INTERVIEWER: This is the 150th anniversary interview with professor emeritus Walter Morrow. Let me start by asking you where were you born and where did you grow up?

MORROW: All right. I was born in Springfield, Massachusetts in a day when it was a big factory town. Lots of armament, the Springfield Armory was there. Many other factories of different types around. That's all gone today, I'm afraid. At any rate, it was a very technical town. I, from an early age, had technical interests.

When I was maybe eight or 10 or something like that, I had my own chemistry laboratory, for instance, in the house. It was a special room filled with chemicals and whatnot. My father was in charge of large electrical construction projects in the Boston area -- not the Boston area, Springfield area and north of there. So he was much into the side of electrical systems. But I became interested in electric systems and this is a fall-out from the chemistry business in which I got sort of bored after a while from electricity. It was a fall-out into electronics, which was just beginning to be a big thing.

So while I was in the schools there -- and I'll talk about the schools in a minute -- I'm busy building things around the house: telegraph systems, short-wave receivers, and later a large antenna on the house to receive TV from a long distance, because there was no TV station in Springfield.

Now, the school system then in Springfield was an entirely different thing that you couldn't find today. This was in the depression, and there were people desperate for jobs. So the teachers that were chosen were the very best people that they could hire. They were at the top of their classes graduating. As you're probably aware, that situation is inverted today, and the teachers are taken from sort of the bottom of the intellectual scale.

In particular, the high school that I attended, Springfield Technical High School, I think it was called, was staffed with people who couldn't get jobs in the depression, but were very, very skilled. For instance, the chemistry teacher came from running a chemical plant. He was the real thing. The physics professor the same way, and taught multiple subjects not only of physics, but he taught electronics and aerodynamics and so forth.

This was a school, a technical school, that was really intensive and there is no duplicate that I've ever seen since then. There were machine shops run by people who used to run machine shops and all kinds of things of the sort. It was a very, very intense place.

The education there was at a level when I came to MIT, and I'll talk about how that came about, I essentially knew everything in the freshman class, all the different courses and whatnot, with the one exception of calculus, which was not taught in that school at that time.

Now, when it came time to graduate it was at the end of World War II, 1945. There was great turbulence, you might say, in the universities at that time because of the draft and all the rest of it. So when I began to look around for places that I'd like to go to, I was looking for technical places, and the two that interested me the most were Yale and MIT.

In both places because of the things that I'd done at the school, building experimental systems that were shown in the classrooms, not by the teacher but by myself, there was an instant acceptance at both places. No test, nothing. Just all they did was talk to the teachers in the school. I got some kind of an award at the end of the time in technology, and it was a unique award. Only one person got it and I was that person.

So, I come to MIT at the end of the war and the place is still in the war when I come because it was July. The course at MIT was a all the year around course. It was a three term course, there was so much rush to get people through the course for the war. So it started in July, the war hadn't ended yet in July. There's still a war in the Pacific. The Radiation Laboratory, which I knew about I guess by other people telling me about this place, was in full bore operation here at the Institute.

That included operations on a number of the current buildings, and included one building which has since been torn down to make the new building for research and artificial intelligence, I guess is what you'd say.

At any rate, I came here at the age of 16 in that spring of 1945. It was a pretty rough place. There were no tutors or anything. It was live or die by the exams that came every three weeks. That was not a big problem for me because of the high school which had covered all of that, essentially, except for calculus before.

The biggest problem came in the sophomore year. There was a transition from professors teaching the classes to assistants covering the classes, teaching the classes. Their quality was definitely different than the professors. These were graduate students who were teaching assistants and they handled most of the classes. So it was a struggle in these classes to get what they were trying to convey and not conveying it terribly well.

INTERVIEWER: Let me back up for one second. Why did you choose MIT over Yale?

MORROW: Yale had very strong chemistry courses and professors, but it had essentially nothing in the electronics area. I knew about the Radiation Lab, and that was the beginning, as I mentioned to you before we came here, of MIT growing to be what is today. MIT's current situation is directly the result of the Radiation Lab being here and being staffed by professors from the Institute.

INTERVIEWER: Do you want to tell that story now since we're--?

MORROW: All right.

Well, when World War II began, there was a serious problem about detection of submarines and detection of aircraft, and so forth. The radars that existed at that time were so-called long wavelength radars -- they operated at 200 megahertz with wavelength of a meter or so. They were not able to do a lot of things that were very desirable. Very hard to put them in an airplane, for instance, because the antennas were too big. The English had been working prior to that time on microwave vacuum tubes, not with the thought of particularly being used to build radars, but just as a new kind of a vacuum tube.

The British, in part for the exchange of the destroyers, the 50 destroyers that we gave the British before we got in the war, came here with a cavity magnetron, one of them, and it was about the only one in the world that existed. That appeared on the scene I think roughly '40, 1940, maybe 1941, but it was right in that period.

The decision was made by people in Washington, and ones from MIT had a large impact on this, that the development of that device into microwave radars for all of the military forces would take place here at MIT with an organization that was separate from the Institute but was using their professors, their facilities, and their buildings. Extra buildings were built for this enterprise.

The speed with which that single device was transmitted into capabilities for naval fleets and aircraft was incredible. Inside of two years they had 1,000 ships equipped with these radars. There's nothing like that that could be done today, but they did do it. A variety of other kinds of radars that were also developed were carried through and deployed in the field.

This effort was not solely carried out here. There were companies that were, you might say recruited, to build the equipment, so nothing was built here except prototypes. Raytheon was one of them, and the other was Western Electric. Those two companies were told you will build them night and day right through Sunday, you will build them by the thousands, and they did. Those things played a very significant role in defeating the German submarine attacks in the Atlantic.

People were crossing the Atlantic with help from the British and later from the US forces over there. Finally with the radars plus new aircraft plus little aircraft carrier to launch the aircraft, and also as a result of the British breaking the German cryptographic systems, these oceans were swept clean of the Russian -- not the Russian, but the German submarines, by about three years after the beginning of the war. They were all found and destroyed.

So there's an incredible impact on war that this place had. In some sense, equivalent to that are the nuclear weapon. It was, at the time, viewed as a balanced thing. They were both equally significant.

INTERVIEWER: Then what happened at the end of World War II?

MORROW: At the end of World War II, the government said, well, we built them all and industry can carry on. So they folded it. The only thing they did is in the final year of '46, they had a year spent to create a series of books that listed all the technology. There are about 20 books in this thing called the *Radiation Laboratory Series.* They're not much looked at today because they're pretty old.

But in the beginning of the Lincoln Laboratory, which occurred several years later -- and I'll go into that in a minute. These were the textbooks that you looked for. No one else had anything like this. They were unique in the world. Foreign countries desperately scooped them up to look at them, and many places in this country used them. Just about everybody in the electrical engineering department would have a set of them on their shelves to look at to see what was described there.

Now, the question that you're asking is where did Lincoln Laboratory come from. The Lincoln Laboratory came from the Radiation Laboratory rather directly. There were a number of professors who were at the Radiation Laboratory still at the Institute. Wiesner, Jerome Wiesner was one, and Radford, Bill Radford was another. These are two people in my undergraduate years that were closest to me and gave me special tasks to do. Not theses, but things they wanted done, and they called on me to do these technical things of one sort or another.

When the Cold War started there was a big concern about Russian bombers. It turned out that this was, because of poor intelligence, this was an assumption that was incorrect. The Russians were not building large numbers of bombers. They were building ballistic missiles, as we learned later. But at any rate, it was decided that we needed to have a very good air defense system for this country. The people who had been involved with the Radiation Laboratory were on advisory committees in Washington in the Defense Department.

The capabilities of these people were widely known in Washington, and the decision was made in Washington that basically the Radiation Laboratory would be recreated. It was put together here in the buildings -- actually, we're practically sitting on one of the buildings. It's been torn down and rebuilt since then. Building 20, left over from the war days was made part of it. There were several other buildings here that were put together to make a start on this new thing, which at the beginning did not have the name Lincoln Laboratory.

The reason Lincoln Laboratory is Lincoln Laboratory in name is that these buildings occupied space that the Institute needed for expansion. The expansion was occurring because the Institute was viewed as the leading place in the world in electronics. There were all kinds of expansions in the courses in Department 6, which was the electrical engineering department -- and in other areas in chemistry and whatnot. They needed the space that was left over from the Radiation Laboratory.

So, Lincoln -- whatever it was called then and I don't remember the name -- at the beginning was told get out of town, and the place it was decided was Hanscom Airfield, which is a state-owned airport. But in World War II it was a fighter aircraft base to attack the bombers. So, the decision was made let's move there. In '53 roughly they started construction in that area -- the lab starting around '51 or so. I was here in the lab as it began, and I'm the last person in the current Lincoln population that was there at the beginning. Everyone else is gone.

At any rate, a big building was built out in Hanscom which had a lot of land. The government owned sort of half of the land from the fighter airplanes, and the commercial people had the airport itself. It's actually something that Massachusetts as a state owns. It's a state-owned airport still to this day. But on part of the base is a piece of land which was set aside then and is still there for development of military electronics. Lincoln is on that land, as well as a large, I guess it's Air Force set of buildings and people who purchase electronic systems, some of which come from the laboratory.

So it's a combination base. There's no actual fighter airplanes or anything like that. It's a laboratory plus a procurement organization is what you're looking at there today.

The building as it began held everybody pretty well. Now how was everybody -- it's about 1,800 people of which maybe 600 or 700 were professional staff people of one sort or another. About an equal number of technicians and another equal number of people to keep the building running and provide the power and the telephones and everything you need to keep a thing like that going. So it was sort of a three to one split of the 1,800 people.

The reason I mention this is later in its life, 1,800 will be looked back on as a very small number in terms of what happened.

The transformation of myself from MIT as a graduate student into the lab really occurred because of Radford, Professor Radford. Now, Radford was a professor who taught electronics, and Wiesner took up teaching about radars. So these two people I knew very well in those days as a student. When I came out of graduate school there was a question, my wife and I, where would we go. There were demands from all over the country for anybody that graduated from MIT at that point.

So we took a look at several locations, one of them was where the atomic bomb was built. Well, not that, it was the support company that made the thing a real device. Not the laboratory, not Los Alamos, but the organization that still continues to this day that manages the whole business. That was one place.

Another place was in western New York State in Buffalo where there was an aircraft company that was working on air-to-air intercept and ground-to-air intercept systems. That was something that I had worked on here as a thesis, a telemetry system for that.

The third place was MIT, the new laboratory. By the way, the new laboratory when it moved to Hanscom originally was going to be put on a piece of land that was entirely in the town of Lincoln. So the name of Lincoln was attached to it. But that's not where the laboratory is located. It turned out that the Air Force wanted that land because it was nice level land, and they wanted to build a laboratory up there for themselves in the electronics area primarily. So they said you take the land that's over there, and the land over there was on the side of a hill -- not the greatest place to build something.

But that's where Lincoln Lab got built. It turns out that Lincoln Lab has a little bit of Lincoln under it, and it has a little bit of Concord under it, and it has a little bit of Lexington under it. All three towns come together under that place -- still called Lincoln Lab though.

INTERVIEWER: Bedford, too. Doesn't it have Bedford there?

MORROW: What was that?

INTERVIEWER: Some of it is Bedford, too?

MORROW: No. Bedford's connected to the airport, but the land doesn't reach where we are. Yes, Bedford is there. No question about it on that airport. At any rate, it got its name incorrectly applied. I don't know what name would have been appropriate for three towns. The building that was built was built at speeds I have never seen replicated anywhere around Boston since then. It was an event which took about, well, about a year roughly.

Then inside of a year they built a huge laboratory of maybe 400,000 or 500,000 square feet, and built to the ideas of people from the Bell Laboratories, because one of the people that joined the Lincoln down here came from Bell Laboratories and was in an administrative position. He brought with him the notions of an accounting system for a research laboratory for a personnel system.

I'll talk more about the personnel system in a little bit. The structure, organizational structure. So his direction was followed. It mounted to having a director's office with a few people -- maybe an assistant director or associate director, and six or seven divisions, each of which had a division head and then there were groups. So it was a structure there that comes from Bell Labs because that's the way it was built at Bell Labs.

The thing that's very significant, most significant I think that came from Bell Labs with that person was the personnel system. The personnel system from the beginning was different than on campus. It's a separate system to this day. It follows the Bell system. This is a very controversial matter. I've ended up in court at least once when I was Director in a fight about that system. The system involves the following.

Each year the group leaders and the divisions rank the people in the division. A division will have, I don't know, maybe 600, 700 people -- no, not that many, 300 people, say. Something like that -- some of the smaller divisions 100. These would be the staff only, not the technicians or any of the support. The promotions and the wage increases were directly connected to the positions of the people on the ladder.

As a matter of fact, the people at the bottom of the ladder were urged to leave -- the bottom 2 percent or 3 percent by one process or another. That process with a lot of change goes down to these days that we have now. Many things happened over the years to tune up the system. They probably went through four or five or six variations, but the basics are still there to this day.

Now this is a very significant thing to the laboratory because what it means is that you are maintaining the quality of the people. Each time you go out to hire people, because some retire or they move to business or to industry or something like that, you replace them. When you do hire them, you or they sometimes make mistakes. It was in the large percentage, maybe 2 percent, 3 percent, maybe 4 percent, something like that. You make a mistake and they make a mistake for coming to the lab.

They just aren't able to contribute -- it's not their world. It's something they're not up to for some reason or other. They may teach very well in a university, but they can't quite take the research game with intensity that it has, or it did have, still has.

So, there is an examination every year for each of the divisions of the whole list and who's on the list and who's going to be promoted off the top of the list and who is going to be asked to leave off the bottom of the list. Now the result of this is that you maintain the quality over decades because you do not allow the accumulation of people that are not too well suited to the situation.

This turns out to be an enormous advantage for the laboratory, and for MIT, for that matter. Because in the government laboratories in the Defense Department are under the Civil Service system. Civil Service system does not allow anybody to be fired. It's sort of like the teachers' union and you fill in the blank, the fireman's union, and so forth. You don't fire someone unless they commit a heinous crime or something like that.

The result of that, and I've done analytic studies on this over the years trying to help the government with its laboratories, is that you accumulate after several decades a population which is not very noteworthy, shall we say. The government is upset about this, of course. But the control of the Civil Service system is not within the control of the Defense Department or any of the other departments. It's a separate piece of Congress that manages it and it's not very easily changed. Athough small changes have occurred recently, mostly due to my pushing on the government to change to allow good people to get more money, and so forth.

At any rate, that personnel system lives on today, and the quality of the people lives on today. So they turn out then to be as attractive as Bell Laboratory turns out to be as attractive source for people that want technical problems solved in the government, mostly in the Defense Department, but also the FAA and the energy people and several others come to the lab to get help in solving some difficult problems.

INTERVIEWER: I'm very interested in something you said a few moments ago about the research game. As somebody who's been involved in research for a lifetime, can you talk a little bit about the kinds of people who are suited to the research game, and what the research game is about?

MORROW: Well, anyone looking at a research laboratory and the people in the research laboratory, there are several classes of people that do the job, do the work. There is a small group, and I would say it's less than 10 percent of the professional staff who are creative. You present a new problem to them and right on the spot they'll start spouting out solutions to the problem. They are the source of solutions to problems that are brought to the laboratory. Or even where we go out to try to help people outside that are in trouble.

Then there's a large party who are very good at the design of advanced systems that no one else has ever built before. These would be the vast majority of the people there. There is always at the edge of this community, people who can sustain a continuing program and a continuing thing that the lab does. A lab doesn't just develop technology. It's not widely known, but it also operates operational systems.

I can't discuss what those are here, except I'll mention one, and that is the case of the FAA. We have provided many of the improvements in safety of air travel over the years, and play a fairly deep role in running experimental advances in these systems. What are these systems developed at Lincoln for the FAA? One example would be the collision avoidance system. I don't know whether you're familiar with that, but we've had air-to-air collisions occur, the worst being in San Diego, I don't know, four decades back maybe, something like that.

There was a severe need of being able to provide pilots and aircraft information that they were about to run into another airplane. The airplanes are equipped with beacons, and we devised a way that you could use the deacons to run a little box that sits in the cockpit of every plane that flies today in this country, every commercial plane. The little box looks at what's around, says, we see several planes, those planes are not dangerous, and so don't worry. If it sees a plane that is likely to be too close to the thing, it shouts out at the pilot, dive or climb. Those things are running all the time in all the airplanes to this day.

That's not the only thing that came out of our work for the FAA. There were other things that were done which involved weather prediction for preventing accidents from planes trying to land in the wrong kind of weather and so forth. Those involve large experiments in the field at airports far from here. Logan was never one of them. They're all scattered through the country. So this lesser group or end group, you might say, or the staff, is heavily in this kind of operation of experimental systems in the field to learn did they work or not work? What were the problems? How could we improve them? So you really have a three class society. You have some geniuses, maybe 10 percent, whatever. People's opinion can vary on what the number is. Then the large class of people who are skilled at transforming new ideas into reality. Then a separate group, a smaller group, that take the stuff into the field and run it experimentally.

I might say certain programs I can't discuss here. We run them for the government all the time. We literally run sensor systems that are unique and no one else has and can build. But they're very important. I'll just say mostly they involve looking at spacecraft, making sure they're not going to run into each other and things like that. But they're all highly classified. I can't discuss the details of those here.

So if we go back to the beginning, these discussions have been sort of generic on the laboratory. If we go back to myself, a few words on what I ran into as the thing opens would be interesting, I think.

The fact that some of the professors in Radiation Lab joined the lab, Radford in particular,

led to an interest in the lab together with Wiesner in the communications area, which was somewhat off the main core direction of the lab, and building new radars and new computer systems to use the data and the airplane sort of run the FAA planes. Basically, as I'll mention in a minute, all of the FAA system basically is based on what was developed at the lab for military purposes.

At any rate, I was not in that core, I was with Radford and Radford was a division head who was interested in communications. He and I knew each other from undergraduate days at the lab in graduate school. He was a graduate advisor, in fact, for myself.

So I arrive at the lab in all innocence at the age of 21 or 20 or something like that. I get told that we want to have you build a radio, but it's a radio made out of transistors. No one knew what transistors were when this was being told to me and I certainly didn't know. They said that these transistors will come from Bell Laboratory and they are experimental and no place else on the earth can you find these things. But we want to have you build the smallest possible radio out of these devices.

What was the motivation? The motivation was that these very small things, if they could be built cheaply enough, could be distributed in countries that were not friendly, shall we say, to receive radio messages from radio transmitters. The State Department operated overseas radio systems, which still exist in one sort or another. They had visions of distributing thousands of these things.

So in the course of a year or so, using transistors that Radford and I got from Bell Labs by going to Bell Labs and getting them handed to us as if they were treasures -- they were treasures -- these first transistor radios were built. As far as I know they're the first that were ever built in the world, and there's one or two of them sitting in my desk still to this day. As soon as they became known, there became demands from Japanese electronics firms that came to see, the US electronics firms came to see. Then the whole transistor radio business burst into the open after the transistors got into production.

INTERVIEWER: Mid to late 50s?

MORROW: Yeah. It didn't happen that first year or two that I was there. It took quite a while to get the transistors understood and get production rates that were reasonable, and get properties of them that were better than the first ones. The first ones are very, very difficult to make anything out of. They had a lot of defects in them, electronic defects that made it difficult to build these things.

So that was my first year, year and a half on the job. At the end of that I was switched suddenly to another area in the communications division. This was to develop long range radio communications for the military, for the country for that matter. You see, up to that point, the only communications overseas basically was short wave radio, which is very flaky, you might say, it doesn't always work. Half the time more or less it doesn't work. The ionosphere does not go along with your intent to get across the Atlantic. We had large numbers of nuclear forces that were beyond reach of control from this country, from the president, because the communications didn't exist.

So it was started there two years after I was there, a program to develop communications that could reach across oceans. The first steps in this came I think from Wiesner's interest, maybe Radford's as well, in something called scatter communications. Most reliable communication systems are line of sight systems and they don't break up because of the direct connection between the transmitter and receiver.

When you go beyond 20 or 30 miles you're beyond line of sight and so then becomes a problem. How do you build a reliable thing that will go more than 20 or 30 miles? Well, somebody in the business of examining the ionosphere had discovered that there were fluctuations in the ionosphere that were independent of whether it was able to communicate radio signals or not strongly. Small fluctuations in the scattering of signals sent at them. By using large radio transmitters with big antennas, you could communicate 1,000 miles reliably through the scatter.

Similarly, with shorter wavelength systems, meter systems or fraction of a meter systems, you could get tropospheric scatter. So, a large program began and I was dragged into the middle of this thing to build systems, experimental systems, to test it out, see how well it would work. We built systems that were based, at least in the beginning, down in Rhode Island, I think it's in Rhode Island -- it may be in Massachusetts.

Anyway, there's a place that was given to MIT by donation from a very wealthy person. A large seaside location with a big house, and so forth. The first links were put down there, and transmissions from there to Bell Labs at Holmdel were started at maybe a 200 mile link, and successfully.

So then the military people said 200 miles won't get us across the Atlantic. We want more. So, in successive steps, one was built at 400 miles, one was built at 600 miles, and one was built at 800 miles to see if it could be done. It could be done. So there was a surge of construction of these systems to try to get connections to the nuclear people that were based overseas. Several of them in Greenland, and some of them in Europe and various places.

Now, at their best, they did not cross the Atlantic, that has to be understood. They could go 1,000 miles without fading. However you could get across the ocean if you're willing to suffer some cold weather. But you go north into Canada and in the upper parts of Canada you can cross to Greenland because the distance is small. So you can go across the top of Greenland, then come out the other side and go to Iceland, and then you can get to Europe.

INTERVIEWER: Sort of hopping?

MORROW: Hopping from one to the other. So, the system was built like that. It was also built for the so-called DEW Line, which we were involved with very heavily. This is a set of radars across the north of Alaska to see the Russian bombers coming, if they ever did come. The only thing that came were birds that set off the system. Pods of birds were migrating all over the place and they were tripping the radar signals. That system now is I don't think operational, but for decades it was operational. All the communications on that were scatter communications to connect the various pieces of it together and to connect it back here.

So there was a big period in there for 10 years, maybe less than 10 years, where I was directly dragged into this business and sort of the leading person. It turned out I also became of interest to international science groups that specialized in radio propagation. So I found myself giving lectures in Russia, believe or not, in France, and Japan. These are yearly meetings of this group and they wanted to hear all about the scatter communications because it was a fabulous new thing that had not been in existence before. These were people interested in radio transmission of various types. This is the international group that had meetings on the subject. So, my wife and I have traveled to a lot of places during those few years.

Well, all this proceeded along satisfactorily until Sputnik. Now before Sputnik had gone up, I had a small discussion/lecture group in one of the groups I had control of at that time. This was based on science fiction books that I had read assiduously earlier. In those books you will find satellite communications described by one of the people -- I've forgotten his name now, but he was one of the writers and he spelled out the whole, how you would do it basically.

At that point in time, and this is before Sputnik, I was thinking about could you do this thing. But there were no abilities to get things into the sky, excepting when Sputnik occurred. Suddenly it was a changed situation. The thing that we started to work on was an artificial ionosphere which became notorious before it was finally finished, and so forth. This was to put into orbit a band of very tiny metallic reflectors -- a little thing about this big, so very thin, and to use scatter communications off of this artificial environment.

There were violent attacks on this whole idea on the part of the astronomers. So part of my involvement with that overseas group, of that international group, was explaining how we were going to get all these things back on the ground. They weren't going to stay there forever. It was a pretty hot political situation, nationally, internationally, and so forth.

INTERVIEWER: This is the Westford program.

MORROW: This is the Westford program.

It came to pass, it did go up, it did work, but we had put it in an orbit that would get it all back down on the ground again. The view changed pretty quickly that building satellites would be a better scheme because you could get more capacity and you wouldn't have this problem of the potential of these things running into things, although they're pretty safe. They're so tiny they would hardly do anything to a satellite if they hit it. But I never thought it would be deadly. So I got into a lot of meetings, international meetings and whatnot, explaining all this and it was a fairly stressful thing.

At this time, the Department of Defense decided they wanted to build communication satellites because Bell Labs was showing that they could probably build -- I think they put up one or so. The first one in low orbit. The department asked the Signal Corps part of the Army to develop a program to build a satellite. This was to go on a launch vehicle that was in existence. The Army proceeded to get a contractor on the west coast to build this thing, and the weight on the vehicle went past the weight that the launch vehicle could lift. It was a terrible controversy.

The general running the thing demanded that the weight be less and the weight wouldn't be less, and the whole thing got hung up and nothing was happening, and the department was pretty furious about it. The people involved in the department at that time were what's now known as DDR&E -- it's a defense development research organization. In those days it ran the show. The people that ran it were two people -- an Italian -- I can't remember his first name. Let's see -- I'm not even sure I remember his last name now. It began with F. Something like Feno or some name of that sort. He was the person in the DDR&E that was furious with the Army not delivering.

So a decision was reached in secret to tell the Army stop, we don't want you to do anything more. We will have Lincoln Laboratory develop the military satellites, which we proceeded to do, and we built a number of them. They were launched and then systems were built by contractors afterwards. Let's see, the man's name was Fubini I think, or something close to Fubini.

The beginning of this whole affair connected with a problem at the laboratory. The problem at the laboratory was that the air defense system, so-called SAGE system, which the majority of the lab was working on, got itself designing the first really big computer in the world that was built to be used in it -- a vacuum tube computer, by the way. My transistors didn't get into it. At the beginning. 60,000 vacuum tubes in this thing. It was being tested around New England with radars and it was successful and it was moving forward and it was going to go into production.

So the government turned to the lab and said, now we're going to have to have you get it into production. The president of the Institute decided, and perhaps others, that it would be not fitting for the Institute to be in the business of procuring huge quantities of radars and computers and things like that.

So a thing called the MITRE corporation was formed, which you may know about. They were given the job of doing that. There was a fairly close relationship between us as we moved the technology into their hands.

Then arose a question. What will Lincoln Laboratory do now that the major program has been handed off to MITRE? There was a great concern inside the laboratory. I was still, at that point, only a group leader -- it was about 30 people or so who had been working on the earlier communication systems that I talked about. The proposal was made to Gene Fubini -- that's the fellow's name -- that the Institute could move on to some other problems that were of concern to the government, to DDR&E. Not the Russian bombers coming over the North Pole. They weren't going to come over the North Pole, but there were new problems.

Two were selected. One because I had been in the communications business and it was a going on thing, and that was to take over the development of the military satellite communications business. The second was to play a leading role in defense against ballistic missiles, which had clearly shown up on the horizon by that time in Russia. So the funding of the laboratory through those early years of the SAGE, which was around $20 million a year was continued. But it turned out that Fubini wanted to feel the goods a little bit about what he was buying for his $20 billion -- $20 million a year. I think I said billions, it's not billions, millions.

So he wanted to meet me because I was clearly a key person for one of those two areas. So I was told to go to the west coast and meet with him and talk with him for 20 minutes and cross back across the country again, all in a short time. That's the only time I've ever gone across the country for a 20 minute discussion with Fubini. He liked what he saw and said, OK, you lead it. A similar thing occurred with the ballistic missile defense area.

So at that point, which would be '61, '62, somewhere in that area, the laboratory suddenly had blessings to go in two directions. So funding would continue, and in addition, more money would be coming into it from other interested parties in the government.

We, in the very early years, stuck pretty much to this business excepting it had fall-out, which got us into other areas as well. One of the things that we built were fairly large radars to be used in the ballistic missile testing to see if you could find things that are in the sky, and so forth. These are very big antennas. They're 50 feet across, 60 feet across. There's 120 foot one up in northern Massachusetts still in existence that was built, and it's still being used now.

There weren't ballistic missiles to look at particularly, hopefully. But these things did exist and they were tried out on satellites. Satellites were going over head, and as you remember, the first Russian launches were detected here by a radar that we had up at Millstone Hill.

So a new phase, a new direction in the lab appeared on the scene, namely find satellites. Find out how many there are, who's launching them, where are they, and so forth. That remains a very strong component of the laboratory to this very day, and we run a number of operational systems, not just experimental systems, but actually checking what's going on upstairs.

There's one curious little thing that we do for group of commercial companies that have satellites up there, communication satellites. There's a patch of the orbit, the synchronous orbit where there are several of these satellites all living together, separated. One of the satellites went berserk and lost its control systems and started drifting -- doing whatever the gravity gradient caused it to do at that point.

The people with the satellites got scared because what happens if it runs into our satellite? We spent $200 million to build this thing and get it into orbit. So they came to us and said -- with industrial money, and by then the Congress had allowed Bell Lab to take industrial money for transfer of technology -- would you please keep track of all the satellites and tell us who to move, where and when to avoid this thing when it comes back and forth through our investments, which are a billion dollars easily at that point. So we've been doing that for a number of years. We're still the people who keep track up there for those people.

We also keep track on a lot of other things that go on in various orbits for intelligence people and whatnot to see who's doing what and where. We're a central factor in the design of a new system to do this even better. So this is a branch sort of thing that I'm talking about.

Another branch occurred because of the SAGE system, and it's with the FAA. The FAA had a terrible air control system in those years gone by. It didn't have radars that could follow the airplanes, it didn't have computers that could present the data to the controllers. It just didn't have anything. So they came to us and said we want to build an air control system that's like the one that you designed for Russian bombers.

So that technology was literally picked up by its root and dropped into the FAA, and that to this day, is their traffic control system. It's an old tired system at this point, needs replacement with a satellite-based sensing system. But to this day, we're very tightly connected to the FAA as a fall-out from that effort with the Russian bombers. Now, that fall-out business, you can see it through several different areas at the laboratory.

INTERVIEWER: Why don't we start by talking about the nature of the relationship between Lincoln Laboratory and MIT.

MORROW: Fine.

There has been a relationship from the very beginning. There was a period in time, however, where this became a controversial matter. It happened not because of the laboratory and what it was doing, but because of what is now known as Draper, but was then known as the Instrument Laboratory. The Instrument Laboratory was the place in the world that developed the high precision navigation devices involving gyros, three gyros. If you use them right you can find out where you are in the airplane in particular. But you can also use them to guide a ballistic missile with nuclear warheads. They designed a system and built prototypes, and so forth.

This became known on the campus and it was considered unworthy of something connected to MIT. So it began a great crusade, maybe not so many people, but they certainly were vocal, to separate the Draper Lab -- that's a latter/late name. The early name was Instrument Lab -- and Lincoln from MIT. There was a very intense few years that went on where the laboratory took the position that we were development place of technology, but we were not actually building anything that goes into nuclear weapons, and so forth, and that it was all radars and communications, which it was very much.

Nevertheless, a distinction was difficult to be seen in the eyes of the protesters. The protesters arrived at the gates of the laboratory on at least one occasion. They certainly arrived at the gates of the Instrument Lab down here in a much larger group. There was a lot of high level discussion about this. I was not director in this period of time. But one of the assistant directors, Gerald Dinneen was asked to run a committee for a year or so to examine this and make some conclusion about the laboratory, maybe about the other place, Instrument Lab, I don't know.

Which I was given the nasty little task of sitting into a meeting each week where programs that were being proposed for the lab and the Instrument Lab would be discussed with a group which included some of the protesters -- they were students. This may be 10 people or something like that. So for a whole year I'm there and I am basically defending these programs that come into the lab -- they're little ones and big ones.

There's not just one program, it's a whole slew of things. Each time I'm explaining how this thing is going to be a good thing to have for the military and it isn't going to be flying with nuclear weapons, which they weren't. It was mostly ballistic missile defense and communications, and a few other things as well.

At the end of the year, a settlement was reached which disconnected the Instrument Lab from the Institute, and kept Lincoln Laboratory connected to the Institute. But there was a desire coming out of it that the people in the leadership here at MIT would keep a closer watch on Lincoln. This led to the notion that there should be reporting to the provost pretty periodically. In my experience as a director, it was one month intervals, on what was going on, and in addition that we should have a committee to review the lab from the outside, including faculty members, to come once a year and see the program listed in front of them for a day or two or something like that.

Those two things were undertaken, and they continue to this day, without a whole lot of change.

INTERVIEWER: What is that like as a former director and when you were director? How does that impact the laboratory?

MORROW: I would say not at all. When I was reporting to -- I was trying to remember which provost now. Well, I can't remember right now which one it was. But there was a desire on his part to have a completely external review committee look at the technical work of the laboratory once or twice a year. That formed with, and the provost would be part of this -- yeah, the provost would be part of this review twice a year, whenever it is. It would be a pretty big discussion of all the activities that were going on in that meeting with presentations of various kinds of things of programs, and so forth. That continues to this day with the provost still coming out. It's part of the normal life of the place now.

As director I was the inheritor, apparently, of the beginning of all that. It started while I was made director. So some said I set a pattern for what's continued on with the other directors now. They're still doing that kind of a process of outsiders. There was intense pressure to get more connections with the faculty on campus, with the graduate students, joint programs of one sort or another, and that continues to this day. It's not vast but it's there. So there's money that flows from us and money flows from the campus so they do things out at the laboratory.

This has been especially significant in a recent time -- recent means back to 9/11. There was a severe concern out of 9/11 about bacteriological attacks. In the solid state division there were one or two people who were very much into building lasers and things of that sort. They had a broader education than just lasers and that sort of thing. They had a connection with some of the biologists down here at the campus. They came to the biologists here and asked if we had a laser, could we excite Raman radiation out of the bacteriological material that would signify it was bacteriological material and maybe identify it. The answer was yes, it could happen.

So, we built an experimental system. It was kind of a prototype, and it went out and it was tested with some other equipment at a range out in the west where they test sensors that sense airborne bacteria and see how well they could detect these things. Now they're not the real thing, they're fake ones, that is, they don't use dangerous biological material, but it's a very similar kind of thing is used. These two people, there were two people, and put together, beat everything on sight -- it could find the bacteriological material inside of about 100 seconds. Air flowing through it, nail it within 100 seconds. Nothing else was as fast as ours, compared with other things.

This instantly transformed our situation in that the government descended on us and said we want those and we want them very, very fast. Now these didn't identify the particular type -- we did develop later something that could be attached, which would tell you also within two minutes what kind of biology this is. The person that led the way as to the biology of this was on the campus. So there was a close relationship between the two, still is for that matter.

These early devices were of such demand in Washington that we were told you'll build 30 of them just as fast as you can, and they were moved around the White House and Congress and Pentagon, and so forth. Then you will also build a production version, maybe patterned on what you've built or something maybe better, and find somebody that can build 1,000 of them, and we want 1,000 of them within a few months.

This was not, we knew that none of the defense industries could do it because they're too slow. We found a company in Florida that could do it and they did do it. So they're scattered all over, God knows where, those things today. Probably more of them.

INTERVIEWER: From Lincoln, there's something like 95 companies that have spun-off from work that started at the laboratory. I wonder if you could you mention a couple of them.

MORROW: Well, I'll mention one, which is -- there were some people at the laboratory who were involved with our long ago thrust into power sources, electrical power sources, which were not using any fuel. They were deriving from the sun electrical power -- solar cell systems. This is the very beginning of the solar cell business, and it was in the late 70's. It was in the years where the price of gas got very high and gas went short. I think this was--

INTERVIEWER: Late 70s?

MORROW: Late 70s, yes, like '78 or so. So, we have somebody in the solid state division who has been developing solar cells more or less out of the line money, he was free to going in various directions. He had a new direction that he thought could improve the efficiency from 10 percent to 30 percent, which is a very big idea. So, we sought money for this from the organizations in the government that were entering into the whole business of building solar cells, and whatever else you could build that didn't use oil.

The entities that we then had to deal with wanted more than him developing a 30 percent efficient thing. They wanted some power plants, solar cell power plants. So we got drawn into the building of the first big solar power plants in the country. Now they weren't that big. They were in the, I don't know, 100 kilowatt class, say. They were put in places that had no power, but they had a big demand -- national park installations and things of that sort.

I can remember going and looking at one of these things. I remember publishing an article in the *Tech Review* on the future of solar energy and where the whole business might go, and the predictions were not realized. They predicted there would be a big turnover by the year 2000, and there would be all kinds of hydrogen being made and new fuels and things of that sort -- it hasn't happened.

Now to get to the business of the people leaving the laboratory. To get the DC power into AC to do something with it, you have to build a converter, and the converter has to like the solar cells and the solar cells have to like the converter. So there were two people here that built a device like that. It was clearly they thought a winner, and it would be a big business in the solar cell business. So they formed a company. I think it was down in Connecticut some place.

The bottom fell out, as you are well aware, a few years later, and the price of oil dropped and scarcity went away, and everything in this whole business died. This company was going to die, until they decided that the very same equipment could be used for computers to protect them from lineage, power lineage drops. You're probably familiar there are sudden drops in the power that you get from power companies. You don't usually see it, it's just a flicker in the light. Not so to a computer, it's death to a computer -- it completely blows it when it happens.

So, the market grew enormously for this company and it's still in business selling cool boxes that will keep the computer happy. Now, most people now have shifted into small computers and they have batteries in them, so the market for this has dropped off significantly. The big computers that sit on desks still need it though. A protection against power fades. So there was a business that started, failed in its original direction, but made a huge amount of money.

There were three people in it, one person left, came back to the laboratory because he got sick of just building things, to do some work there. He was independently wealthy -- very, very wealthy. Then left the lab to devote himself to fancy racing cars from Europe which he sells in a place in New Hampshire. So that's a story, a local story of something that happened here.

Another story that is more widespread is the laser diode. For that matter the diode as an emitter was being worked out at the laboratories in the Bell Labs and several other places. Pretty much simultaneously in three locations, people figured out how to make it lase. It's likely that the work at Lincoln was what led to it. They did all the preliminary work, and the final agreement it was going to be a three-way split if there were any patents on this.

Well, that device covers the earth at this point. Every time you put a disk in your audio system or in your TV system, or make a recording here, there's a laser diode doing the job. So it's a worldwide transformation that thing that was done in Division 8.

INTERVIEWER: For somebody like you who's been directly involved in creating so many new systems, what is it about administration that appeals to you?

MORROW: I think you have to view me as a victim of the process of administration, not a seeker.

To go back to the beginning, I was a staff member for the first three, four, five years, something like that, and we got to a point where the person leading the group was going to depart or something -- I've forgotten the details of it now. They wanted to start a company I think or something having to do with the SAGE system or whatever. So I was asked to run that group. I didn't ask to run the group. I was suddenly told to run the group. The first thing I was told to do was to make a chart of who's the best and who's the poorest. Times were tough and we had to fire four people off the bottom tank list. That was the first task I was given.

It went that way pretty much all the way. I'm busy doing whatever I'm doing and I'm pretty happy with what I'm doing, and suddenly I'm pushed into a higher position. They're not positions that I ever sought.

INTERVIEWER: Did you find that as director of the laboratory you were able to do things you couldn't have done any other way?

MORROW: Yes. In the following sense that we grew in size from the 1,800 due to more finance from the government and from the Department of Defense mainly, and FAA and all these places. So the number of the population began growing. It grew to the point where we had to put people in buildings that weren't at the main building -- on several buildings actually. This demolishes the interaction between people when you do a thing like that. So there became a desire for a building big enough to hold them all.

So I had a new person come in for the position that handles the administration of the money and building maintenance and things like that. It turned out to be a former Navy captain. It was a shot in the dark and it was both good and bad. He got along with people very badly, but those are the people in the lab. He got along with the people in the Pentagon because he was a captain. On the Hill because he was a captain very, very well. He alone is responsible for the big lab that was built there. I don't know if you've ever seen it, but it's a doubling of the size of the lab. That one person did it.

INTERVIEWER: Who was that person?

MORROW: John McCook, I think that's his name. He was very good at that. But then there was nothing for him to do after that, so he had to leave the laboratory because we had no more buildings to build. By the way, we've expanded enough now so we're in a desperate situation again, very similar. We're having to take a division and put it outside, and there was talk of building a new building connecting to the old building.

See, the essence here is to have the building one entity -- like MIT is. All the corridors connect together, so that you can go anywhere in the building without going outside, and it's a sprawling, complex place, but it pulls the people together. If you separate, and instantly you've got a problem without people working together, and it's a very bad thing. So the current director will have to solve that problem. I'm not going to get involved a second time.

It was a pretty difficult thing, and this fellow, McCook his name was, brought it off by himself pretty much without any help from myself. He had the contacts inside the Pentagon, he had the contacts on the Hill. He managed it, which was a very, very difficult thing. He also managed choosing an architect and getting the design of the building. I had a role, I was on the Steering Committee reviewing the design area. But it was a big, big effort. Cost a lot of money. We're still paying for it and we've got five years to go.

INTERVIEWER: I would imagine that one of the things that happened when you became director of the laboratory is that gave you access in Washington, DC, and some significant influence -- you served on a lot of committees.

MORROW: Well, before that ever happened, I was on a lot of committees. In fact, my secretary, for other purposes, recently put a list of all the committees together for some other purpose. I was overwhelmed by what I saw. I had no idea that -- because it's now 50 years or more. But incredible number of committees starting very early.

When I was a group leader I was on committees. When I was division head I was on committees. When I was director I was on -- an associate director -- yes, I was on committees, and still more committees when I was director. Now I've managed to cut back down. We've managed to get the current director onto the Defense Science Board, which was one that I was on for many years and one of the faculty was on as well. John Deutch. The one in chemistry that had all the problems at CIA.

INTERVIEWER: Yes, Deutch.

MORROW: Deutch, exactly. At any rate, he and I were on some of these committees, and we've tapered down now to get the new director onto the Defense Science Board, which went through a problem with the White House and couldn't get him on till recently.

On another committee that I'm finally working with, which the chief of Naval Operations has a very private committee of about 30 people that are very broad in spectrum of capabilities. There are two women, for instance, that used to be in the House of Representatives as representatives, not as staff, but the real thing. There are people who are in the State Department who are experts on this country or that country. There's one fellow there that is the second guy on a ship company that has 1,000 ships, a shipping company. He's of interest to the chief of naval operations, because here is a big operation buying ships, and the Navy could learn a lot from that.

So that one committee is the one thing I'm left on at this point. I, in fact, yesterday went down to the War College in Rhode Island on one of the meetings where I was chair with a leader of the study. There's a continuing study going on down there and I'm sort of the daddy rabbit that got it started 15 years ago. So a huge number of committees all through the years beginning when I was a group leader and continuing all the way.

Now the other interesting thing about this is that at no time in all of this did I ever really think about the next step up. It just happened out of the blue to me. It just didn't occur to me, you know, I was too busy doing other things. I wasn't thinking at all. The notion that when I started all this that I would be director is absolutely and totally foreign to any thought that I might have because of all these people that are from the Radiation Lab who knew so much and I knew so little.

INTERVIEWER: I want to make sure we spend a little bit of time talking about MIT because you joined the faculty in '77, I believe. Can you talk a little bit about being on the faculty here and what that's like?

MORROW: Well, it's not a very great connection. The laboratory's an extremely intensive thing. That was when I became director. That has you on the airplane to Washington, will you believe 1,000 times at this point? 1,000 trips to Washington. At the beginning of the beginning it was happening in that first year when I started making that transistor device and hasn't stopped to this day.

So, the connections here are pretty thin over the years. Maybe this is not a good thing, and it's a parallel thing with recent directors of the laboratory -- not an intensive connection here.

Now there was an intensive connection at the beginning, because the founders, you might say, came from Radiation Laboratory, but they came from the faculty, and they were still with the faculty as they moved into the lab. But they then retired or died or whatever. So that kind of a connection disappeared. So it's a relatively thin connection, which maybe it shouldn't be, but it is because the distance is what the distance is.

I think if it were local, the whole thing were local, it would be very different. We would have many more graduate students present out there. We do have sizable numbers of graduate students at the college, at the lab. The supervisors of the theses are staff. They're considered by the faculty here to be of enough stature.

INTERVIEWER: Because you've spent so much of your time at the laboratory, do you think of yourself as an MIT lifer?

MORROW: Well, yes in the sense that I'm now retired, and there's sort of a continuum. I've been here since I was 16 years old. That's a long time. But I don't get heavily involved in anything that the faculty is busy doing down here. I read the faculty reports and they have their own letters, you probably know. It's interesting their concerns of one sort or another, but the concerns we have and the concerns they have are quite different.

We have the potential of helping them in many areas and do, providing positions for research for people getting degrees, experiments of one sort or another. There's usually two or three people to help the student get his degree. But we're the one who usually supervises the experimental work at the lab that he does. The other two review the work that he's doing, but they're not as strong in connection.

So there are connections of the previous director that came after me down here working with various groups. There are connections in the biology area, no question about that, because it turns out that that original work on the biologics led to all kinds of new instruments and new ideas at the laboratory, which involve people down here in the biology department. We have our own collection of biologists now. I don't know how many there are, but there are dozens of them.

A big chunk of a division is just working in the biology area is almost completely in the area of sensors. Well, it's a broad area in some sense. Most of it's focused on detection of bacteriological materials. There is at least one person in there who is very creative and has a notion that is incredible, and whether he'll bring it off or not I don't know. If he does, it's an instant acclamation in the world.

He believes he knows how to manipulate cells in the human so that they will reject any disease, any virus disease, any biological disease. He has done a lot of experimental work on this, including with mice -- the mice being down here, I believe. So there are these people who are into new areas that are really not connected in a sense with the old laboratory, you might say, but they're entirely new things that are being poked at with these biological people of one sort or another. Always with a fairly big connection with the biology department here.

By the way, I might say that the biology department has a very strong effort in brain science, and it has a building associated with that, as you're probably aware. It's right, sort of that way. That building and the one across the street that has the brain scientists or the artificial intelligence people there, I believe is the result of my beating on a previous provost and saying the Institute has to get into this business. That happened because of that. I believe that's why it happened. It happened. It took some pressure to bring those groups together, by the way, as you probably know or maybe you don't know to get them together.

My final notion was we build a bridge across the street out here, so the two connect together because they're related. This turns out to be an area that I'm somewhat interested in. Not brain science or the biological area, but in the structure of the brain and how it does its operations. This is sort of a thing I do on my own at home, not in the lab, but not at here either.

Looking at the mathematics of what you want to do for recognition, forgetting the brain, and then looking at what is the brain doing, and it turns out the brain always got there [INAUDIBLE]. A good idea you think about for the electronics and then you look carefully at what's happening in the brain and it's done it before. For instance, just to give an example. There are lots of neurons in the brain. It turns out that every neuron is busy converting everything into logarithms of the inputs. It isn't just passing on things directly.

It takes the logarithm of what was put to it and passes it on. It then turns out that processes are undertaken in the brain, which amount to combining things together, not by adding them together, which is all of work that's been done on artificial brains in the past -- a simple addition of inputs. It's done by taking a higher order root of the signal that came out of the brain cell. That's done in the format of the thing that was constructed by the doing actually a modulation of the intensity of a signal.

That turns out to be rooting it -- taking the root of the number that originally went into the thing. Then it adds it when it goes into the next run. That's equivalent to doing a multiplication. So the basic processing that's going on in the brain is taking the root and then taking and multiplying the signal, so they're going in all these various directions. That's completely different than anything that's understood today.

A few brain scientists have stumbled on the fact that there is a logarithm operation going on and then looking at it and saying gee, this looks exactly like the logarithms being taken. Well, that's exactly what you want to do when you want to build a very good system that will do recognition. So I'm not interested in anything beyond recognition. So nothing about creative art, music or anything. Brains are good in those areas, but I'm most interested in that one area.

Why am I interested in that area? Because there's a lot of problems today, as you know, with regular warfare and terrorists, and so forth, and those are problems of finding one entity in a huge bundle of others who are innocent. So it's a recognition problem of a very difficult nature. So that's something I play around with a bit to keep in the science area. It's something you have to do even as you were director just to keep some hold on something on the technical sense.

INTERVIEWER: From your various associations with MIT over the years, what is it that you think makes MIT's culture or environment unique?

MORROW: Well, I think that MIT goes back a long way in history, as you know. It goes back to just after the Civil War. At that point the institutions that existed in this country, the higher institutions that existed in the country, were primarily liberal arts organizations and they had their roots as teachers of priests and directors of various kinds of churches of one sort or another, directors and whatnot.

That Civil War showed the face of an enormous industrial system starting in this country, and in England too for that matter. Railways were a big thing, and telegraph and all kinds of things. So somebody, and I don't know who they were, said we need to have a higher educational institution which deals with that world, not with the liberal arts world. That was the basis that it started out on.

Now, it was not very unique for a long, long, long time. There were other schools that started, one in Worcester, for instance, and there's one down in New York State some place and somewhere else has one of these things. So you asked the question why did MIT change, what caused a change. All these places were pretty tough on the students. That is, these are not easy places to go to -- have high level mathematics involved and all the rest of it.

So I don't think MIT was particularly unique in that sense. But the transition probably came after they moved across the river and probably with the beginning of the Great Depression is where I think the transformation began. Because at that point times were very difficult, and the institute I believe felt it had to produce students who were able to get a job, I guess is a simple way to put it. They were so good that they could do that.

That started to build up through the depression. Then the idea of going out and doing original science, and so forth, also was part of this, and is not evident in some of these other places like Worcester Polytech. More so today, but it wasn't characteristic in those days. So there were ventures out into the unknown.

For instance, the reason that Radiation Lab came here is that people were exploring waveguides for use in aircraft landings or something like that in the depression. They were the world's experts on waveguides. Now waveguides are needed for microwave radar, so where do these people go, the British with their little Magnetron, they went to MIT. So they built during the depression is my view of it.

INTERVIEWER: So the first, say, during its first 50 years, your sense is that MIT was not--

MORROW: Was not unique.

INTERVIEWER: --unique and was not known as sort of the technological center.

MORROW: No. I mean it was in a class and they were all about business, so it wasn't the best of all. It wasn't that at all in that period. In fact they had terrible quarters across the river in the city. Other places had much better quarters in the beginning.

Then the thing that did it, absolutely did it is the Radiation Lab. When that occurred here, and the power of what was done with it, instantly changed the status of this place to the best in the world. It was in a class with the nuclear weapon business. It was that kind of a thing. So, everybody rushed to come here. I experienced this when I came here. I was sort of an innocent 16-year-old, and things were pre-war, you might say. We had somebody clean the rooms for us and make the beds and whatnot. The war ends and a flight of students appear on the scene who all want to go to MIT.

Everything changes at MIT at that point. All the people have to do their own keeping the sheets up, and so forth. Have to make their own beds, all the rooms are doubled. It used to be one to a room, now it's two to a room. You could see this massive group of people coming in to MIT because they thought it was the place to get a degree. They overwhelmed the place. We had a size class of maybe 600 -- 500, 600. It was instantly 1,000 -- that fast.

INTERVIEWER: What about today? How do you see MIT and its place in the world?

MORROW: It may be a prejudiced view. I think it is the best technical university in the world. There's nothing even close. Nothing. You can tell by the attempts of overseas people to get invited here, shall we say. As you know for the undergraduates there's a limit. If we didn't have that limit here it would be filled with foreigners. Because the education outside this country in many countries is better than it is here.

The schools that I knew in Springfield 50, 60 years ago, there is not a single school in this country of that caliber. For instance, the English class that we had at the senior year I guess was taught by a Yale professor who couldn't get tenure, but he could get a job -- very few people could get any jobs at that point, of course, in the country. The same with all the rest of the faculty. These people were real experts in their fields. We don't find that in our schools today. Overseas you find much better teachers. They're appreciated a great deal better. They're highly ranked.

If you go back 100 years here, the schoolmarm that was going to teach the one-room schoolhouse was the most advanced person in the village in education. A director maybe could be a competitor to her, but she was his equal. That's not true today over the entire country, it's gone. That is a disaster for this country in my view. There are a few very good private schools that can produce people, and there are some fairly good schools, technical schools that can get people into MIT.

But there's nothing even close, not even close to that school that I went to in Springfield. That was entirely a different world. Those people were technical experts in their fields. Real experts. I mean they had run companies, for instance, some of them. That their companies had gone bankrupt. In those days you didn't have to go to a teaching school, by the way. They received people who wanted to come and listen to them talk to them, and hired them on the spot. There were no unions. The wage scale went with how well you worked. If somebody didn't work out they were out, gone. We don't have anything like that today.

INTERVIEWER: So how do you think MIT has managed to maintain its excellence?

MORROW: How does it manage this you wonder? Well, a starting point is attracting very good people, some of whom become professors. You have a basic regeneration process. If you have a company like General Motors, to say the terrible example, there was not a regeneration process. The company processes and organizations stayed fixed, and no matter how good the people coming in were, it didn't get any better. In fact, it got worse. Then finally almost, well, did go bankrupt.

Here, the very good students that came were, the very best of them were made professors, became professors -- well, teaching assistants first, maybe not professors. So there was an intense screening of the people to get the very best. I think between attracting the very best and then educating them, you got a faculty that was extremely unique. Not like what existed in the other technical universities. Now there are exceptions, of course, there's Stanford to some extent, and then there's one in Los Angeles.

INTERVIEWER: Cal Tech?

MORROW: Cal Tech, yes. Cal Tech and Stanford are both places that, in some sense, emulate MIT. What's missing though are the huge research efforts that MIT has accumulated over the years, which attract very, very good people and produce results that are published that other good people see and they say I want to go there. So it's a self-generating process of some sort. I don't think they ever set up with malice or forethought to do it. It just happened.

INTERVIEWER: It does seem that a lot of the people who were graduate students then become faculty members wind up staying here.

MORROW: Yes, if they get to be a professor. Most don't. Those are, by the way, hired by the lesser technical places. Literally, that's where they go.

INTERVIEWER: Is there something about working at MIT that keeps you wanting to stay here?

MORROW: Well, I can't speak too well for the faculty on campus. I can only speak for the laboratory, and the laboratory people know very well what the rest of the world is like because they deal with the rest of the world, the technical world. Because they have to deal with industry and transforming some of their work into production. They have to deal with government laboratories because some of the government laboratories are where the money comes from, and so forth. They are very good calibrators of quality.

They know probably more about the quality of our technical institutions in this country than anybody else, because they see it and feel it, it's part of their work. They can easily draw the conclusion that there's no place better than Lincoln Lab, and probably the same is true on campus, that there is a large contact here with other similar institutions around the country, wherever they may be, and they have a very significant calibration, you might say. Therefore they stay.

Now, of course, the ones that don't make tenure leave. That's an intense process. It's much tougher than anything that we apply at the laboratory, because you know the number that successfully make it are not 100 percent. They're not 50 percent. They may be 20 percent, maybe even less, I don't know.

INTERVIEWER: What role do you think the collaboration between departments here, does that play into the success of the Institute?

MORROW: It may very well. One of the things that this place has which others do not have is entities that are not parts of departments. They are collections of people from various departments that are interested in a single field. The brain science people may very well come from more than just a biology department. The range of interests in a thing like that could really be beyond the walls of the classic departments.

The good question on whether departments are organized properly at this point or not, that keeps being examined. No big changes occur that I can see. So maybe it's OK. But it may be that over the longer haul with some different structure is in order. I don't know what the structure might be, both in terms of the kinds of things that were being handled, and the arrangements for interactions between departments.

See, one of the things that is weak here I think and not weak at the lab is the interaction between groups. There is a strong pressure at the laboratory for research to get spread, not just among the people in one group, but many other groups. Many projects there -- in fact, when the director gets reports by the group leaders, which I sit in on every Monday -- well, almost every Monday -- there's a question that always has to be answered, what are your connections to other groups? Then up goes a plot which shows all the connections -- we're getting money from them to do this, and we're sending money there to do that, and so forth.

That intensity of interaction I don't think exists here among the departments. There is probably some of it, but it's not as intense as it is there. Most of those research efforts of one sort have more of a project being done outside the group that owns the thing, than inside the group that owns it. This group went up and got the money and sold it to somebody.

Then they turn to other groups that have expertise that they want. They all turn to the mechanical engineering division, because almost anything you want to build has to be built, and those people build it. They provide more than that, they provide management advice. The mechanical engineering division provides program guidance. They will tell the group how you should organize your project to get it done in the fastest time and not overrun the money, and so forth.

So curiously enough, that's the place where the programs are laid out, the big programs, and the reports on who's doing what and are they doing it on time, and are we all locked together -- are done by that particular division. That kind of interaction I don't see here at this point, with the one exception of the biological people all being pushed together. There must be some interaction going on there because of the recent consolidatoins, kicking and screaming they got put together in that area. The artificial intelligence people the same way.

There's been some compression to near neighbors. The near neighbor business doesn't have to be done at the lab though. Everybody knows where the experts are. Even though the place may be quite a long walk away inside the lab -- now, it's important, it has to be inside a laboratory with a continuous corridor system that will take you anywhere. That's vital. Absolutely vital. If you don't have that, you're going to have isolation -- you can't do this cross-connection business. Which is very, very intense at the lab and has been for a long time.

INTERVIEWER: How about if you tell me a little bit about your dealings with Washington.

MORROW: Not so pleasing problems.

Well, there were two classes of problems. One of them an institute faces as well, I've discovered -- one of them has to do with this business of discharging staff for poor performance or whatever. We have been quite successful in handling people that have to go with a long term process with them -- it could extend out to two years, we may even find them a place to work. However, there are some individuals where this is not acceptable, I guess is a way to put it. They sue the Institute or the lab, and you get involved in legal cases as the director, even though you weren't the person that actually fired the person.

The reason I bring this up as parallel here is that you have a large group of people who did not get tenure. On one occasion, and I won't mention which provost this was, I came down to report to the provost as director once a month to report on how are things going at the lab and all like that. He had a long table, you may have seen this table in his room. The table was completely covered with piles of paper. There must have been 25 piles at least. These were lawsuits by professors who didn't make it.

So we have been relatively better off. I think our processes are such that you can avoid most of the cases by helping the people get jobs and having a long transition period, if it's going to happen. Now if the person is totally useless, things happen quicker. But they know they're useless and there's no problem.

This is an aspect, and not a pleasant aspect, and I have been in courts of law several times, shall we say. We've won all the cases, but it requires a lot of time with lawyers and examination of our personnel system, see that there's no whole in it that you could be used. So that's one aspect that is thrust upon directors.

Another one has to do with the Congress of the United States. The Institute and some other organizations are organized as a class of entities which the government will deal with in a specialized process. I won't go into the details of it, except to say that there have been complaints by profit-making companies that some of these entities on the outside, not the lab, but particularly ones that did work of an assistance nature that is trying to help out some entity in the government. Those people who were profit makers complained about the DDR&E classes. There are about 10 of them. Maybe, maybe less than 10 now. Most of them were small. There were two big ones. One is Lincoln and one is -- the Johns Hopkins FFRDC -- I've forgotten its exact name now. But at any rate, there are two big ones.

There have been attacks at least three times on these classes of organizations by these profit-making groups, which have fallen on bad times, when the countries have fallen on bad times and the amount of money available out of the Department of Defense to fund them, drops and they start complaining about these organizations. Why are they complaining about them? Well, the fact is that these organizations were able to operate under contracts which are all inclusive.

That means that each piece of work, each little project or big project, does not have to involve the development of a separate contract. It involves sending money into a omnibus contract, which the Air Force prepares. So it's quite easy to send money into the laboratory. But you have to have the money to send, of course, from Washington, but you can send this money easily. Whereas the other companies, they have to have contracts and they feel they're being abused, shall we say.

There have been, as I said, three blow-ups of the sort. The first one I know very little about because the directors were involved. I wasn't in that position. But the second two I was heavily involved. I don't want to go into all the details, but they tended to end up in a congressional hearing and having to defend the laboratory as an important national capability. The whole process of that is not one of the great parts of being a director.

You have to operate by developing support out of the military departments there, particularly the OSD, DDR&E. You have to get the fellow that runs that on your side in this business. You have to get it done by, at least one case, by having him take the lead and setting up a hearing in which it's all explained and which can get a positive statement out of it. Namely, that they will not disengage or undo all these places, make them be profit-makers or get rid of them because of the contrast in the way they operate against the public companies.

Those public companies have profited enormously. They've grown to billion dollar a year things in some cases, so there's nothing to complain about particularly. Some of the little ones still are maybe complaining, and it may come back again. The last attack was about in the mid 90's, somewhere in the mid-'90s there was one. Then the previous one was way back maybe 20 years earlier than that. When times are tough, that would be in the 70s.

Right in the middle of the 70s there was an attack, and that one was solved without getting a hearing. We solved it by having the right person in the right place who did things for us.

So that size of the activity I haven't talked about. There are other worse problems even than that I think, and that is that in any company or any organization or any university of any size, you're going to have some people that have some severe emotional problems. You end up, as director, having to face some really nasty situations. I won't go into the details of those, but it's not pleasant and it's not a good thing for anybody.

The size of the organization is the important factor in this. If you're a little bitty organization you probably won't have any of these people. If you're an organization that has a couple thousand people, you're going to have some but they're probably OK. If you a university that has 20,000 students, you've got some killers on the campus and they've gone out and killed, as you probably are well aware.

The management failure of the large universities is that they haven't provided enough supervision of the students to spot them and save them before they do something horrible. In the smaller organization of MIT you can spot them, and MIT is one where you do have people watching. They're the people that are helping out as tutors but they have another job, to watch for these people and help them and prevent them from doing something horrible.

So that's another not too great thing that the director has to deal with. Not all the time. I mean these are rare events that occur from time to time. It's a very demanding job in the sense that it is not an internal job all in one small package. It's a thing that involves people in Washington, you know, hence 1,000 trips to Washington on my part. People that are engaged with the industrial organizations and things of that sort because what we develop has to be built somewhere, so there's a transition and you have to get involved with the transition of the technology to another entity.

So, unlike a professor here who can, if he wants to be pretty localized, and his world can be pretty finite. The director of the lab is not in that situation. He is in an exposed position and has lots of lots of things and has to worry about many different directions.

For some odd reason they kept me on as director for 20 years. Actually, 21 years. Now they're turning directors over in five year intervals. They perhaps think it's too much for somebody to stay longer.