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Discussion - Session One

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CHAIRMAN JEROME LEDERER: Gen. Seawell has to leave very soon, so suppose we ask questions concerning his presentation. I might say that Bill Littlewood and I worked very closely together in 1929, and he developed a phrase which is the best of safety phrases, "What happens if?" Keep this in mind all the time. If you do this you will automatically come to a good safety record.

MR. PAUL LARSEN: Mr. Lederer, you asked the question yourself about the deterrent effect from the engineer's point of view of legal responsibility. I would like for you to elaborate a little further on this, because from a lawyer's point of view, this is a very interesting problem. We do a lot of speculating about this in our formulation of legal philosophy.

CHAIRMAN LEDERER: I think part of what you are getting at is lawsuits involving product liability. I mentioned that this pressure is caused by a new discipline of system safety engineering which arrives at the same end—the end being that the manufacturer must take every conceivable known means to assure himself and the public that his product is designed and built in accordance with full state of the art. If he doesn't do that, he becomes very vulnerable to law suits or embarrassment in image and costs. It costs money when the insurance rates are increased, depending on the type in the insurance field; and generally, it is very embarrassing for the designers to be subpoenaed and to be compelled to appear on the stand to answer questions presented by very, very knowledgeable lawyers, many of whom are not only lawyers but also pilots with good experience. So this trend is now not, I believe, in effect. Does any lawyer here want to counteract that? Is my statement correct in point of view of the lawyers? No? I heard a "no." Nobody wants to fight that, Jerry.

I predicted this in 1951; I gave a talk in Brighton, England, at which time I mentioned that engineers make mistakes. Engineers should recognize that lawyers will look over their shoulders and pick out these mistakes and can make it embarrassing for them. The *London Times* the next day—and by the way, I did not mention anywhere in my talks any nationality—read: *American Engineers Make Mistakes.* This hurt me terribly.

MR. THEODORE PHILLIPS: I am a lawyer from San Francisco, and I have a question for Mr. Kemp or perhaps a two fold question. First, you gave us an illustration of a history of a particular airplane which from my standpoint was very helpful because I think that we understand some of the more abstract safety concepts when we see them applied to a particular situation. My question of you is whether you are satisfied with the CAB findings of probable cause of the three fatal accidents involving the 727's.

CHAIRMAN LEDERER: This is not the adversary preceeding that I mentioned this morning.

MR. DONALD E. KEMP: No, I think this is a real easy one to answer. The act provides we cannot participate in the determination of the probable cause.

CHAIRMAN LEDERER: Any other questions?

MR. B. J. COOPER: I am an attorney from Oklahoma City, and my question is directed to Mr. Miller. He suggested eliminating the pursuit of the single concept of investigative study. My question is, if you do eliminate it, what do you

have as a goal or criteria for evaluating the completeness of your investigation?

MR. C. O. MILLER: First of all, if you will see the whole paper, you will see that I did not suggest the elimination of it "period." I said that in the interest of accident prevention, if this is the goal to which your question is directed, that the probable cause, a single probable cause, is not only unnecessary, but it is highly misleading. Let me give you a specific example. I hope Bobby Allen will forgive me for citing this. It is something that occurred purely by accident in Washington a few weeks back. I was at the Bureau of the Budget talking to people about the economics of safety; after this gentleman and I got to know each other he said, "Say, incidentally, what do you think of this report?" He brought forth a one page document which was the public relations release on the result of the DC-9 accident in Oregon. This release—the first paragraph had time, date, and place—said the Board determined the probable cause was: "We don't know." Now, on the back of this sheet—it came down from somewhere above this relatively high level man in the White House—were comments like, "What the hell did they take a year to find out 'we don't know' for? How much money did we spend on this one?" The fact remains, as anyone familiar with Mr. Allen's operation knows, a tremendous amount of accident prevention information is gained in their studies. A tremendous amount is, in fact, delineated in their findings. On the other hand, on the way to the public, or on the way in this case to the guy who has to give Mr. Allen his budget, the entire meaning of that accident investigation was lost because they were after a probable cause; and the public and the congressmen and many of you, perhaps, do not realize that the end point in accident investigation for prevention purposes is finding things you can do something about. In other words, I want to summarize again, my point is not "eliminate the concept of trying to investigate things;" my point is to try to put the emphasis where it is properly desired in accident prevention programs. Investigation is part of prevention, and that is all it is. In the safety field you try to identify all factors, and that is different from what you are after in accident investigation for legal purposes. Does that help clarify my position?

MR. COOPER: An investigation obviously is to determine some unknown factors. Unless you have an equation you are trying to find an answer to, you can not test the information you have to determine its completeness. If you eliminate the cause concept as being the objective of your investigation or test of your investigation, what would you substitute for it?

MR. MILLER: I am saying that the causal "factors," if I may play on the word . . . I want to know all the elements in the sequence of events, because I may not be able to do a thing about the probable cause; for example, I do not think anybody, practically speaking, can attack the probable cause of the 727 accident the way it was phrased. I think somebody can go back and make sure the next time an airplane comes along and Gen. Seawell has a training program that makes sure that the characteristics of high drag aircraft, if that is one of the new things that comes along, are introduced into the training program. That is something I can do very specifically; so if the findings of the 727 accident were such that, for example, the people did not really have a good understanding of high drag airplane approaches introduced into the training program, and that in fact this contributed to these accidents, that is something I can do something about. This old business of "don't let the pilot get below glide path" is utterly ridiculous from the standpoint of prevention of those accidents.

CHAIRMAN LEDERER: I think the key to your personal example is that you should give causes, not cause.

MR. MILLER: That is correct.

MR. EUGENE J. FELDHAUSEN: Mr. Miller, I believe you, sir, referred in your talk to a "Fault tree" analysis.

CHAIRMAN LEDERER: Yes, it looks like a tree. Gen. Stewart, do you want to describe it?

GEN. C. B. STEWART: It would take quite a little time to explain the "Fault tree." As briefly as I can, the "Fault tree" is a logic diagram that starts at the top with an undesired event. It branches out (that is where it gets the name of a tree) step by step, to all of the events that lead to this undesired event. Now, if you take the undesired event, A, it may be able to happen because immediately preceding that, two events happened, and the "Fault tree" analyst has to be very careful to make sure that he has really identified the immediately preceding causative events. There is a mathematical logic applied to this process with various types of "Gates." An "or" Gate symbolizes the case where you have two events either one of which can cause the next succeeding event. An "and" Gate symbolizes the case where the two events *both* have to occur to cause the next event up the tree to happen.

When you get through with these trees you get down to the bottom; you're now down to the component level where you know the rate of failure of a given valve, for instance, which is part of this system. You can now apply failure rates to all the events across the bottom of the tree and computerize it and put it in the machine. The machine will then (this is much too difficult to do manually) tell you, based on the given failure rates of the, perhaps, hundred events across the bottom of the tree, what is the probability of occurrence of the top undesired event.

MR. FELDHAUSEN: The top undesired event, then, is the crux; it is the way it is related to most causes.

GEN. STEWART: That's right. Thus it is different from a single thread analysis that starts at the bottom, because it will cross over systems, in the event you have defined an event that might be basically associated with the environmental control system; but as you go down through the tree, you will often find that it will branch off into other systems. So it is more than a single thread analysis; and for this reason it is the sort of thing which identifies ways in which accidents can happen, that have never happened that way before, and that you cannot find in searching accident or incident experience.

MR. FELDHAUSEN: Can this be used in computer technology?

GEN STEWART: For a tree of any size you must use a computer because the events pyramid. Manual processing is tremendously difficult.

CHAIRMAN LEDERER: You can see how useful this would be in accident investigation, if the "Fault tree" analysis had been made, and the ship was involved in an accident. You can go back to the "Fault tree" analysis and have a much better chance of finding out the probabilities of the cause of the accident. It is a very expensive process, and also requires men of considerable background and imagination who may know what happened in the sequence of events that occurred.

MR. MILLER: Jerry, may I add one comment, which I think would be of interest to this group? One of the major breakthroughs in "Fault tree" analysis in my opinion is the graphical presentation. Graphical presentation allows not only untrained people to see this thing but also to trace these problems down in a logical fashion, which is similar to taking a picture of the action.

CHAIRMAN LEDERER: We are having a three day meeting at NASA headquarters May 1, 2, and 3, on systems safety engineering. "Fault tree" analysis will be one of the things described. Going back to the question asked of me, I have

here an inhouse communication of one of the manufacturers from the vice president to the chief engineer. It says, "I am impressed by the rate of growth of exposure to liability suits represented by the products of our commercial airplane section. I am anxious that our precautions with respect to the legal aspects of this exposure do not unnecessarily inhibit the best in current safety and reliability engineering technology to our product. I believe our best defense in this increasing exposure is to make sure our designs are as safe as the state of the art can make them and that safe operating procedures are employed in their use." That is a better answer to your question than I could give.

MR. HAROLD McCOY: I would like to address a question to Mr. Kemp. Are federal regulations, particularly those with design criteria, contemporaneous with current knowledge?

CHAIRMAN LEDERER: Are federal regulations up to the state of the art is what you are asking.

MR. KEMP: I do not know whose standard you would base this on. I do not think there is any state of the art in any regulation on the books. Many manufacturers normally go beyond what our minimums are on the books. I think we are pretty much industry-wise up to the state of the arts, as well as can be expected.

MR. McCOY: Well, then, can you expect manufacturers to ask what your reasonable qualified standards are?

MR. KEMP: The manufacturer, from an economic standpoint, can not afford to have a bad design.

MR. McCOY: In answer to the federal regulations criteria, how can you, then, expect to go further?

MR. KEMP: Federal regulations only give you minimum standards; in other words, you have to give them a base line. You have to give them this level at least. There are very few manufacturers that only reach this level. In fact, I do not think any of them have to go beyond it.

MR. MILLER: Something I said may very well have been interpreted to seem that I do not agree with the minimum standard concept. I would like to clarify that because I would hate to be in a world where we are told precisely what to do, not above and not below. The minimum standard concept to me is highly fundamental in our business, where there is competitive enterprise which, in fact, rewards people for going beyond minimum standards. I personally agree, Mr. Kemp, that all manufacturers do go beyond the minimum standard, at least in the commercial airline business. I am not sure that this takes place in the general aviation business. But I think another part of the up-to-dateness here is the real world. It takes X number of months or perhaps years to get accurate review of a proposed standard, and get it on the books, and in fact get the system developed. But you have got that undeniable delta of time which has to do with the state of the art as compared with regulations itself. There is no way of getting around this consistent with trying to encourage a competitive enterprise system.

CHAIRMAN LEDERER: There is one development that tends to solve this problem which has not yet been applied to commercial aviation. It has been applied to military aviation. I am speaking of the concept of systems safety engineering developed by the military services. This enables the government, in this case the military and NASA also, to put safety on a contractual basis. The concept defines explicitly what is required from the point of view of safety, and another of the requirements is a great number of details which force the manufacturer to explore every known piece of information and to carry on the safe design of the aircraft. If he has to make compromises or take alternative risks, the contract requires him to document and to prove his point. So there you are getting beyond the minimum

levels of safety and into the higher levels of safety, and I suspect this is in the SST. Aren't you using system safety engineering in the SST, by contract?

MR. JOHN E. LINDBERG: FAA standards, which affect all manufacturers with little exception, are the prior detection standards established fifteen to seventeen years ago by the best engineering talent at that time, which have become the international standards—five seconds maximum response reached under standardized claimed conditions. Yet, today, exceptions have been made by the manufacturers; they have put out or up to fifteen, sometimes seventeen seconds. This obviously puts a manufacturer who can develop and exceed the present standards at a very high economic disadvantage. There is work being done in the FAA to raise the standards, but it is exceedingly slow in being given due credit. It was planned throughout an advisory circular to interpret the standards of the proposed five seconds and to publish this as the installed structure used with the device of the FAA TSO C11. But this has not yet gone to print because, of all things, the legal interpretation by the legal counsel of the FAA saying: "You can't do this. You have to modify the FAR 25 before you do it." But now almost a year's time is gone by, and aircraft are being built, and this is costing both the airline industry and manufacturers a great deal of money. I think it is a good point then, that standards should be kept up to date, very currently up to date. We need to set goals and opportunities to exceed the standard of safety abuse, and meet where this being well pointed out by testing government concord work where it is shown that even five seconds probably is not efficient, that it should even be a little faster. Because surface temperatures exceed the readmission point, should you put out a fire and recombustion occur, it will reignite.

MR. KEMP: I think he very well stated the question that the rule making process is not bad; it requires comment from all segments of industry. They have to come in to evaluate it. I do not know; I guess I am like you in that I like to see what happens tomorrow. I think it is needed. But it just will not work that way. You have by law a certain process rule that must be followed. If you want to change the rules, get the public and the manufacturers and the airlines and everyone else to cooperate and make comments.

CHAIRMAN LEDERER: There is an administrative procedure that is required by Congress. I read about this when I was director of the Safety Bureau, in regard to civil air regulations. You have got to give people who are affected by whatever you want to put into the rules a chance to respond to the rule. This takes a lot of time, and very often there are delays interposed for obvious reasons, and requests for extension. You can so write a regulation where only one manufacturer would benefit. This can become embarrassing in some cases. I think I mentioned in my talk one of the "psychedelic" ideals is to adopt the latest devices with minimum time. Anyone want to respond to this?

MR. PAUL W. ENGSTROM: I would like to address a question once again to investigation and accident prevention problems, that both Mr. Miller and Mr. Kemp discussed. Mr. Miller's position is that the report of the FAA or NTSB should be more on the causes as opposed to the single cause. I am just wondering if this is not the real problem. But instead, the problem is the actual investigation of an accident and the factual reports that are put out by various specialists structures, such as the system specialists, the flight recorder specialists, the witness specialists, and the other various factors. Don't these reports provide the basic information upon which anybody, the FAA, the manufacturers, the airlines, can review this material and come up with what the probable cause is or what the causes are?

CHAIRMAN LEDERER: Your idea is to state the facts so we can come to a conclusion.

MR. MILLER: I do not mean to sound facetious, but anybody, the manufacturers, or the airlines, or the University of Southern California, or a law firm, in fact each and everyone, could investigate the entire accident. I might argue in certain cases that if it had been my family aboard that aircraft, I would like to investigate the accident; but somewhere we have to draw the line. *We* have to delegate the fact-finding ability to certain people. And again in the NTSB case, I think they do a truly outstanding job of it. I have on occasion tried to go through these lists we have talked about, and I find it difficult to take that kind of time. I am saying that I am willing and certainly encourage the delegation of determining causal factors to some group who has been living with this thing from day one.

I think that what you are suggesting is very fine in theory, that each of us would wade through all those materials and come up with a prevention activity we like; and in fact we might come up with more data than even Bobby Allen's group does. But from the practical, real world point of view, I do not believe the time is available. Somebody has to gather the material and sift through it and try to come up with nuggets, not the nugget. That is my position.

CHAIRMAN LEDERER: I suspect that the lawyers do just that.

MR. KEMP: I would like to add that in this factual report any deficiency that is uncovered in an accident investigation, whether it is related to the cause area or not, is corrected. For example, you have an accident due to a landing gear failing. It so happens that you butchered up the wing a little bit, and maybe there was a little corrosion on the spar. It has nothing to do with the landing gear failure, but you have some other problems. Do you go back to the manufacturer and see what his corrective recommendation would be? Maybe it is an error in his directives. This may not be related to the accident. You make correction on any deficiency you find, not just what they determine as probable cause. Also for your information, the docket section is available for anyone to review any reports related to the accident. Now what you are referring to is only the public report. This is usually anywhere from eight to fifty pages. But it is very similar to the one you are reading.

MR. LARSEN: Did I understand Gen. Stewart correctly to say that he agrees with Bo Lundberg that a plateau has been reached at this point?

CHAIRMAN LEDERER: Do you agree with Bo Lundberg that a plateau in air safety has been reached? I do not think that Bo Lundberg said that there had been a plateau. He said that if you stay at this present plateau with the increase in traffic you will have a lot more accidents than the public is willing to take. Do you want to answer this question?

MR. STEWART: I think what I agree with, is the rate of improvement of the accident safety record over the past twenty years. The safety record has been improving at a given rate. But you take the forecast between now and say 1990 on the rate of growth; take some of the upper estimates of the rate of growth of air traffic, and apply it with the present safety record just assuming the rate of improvement that we have had over the past 20 years. Your total number of fatalities, your total number of accidents, is going to go up. This is just mathematical. No one can dispute this if you postulate what I have said. The arithemetic comes out that the total number of accidents and the total number of fatalities per year is going to go up. We agree that this is not good, and we make every effort to improve on the rate of improvement.

MR. A. D. TINKELENBERG: I would like to address a question to Mr. Kemp, and perhaps also to Mr. Miller, to discuss the investigation which is conducted on an individual accident. I have gone through some of the accident reports, and I find them very thorough. In normal development work for developing a system,

it is most advantageous to look at a whole system of failures that occur—all the failures that have occurred to an engine, or all the failures that have occurred to the pressure gauge or something like this. Does the FAA have any program whereby you look at all the failures or go into detail on the failures of the kind that have caused accidents? In the past, have you tried to pick up partial causes of these factors from one accident to piece them together? This would tie right in with, say, the "Fault tree" analysis.

MR. KEMP: Our system is set up on the A.T.A. code, so that you can pull out any system. It is not just on accidents; its on any occurrence.

MR. TINKELENBERG: The exact date of the data you get is of a pretty general type. For instance, they have failures on the ATA code which they give the same identifying numbers, say for all landing gears regardless of types of individual aircraft. Of course, there is a wide variety of landing gears amongst the aircraft. If you could go into the individual mechanics of a failure, in considerable detail, which have occurred on one accident, and then look at that from accident to accident, there would be more of a failure analysis type that would normally be done, not in just looking at one failure, but in the whole trend effect. I wonder if you are doing this and to what extent?

MR. KEMP: I will have to say I do not really know to what extent they are pulling these out; but certainly I hope they are going farther into all areas to identify a common gear if there is any similarity between failure. I want to point out that we are not talking about accidents alone; we are talking about incidents as well; we are talking about 2,500 occurrences per year as compared to maybe 70 or 80 accidents.

MR. MILLER: I took a real crack at a sacred cow this morning when I went on this primary single cause bit. Unsatisfactory reports and things like this as all single cause oriented, in my opinion, deny the fundamental nature of an accident. Accidents do not occur from single causes. Until our data system, through advanced technology and computers, can do a better job of relating these factors one to the other, you are going to continue to have the kind of problems you describe. Unless I am mistaken, Mr. Russler, in his presentation later on in this symposium, is going to perhaps attack this problem; but I defy anybody in this room to come up with an accident which has been truly single cause produced. I will put it this way: I can think of a lot of ways to prevent it besides what is included in the cause statement. We had better take a serious look at our entire method of collecting and storing accident data because right now, I am not real sure. We have the ability to relate many aspects that go into accident causation. At least that is quite a challenge today to the people in this business.

CHAIRMAN LEDERER: Thank you very much.

End of Tuesday morning discussion.