstated goal of "zero effluents" prevents our developing productivity—especially the productivity that we need to enhance our environment. No one will argue that great, planned, practical efforts must be made to prevent the further pollution of our land, air and water. But we must make realistic engineering plans and stimulate our technology, business, and industry to use their muscles in a waxing technological, business and industrial effort to achieve the cleanup that we desire.

We need to move toward a better public understanding of what I've called an "ecolibrium" position—balancing the desired ecology (an harmonious pattern between organisms and their environment) with the necessary economy (the management of affairs with a view to maintaining productiveness).

"Zero risk." Nonsense! There must be more realistic awareness in all activities that there is an acceptable risk and that it is not zero.

"Zero effluents." Nonsense! There must be more awareness that in the use of the components of our environment—air, land and water—there is an acceptable burden of man's wastes of the proper kind that these components can carry and that this is not zero.

There must be more awareness of the fact that one proper use of air and water is to dirty it—whether we use it in the organisms that are our bodies or in the organisms we call industry. We should be aware that certainly both our own body organisms and the organisms we call industry would die under a policy of zero effluents.

There must be awareness that water and air are commodities that we must use, clean and reuse, just as the commodity food is grown, used and regrown. We must think of the culture of our air and water—atmoculture and hydroculture, if you like—as we think of agriculture today.

We must realize that there is a cost for these new commodities—air and water—that cleaning up is not a one-shot proposition, but a continual added cost to the commodities which we borrow from our environment. Underpricing water, air and energy promotes the waste of them, and thus promotes pollution.

Above all, there must be awareness that to continue to give people the things they need to ease their lives and at the same time preserve a clean environment and a clean world will take more energy per capita, not less. Starting with a given population to achieve the intermediate steps involving food, cleanliness of the environment, better indoor environment quality, housing, to reduce depletion of resources, we need to increase the basic currency of civilization for each individual—namely the energy at his command. Yet, there are many who are delaying and inhibiting the production of the energy we need.

Nowhere is this more striking than in the present misguided notions, which are voiced loudly in the controversy of oil production, tanker imports, nuclear power plants and the like.

This is where we come to the sea.

I entitled my talk Bountiful Grants of the Sea because Sea Grant Program's purpose is to make available to people the Grants of the Sea.

A grant is a gift for a particular purpose and in this way the principal potential grant of the sea to man is the space it offers him to extend his living to the other three-quarters of the earth. The problems of the smaller and more crowded areas of land can be alleviated by great ocean engineering. The most bountiful grant of the sea is space—space to offer man for his activities; space close to the coasts where people crowd; space close to the majority of the cities of the world that are on the coasts; space close to the principal terminals of world trade. Coastlines, after all, are a constant length. They are lines—one dimensional yet man and his activities are three-dimensional. Man is not one or two dimensional—he's not a square, he's a cube.

So far, man has broadened his line of coastline by extending it inland. He has so far not broadened his coastline by extending it much out to sea. We come inescapably to the fact that any land use plan must also be a sea use plan. But the sea has space to offer us and particularly space near to the shores where 70% of the world's people congregate. (53% of the people in the U.S. live within 50 miles of the coast; projections say by 2000 80% of the U.S. population will live in the same area.)

The land use battle that is going on all over the United States is probably most intensely fought in view of the current environmental concern—it is most intensely fought about the use of the coasts and it is a perfectly proper concern to view one of the most important and unique uses of the immediate coast and beach as being for people's recreation.

Land use involves sea use. Yet there are now coastal management bills pressing 30 states to develop land use plans for their 100,000 miles of irreplaceable coastline. The Coastal Zone Management Bill extends seaward but, while it is concerned with the preservation of the coasts to protect them as natural resources, it does not seem to have the balancing of adequate positive encouragements for renovating the coastline to benefit human uses of these resources.

I endorse the validity of land use and environmental concerns. Should we not then have a vigorous national program of sea use to move such activities as we can, that are presently cluttering up the shoreline, out to sea?

All the area of land on earth is constant—less than one-third of the earth's surface. Land is not boundless as man once thought it to be when there were fewer of us. But an inventive, imaginative, daring and adventurous ocean engineering program could multiply our living space by the proper use of the sea.

The bounds of land are only the bounds of men's minds limiting their imagination. Man's use of land should not be bounded by seashores.

If what I say may seem like dreams to some of you, I remind you that you and I have had dreams and seen them rapidly become reality. If some of the components of what I suggest seem like stunts, I would remind you that you and I have seen stunts become routine.

Indeed, dreams are the stuff that practical progress is made on.

Non-engineering or status quo practices are the material for nightmares. Dreams go beyond the state of the art and challenge the state of the heart of innovators. Stout hearts can take us beyond present art.

Fifteen years ago in a little pamphlet called "Turn to the Sea," I dreamt about man's return to the sea. I compiled dreams of the study and use of the sea into a little story. Almost all of the dreams in that little book have come to pass today—have become reality.

Man has indeed been turning to the sea, returning to the sea, for thousands upon thousands of years.

The first light that warned sailors of dangerous shoals and rocks or guided them into protective harbors safe from storms was probably a fire on a cape. The first lighthouses were built on shores, but the lighthouse then tiptoed out to sea—at first onto a shoal and, for their day, what daring and imaginative structures these lighthouses seemed that were built so far at sea! But then the lights stepped further out on floating houses—the light ships.

Man first found oil naturally seeping out on land, and he sucked up naphtha with sponges from the edge of the sea. He first drilled for oil on our land, but then he built the Texas towers that strode out to sea on their long legs. Then man drilled oil from floating rigs in deeper water. And now we see moving under the sea not only prospect drilling, but also production and storage.

Harbors have traditionally been at the meeting point of sea, air and land—the worst point where tides, waves, winds and shoals combine to make the harbor a potentially dangerous entity as well as a refuge. As ships grow larger and larger they cannot come into these dangerous harbors and so they discharge their cargoes often to smaller ships—an uneconomical process. Now we fill tankers from buoys out to sea, and in the North Sea companies are building artificial islands as harbors for large vessels. Harbors too are striding out to sea.

But now they must stride more quickly because they have the gun of environmental restrictions on land at their backs. And the moral duty of meeting the impending energy shortage which is beckoning them to sea. Yet at the same time, people and government are banning refineries from the coastlines of Delaware, Maine, New Jersey, Florida, and many other coastal states. And even if they don't ban them, the environmental restrictions they place on the refineries make it economically impossible for industry to go ahead with the urgent plans to supply the energy we all need—not just for our ease, but also to accomplish the environmental cleanup.

The East Coast needs eight new oil refineries by 1975. Yet the President of a large oil company says no company will build them here because the restrictions will force them to build overseas instead. The US needs seventy-eight new refineries, each costing $150 million and requiring three years to build, by 1980. None of these are even on the drawing boards.

Land use restrictions and the environmental concerns, thus, if too extreme and too hasty in their implementation, will cause companies to export these plants, the refineries, and the jobs that go with them. And in addition, this exporting will merely move the pollution associated with them to someone else's backyard. Would it not be better by good imaginative engineering and the provision of a sufficient time scale, to retain these plants, refineries, and the jobs and wealth that go with them and to contain the pollution associated with them? We can do this by considering imaginatively the proper use of the sea.

We must completely reverse the current popular doom-saying attitude toward energy. Far from curtailing our energy production, we must vigorously increase the amount of energy we produce so that we may invest some of this energy in producing new energy sources.

Nuclear power is the most important investment we can make. Yet it, too, has a gun behind its back. People live on the coastline. Power plants are necessary where the people are. Power plants choose sites on capes or seashores where they're close to the people and to the huge amounts of water required for their cooling. Yet, environmental pressurists delay and prevent these plants from being built. By using the sea, can we have our cape and heat it too?

Harbors are urgently needed and in connection with the same problem—energy, the fundamental currency of civilization. Yet the kinds of harbors that we need for the ships of the future—the huge safe ships of the future—are ones which, if we build them in the existing way on the shoreline, will take this shoreline away from the use of people for their re-creation.

The cheapest ways of transporting oil are by tanker over the sea and by pipeline over the land. The larger the tanker, the more economical it is. And the more safe it should be made from spillage and from collision. The larger the tanker, the more feasible it is to spend the money to make it free from the possibility of oil spills and collisions.

We do not have a single harbor in the United States that can accept the half-million ton tankers that the Japanese, for one, are building to use tomorrow. To adopt the expedient of offloading these tankers into small barges is the wrong way to go. This increases the possibility of spills and pollution. Can we not take the harbor out to sea and contain the oil spills?

I believe that proper engineering can completely protect shore and adjacent waters from pollution and spills near the coast. A harbor out to sea would be the garage, the marina of highly sophisticated spill equipment. A harbor to sea would have the spill emergency equipment, an environmental control brigade, just as a city on land has a fire brigade—for emergencies.

We must develop pipelines vigorously, not only for transferring oil and slurries from offshore harbor to points inland, but also for transporting all kinds of other goods. Traveling bands, chains of hoppers, and other forms of pipe transportation are necessary.

We could even transport fish conveniently in a slurry with water!

Submarine tankers are an imaginative idea, but they have been ruled out in the past because of the complications of offloading them on the surface. However, if they can offload underwater into submerged pipelines, they may someday become feasible.

Fishing, for U.S. fishing vessels, has only one hope—to take a technological overleap in automation and sophistication. To justify this cost, fishing vessels must spend more time at sea and less in port. They must be coupled to fish factories. One can imagine these fish factories and processing plants associated with the complex out at sea separating the seafood wastes from the food parts and piping the food parts into shore through pipelines.

The catching vessels could discharge rapidly to the harbors at sea directly to the fish processing plants there. The wastes of the fishes themselves could be treated and used as nutrients for beneath the sea portions of these complexes which would be used for fish farming. Thus, aquaculture would grow around the sea city just as agriculture surrounds our land cities.

Organic wastes from the land could be piped out to waste treatment plants at sea, there to be used for aquaculture purposes. Here at MIT, I am fascinated to learn of a most exciting project to irradiate sewage with electron beams and destroy viruses, bacteria, deactivate detergents, so that the sewage can be returned either to the land or to the ocean with fertilizing instead of polluting effects. This is a tremendously important project.

I recall when I was in Seoul, Korea last year, I was discussing the problem of "night soil" with the Minister of Health and he was explaining to me that he was having great difficulty trying to educate the rural Korean population that they should not put their night soil on the land, as has been their tradition for thousands and thousands of years. I countered by saying that I was having great difficulty with the people of the United States in convincing them that the only proper thing to do with the night soil was to put it back on the land! I hope the MIT project will find economical ways to make the sewage safe to put back on the land or in the sea.

The low-grade heat (so-called "waste heat") could be used also in aquaculture to regulate the temperature of the water to the optimum conditions for fish farming.

The extraction of minerals from the sea could also be done in these complexes, such as mined phosphate rock or the production of such things as magnesium from seawater. One of the great costs of extracting things from seawater is that you have to pump an awful lot of water, but if you pump this water, you may be able to use the same pumps and use the water for several purposes — extracting minerals, deriving fresh water, using cool water for air conditioning.

Airports are somewhat in the same plight as power plants. They need to be near where the people are. Yet they can occupy huge tracts of land near the cities that people constantly need for other purposes. Traffic congestion on the ground to and from the center of the city reduces the airports' usefulness. Airports are also under fire for increasing noise, and the planes are under restrictions relating to the reduction of power on take-off and land that either increases the hazard of flying or increases the cost of the aircraft by having to over-power them. Couldn't airports move out and join the complex at sea?

A city anywhere must start with a purpose. Then people come to work toward that purpose and build houses to house the workers, and thus the city grows. This is the proper way for a city to grow; otherwise, if one builds a city at sea, you will have merely a bedroom city or a city in search of a purpose. But with the multiple uses I've described here constitute the real purpose of what we might call a sea city. With airports and harbors, hotels for travelers would be necessary, as would housing for the freight handlers, the airport workers, and harbor workers. Hotels at airports on land have to be insulated from the aircraft noise. What better insulator could there be than seawater with hotel accommodations within the huge floats or pylons beneath the sea surface. Travelers would truly have an "ocean view"—from below!

Recreational facilities—marinas and sub-marinas, underwater parks, things that are all in their embryo stages, would all join the complex away from the shore.

You will all recognize, I'm sure, this complex is just the putting together of many well known suggestions.

In fact, many parts of this complex are being worked on already, either in the Sea Grant Program or in related programs here at M.I.T. and other institutions.

Here at MIT I have learned that work is going on on the sea environment, marine resources, aquaculture, the better use of foods from the sea such as squid, the disposition of food wastes, offshore petroleum, ocean borne commerce, port design, commodity transport, liquified natural gas, harbor traffic control, navigation, oil pollution and preventing its spread at sea, and aquaculture. Also, some of your people have been making sophisticated anlyses of complex ocean structures necessary to support various sealoads. And most important, here at MIT you have people in public policy working on the development of public acceptance of the proper uses of the sea—acceptance not only naturally by the public but also acceptance within what will have to be a new structure of national and international law and policy.

Actual engineering works are going on in some of these directions. Last week we read of the offshore nuclear plant which is to be floated three miles off the Jersey coast. Some of us know of John Craven's imaginative model of a floating city to be associated with the bicentennial celebrations in Hawaii. And again in Hawaii, Honolulu's airport is to be multiplied in capacity by extending a runway on a reef offshore, and others are planning a port offshore to serve Texas. These things are going on in our country.

But other nations are ahead of us. The Japanese already have great plans for a floating city. European nations around the North Sea are planning—some even building—a considerable number of offshore harbor and industrial islands in the North Sea. All of these steps are good ones, and they can contribute the experience they represent to the complexes we will put together in the future. But the question is:

How can we in the U.S. take a step jump and put the whole system together instead of whittling piecemeal and having to solve all the public policy questions and the endless national and international debates over and over again for each step we take seaward?

It is probably not economical for an individual activity by itself—for example, oil refining—to move out to sea as a single activity and in the short time scale available to meet the urgent energy demands. But if we join uses in a systems concept that has a common kind of underpinning moving out to sea is feasible. The total cost of such a sea complex would be less than the sum of the individual costs of the components and the total system will add more in social value, environmental and economic gains for society than the sum of the individual social goods of the components of the system.

But how to do it? First of all, public policy—that is, new policies and new thinkings in government, industry and the universities—new because we must recognize that the dimensions of the task for the proper use of the sea are very large indeed. The dimensions are so great that government's initiative must be comparable to former national goals that we have achieved in space and in atomic energy. But industry's effort is probably larger than even the largest of our industries would undertake alone. We must recognize that the basic underpinning of science and technology that we will need and that our universities can contribute is greater than that any single university can provide. The size of the engineering and management job to be done requires new crossings, new meetings and new aglomerations in government departments, among industries, and among universities.

For government, we know that already there are positive discussions going on in Washington on inter-agency cooperation in the new uses of the sea so that the Maritime Administration with its harbor problems, the AEC with its nuclear plants, the EPA with its waste disposal and NOAA with its experimental platforms can join with FAA and its airports to plan a synergistic sea system. I wonder, however, whether inter-agency cooperation is sufficient. We will need to jump that barrier that defines the traditional missions of government departments. Government has done this before by establishing for atomic energy the AEC, and for space, NASA. These were autonomous agencies that had the clout commensurate with the job to be done. We have a sea agency in NOAA, but if NOAA and its parent department, Commerce, are to embark on this massive program, they too must have the support, clout and muscle commensurate to do the job.

This cannot be done unless the government sets up, as they did in atomic energy and in space, the sea-use project as a national goal on a time scale that is both realistically long enough to achieve its aims, yet realistically short enough to meet the urgency.

To illustrate the kinds of rearrangements of government that we need, here's an example: We have a Department of Housing and Urban Development, yet urban development depends much less on simple Housing and much more on Commerce, Labor and the people's services for Health, Education and Transport that lead to well being and reduce the need for Welfare. Thus, I've described the task contained in the name of HUD in words that are the lead words of five other departments of government.

Perhaps in addition to the watchdog Environmental Protection Agency, we need an Environmental Promotion Agency!

On the international governmental side, if we are to move complexes out to sea we get involved with the knotty problems of the international law of the sea. Practical considerations are dictated by nature—how steeply does the seabottom shelve into deep enough water—and will often be in conflict with the arbitrary man-made limits of three, twelve or X miles. Where water is shallow, as in the Gulf of Mexico, we'll need to go far out; where water is deeper, not so far. It seems that we can resolve these problems better by multilateral or bilateral agreements of the states and nations affected with due regard to particular geographical situations, rather than by any blanket international agreements that would tend to presume a geographical sameness of all situations.

In industry, the size of the effort necessary to accomplish this task is such that we will need to abandon old or social assumptions of the badness of size, of monopolies, and of cartels. In industry, we will need to see associations of a number of our very largest industrial concerns to achieve the building of the complex. Far from discouraging partnerships among our largest industries, we will need to encourage new kinds of combinations, new kinds of consortiums of industries, perhaps in the manner of the space program.

Universities which must supply much of the scientific and technological underpinning of enterprise in the sea will likewise need to integrate the separate pieces that are going on, both under the Sea Grant Program and in related programs in many institutions in the United States. Here we need, perhaps through the Sea Grant Program, to give a contract to some institution —perhaps, MIT—to bring together, to correlate, and to aim all the developments in sea use toward the synergism and economy that could be gained in a combined complex.

We don't need to invent how to do this. We have many examples right here at MIT, where national scientic and technological talent is or has been coordinated for special tasks, such as in the Radiation Lab in World War II, in the Draper Lab for navigational guidance systems, and in the Lincoln Lab.

Jefferson, in 1801, wrote about the ocean, "Nature . . . has made it common to all for the purposes to which it is fitted." You have a Lincoln Lab. How about a Jefferson Lab dedicated to the development of these purposes for which the ocean is fitted?

This project viewed in its holistic sense and not in fragmented components is the challenge I see for you as, more and more, MIT "turns to the sea."

ATHELSTAN SPILHAUS

SEA GRANT COLLEGES. It was this phrase, Dr. Spilhaus suggests, that did the trick. At an American Fisheries Society meeting nine years ago this month, he asked, "Why, to promote the relationship between academic, state, federal, and industrial institutions in fisheries, do we not do what wise men had done for the better cultivation of the land a century ago. Why not have 'Sea Grant Colleges'?"

Shortly after Dr. Spilhaus asked his question, he began to receive enthusiastic responses. Then, with help from John Knauss, now Provost for Marine Affairs and Dean, Graduate School of Oceanography, University of Rhode Island (one of the first four Sea Grant Colleges); Congressman Paul Rogers, Florida; Wilber M. Chapman, until his death in 1970, one of the world's foremost fisheries scientists; Senator Warren Magnuson, Washington; and Senator Claiborne Pell, Rhode Island, Dr. Spilhaus saw his suggestion become law on 15 October 1966 — three years and one month after he had made that suggestion.

But his role as Sea Grant's fond father — his description — is only one reason it is especially appropriate for Dr. Spilhaus to be the first Annual MIT Sea Grant Lecturer. Another: after he earned his B.S. from the University of Cape Town in 1931, he took his M.S. from MIT in 1933 for his research here on aeronautical and meteorological instruments. He was a Research Assistant at the Woods Hole Oceanographic Institution (1936-1937), with which MIT now has a joint degree program. At WHOI Dr. Spilhaus did model experiments in oceanography and in developing the bathythermograph. He was a WHOI Investigator in Physical Oceanography (1938-1960); next, an Associate in Physical Oceanography; and then an Honorary Staff Member of the Institution. He took his doctorate from the University of Cape Town in 1948. He also holds nine honorary D.Sc. degrees and one honorary L.L.D.

He is now a Fellow at the Woodrow Wilson International Center for Scholars in Washington, D. C. and a member of the National Science Board. He has been chairman (1971), president (1970), and president elect (1969) of the American Association for the Advancement of Science; president of Aqua International (1969-1970) and of The Franklin Institute (1967-1969). For 17 years (1949-1966), he was Dean, Institute of Technology, University of Minnesota. His earlier work includes scientific research and administration at New York University, where he started the Department of Meteorology and Oceanography and chaired it for nine years (1938-1947), and with the government's meteorological services in South Africa.

Dr. Spilhaus is also a Fellow of three societies — Royal Meteorological Society, American Institute of Aeronautics and Astronautics, and the American Association for the Advancement of Science — and a member of five more. He has written eight books, over 200 articles in scientific journals and magazines, and "Our New Age," a Sunday illustrated feature on science. He has invented the Spilhaus Space Clock, which tells not only time, but also tides, phases of the moon, and other planetary data.