The Technological Environment

MIKE FROM[1]

I am assuming that most of you do not have a technical background. Therefore I will try to give you a top level view of the new airplane without boring you with too many details.

This conference has given us a great chance to see each other's worlds. I know I have learned a lot about the legal environment in the last day and a half. Now it's my turn to show you a little about the technical environment.

Let's get started: First, I'd like to start off with a little background as to why Boeing decided to build the airplane. Then proceed with some specifics about the technical advances that will be a part of the 777. And finally the future development and growth potential of the 777.

Boeing Marketing and Sales Department, after conferring with the airlines, divided the world into three major markets. Market A consists of airline routes of 4,000 nautical miles or less. Market B routes are an average of 5,500 nautical miles. Market C routes are about 7,300 nautical miles.

Market A, being across the U.S. continent, the west coast to Hawaii, the European countries to the Middle East. The B market being from Chicago to Europe and across the Asia continent. The C market being the very long range markets of the 7,300 nautical miles which are essentially across Asia and the Pacific. Now let's take a look at what marketing predicted the number of airplane sales to be between 1991 and 2005; they predict it to be 8,848 units. Of the range that we're talking about, the medium size range, Boeing initially had only one airplane in that market, the 767. Whereas their direct competitor, Airbus, had essentially four airplanes that they were offering. This was a couple of years ago. They offered these four airplanes that would fit into that size category and the MD-11 was well under development and now we are able to offer the 777 that will enter into that market.

To give you a little idea of where Boeing Marketing perceives the market to be going is that growth is about three-quarters, one-quarter being the replacement of the DC10 and L1011's. The U.S. Airlines, essen-

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tially the big three, United, American and Delta, taking up about forty percent of the new airplanes, Asian and Pacific taking about twenty-two percent and Europe taking about twenty-five percent.

What Boeing did before they introduced the 777 to the airlines, was to take a hard look at what Boeing already had in their arsenal and that was the 737 family which is about a 110-140 passenger airplane, the 757 which is about 160-180, the 767 which is anywhere from about 210-260 depending on your configuration and your particular airline. And the 747 which is about 410-450, again depending on airplane configuration. So Boeing really didn't have anything between the 250 range and the 400 range in passenger count. So they decided to try different derivatives of the 767 to see what they could come up with.

First they tried to stretch the fuselage of the 767. Then tried putting a new wing on the 767. But those ideas proved uneconomical. They tried other things where they shrank a 747 model and put a 767 wing on it, again the economics just didn't prove out. So what happened next was the airlines said we don't want old technology, the 767 being late seventies technology. The 747 is mid-sixties technology. What we really want is something that is the latest and greatest. And so with that, they went on to help Boeing define what the new airplane would be.

The new airplane would have regional and intercontinental market capabilities. It will have state of the art service, features and technology. It will aid the airlines, as was pointed out, in their economics to be able to get through tight times. It will have industry leading performance and economics again strictly to save the airlines some money and to allow growth and we'll get into the future growth of this airplane.

Anybody here from United? Since we are in United's backyard, I had to bring a picture of the 777 in United's livery.

Let's take a look at how this airplane looks stacked against its competitors. Boeing has decided that going to the customer and finding out what the customer wants is a better philosophy and have gone to key airlines. The eight key airlines consist of the three big airlines in the United States. United, American and Delta, also the two biggies in Japan, which are Japan Airlines and All Nippon Airways, British, Quantas, and Cathay Pacific. All are big, heavy airplane flyers. With that, we polled them as to what they wanted in this next generation of airplanes. They wanted to replace the DC10 and the L1011. They also wanted to replace the larger of the DC1030s and they also wanted to help out their international markets which are currently covered by the 747SP's. There aren't many SP's out there. The SP is a special performance airplane and they were not a big seller and as a result, they do want to hit that market as well. And they also want to be able to replace the early 747-100, which was introduced in the early seventies and is now becoming an older airplane. So what you have is, if you look at the DC10 and the L1011 we are replacing, those again with a little bit higher passenger count, this is a tri-class seating. First class, business, and coach. The DC10 has a smaller range of passenger seating on its typical tri-class. The 777, in its interior flexibility, has a larger tri-class or world class capability. So even though it's drawn as having 300 passenger capability, you can also drop that down into these ranges and still run it more economically than its competitors.

Again, we are coming out in May 1995, we have a growth airplane of a higher gross weight capability airplane, more fuel, coming out in December, 1996. We'll eventually stretch the airplane and get a higher passenger count, and then in the future offer longer range derivatives. So that one airplane, one flight crew, will be able to fly in any of that range. That's the amount of capability.

One of the things the airlines are very concerned about is the economics of the airplane. One of the things that is paramount in our minds is that if you can get a larger wing span then you're going to produce a more economical airplane. What we have found is that the airplanes we wanted to replace, strictly the DC10 and the L1011, have about a 156 foot wing span. The other airplanes that park in similar gates at airports are the 767 and the A310. The 777 has about 196-197 foot wing span and the problem with that is you can't park that in one of these gates. The 747 has about a 200 foot wing span, i.e., the only gate we can park this airplane in is a 747 gate and there are only a limited number of 747 gates available. Our competitor with their counterpart the A340, which is a four engine airplane, (essentially the same airplane just two engines versus four engines), has a much larger wing span and they are not operating with the folded wing tip option.

To give you a dramatic view of what this looks like, if you look at Chicago O'Hare, you can take a look at the DC10s parked in their DC10 gates and you can see the 777, as depicted with the folded wing tip fitting into the DC10 gate. Out here on the end, you can see the 747-400 with its wing tips, which are not folded. You can see that it takes up a large amount of space for a 747, in a 747 gate. There are only a limited number of 747 gates at Chicago O'Hare airport, as well as other airports.

Next I would like to cover performance, reliability and economy. Computer aided design is an extremely helpful tool for all of engineering. They have to have a better way of doing things other than just straight mockups. A mockup is essentially that. It is built from scratch. It is extremely expensive and time consuming. There are a whole lot of people out in the factory that have to do these mockups that curse up one side and down the other at the engineer that designed it, because the design and the mockup, in the past, have always been a back and forth issue. It has never been a one way gate and what we're trying to do this time is to do digital preassembly.

Digital preassembly is where one part of the airplane is designed, fit in with the rest of the design in the computer and you can't fool the computer. You can draw a line and say it doesn't quite meet it, I'll just erase it. And that's great on paper, but when you try to go and build something like that, that's when the boys in the factory get really upset with the design engineer. This one will make the engineers be honest. They can erase their line and draw it so it will fit on the computer and from there, all of the parts are built together and assembled in the computer.

The Class Three mockup is essentially a full buildup of the airplane. This way we're going to skip Class One and Class Two. Class One is strictly nuts and bolts where they're just trying to make things fit together. Class Two is in between. Class Three is essentially a full airplane mockup. We're going to go from digital preassembly to the full mockup right away. Tremendous savings there.

I alluded to aerodynamic efficiency here a moment ago with large wing span, but there's a little bit more to it than just a large wing span. I hope you'll allow me to digress here a minute into my aerodynamic engineering background, to give you an idea about technology that will help us to make a better airplane.

One of the things that we're doing on this airplane is that, through the technological advances in structures, we're allowed to build a thicker wing, which can cruise at mach point eighty-three. Previous airplanes, the 757 and 767, cruised at eighty. So it will be a little faster airplane, not quite as fast as the 747, but more economical than the 747. As a result, if you can increase your cruise speed and wing thickness, you will have an improvement in technology and improvement in efficiency. If we can increase the wing span, we can increase the range, then there is another improvement in performance. If we can increase the wing area, we can increase the altitude capability. A heavyweight airplane with a big wing can fly at a higher altitude than a heavyweight airplane with a small wing. You'll find that our counterparts, Airbus and McDonnell Douglas, do not have a big wing. Boeing has typically been a big wing builder because of the potential growth of the airplane.

Initially, right off the factory line, there will be a 515,000 pound maximum takeoff weight Market A airplane. Eventually, we're going to grow the plane into the B market. And you can see when you get to that size airplane, you're talking an increase in the amount of fuel capability and you can see the extended range will enable the 777 to go from Chicago to Tokyo and Chicago to Bejing. You open up a tremendous amount of the world straight from Chicago with this airplane.

Let's talk about the three engine manufacturers. Boeing is an airplane assembler. They're not a manufacturer. They have many separate companies that support manufacturing. We're essentially the assembler. And one of the things that we assemble or we mount on the airplanes are the engines. So, we'll talk about the three engine manufacturers.

The three big engine manufactures are General Electric, Pratt & Whitney, and Rolls Royce. All three of them are offering engines that will work on this airplane. And the thing to point out here is the relative size of these engines. The size is essentially a ten foot diameter engine and you wrap a nacelle around it and you're talking about thirteen to fourteen feet. How many of you flew in on a 737 or an MD80 or a 757? The diameter of the fuselage, the interior of it, would be the diameter of this engine. So that'll give you an idea of the relative size. And we're not too concerned about it because technology that has advanced over the years has enabled us to build this engine. The engine core, essentially the meat and potatoes of this engine, is essentially the same as that on the present day 747 and 767. And what they've done is they've made the fan, the bypass ratio, much larger and that improves fuel efficiency.

One of the questions that comes to mind is why build an engine so big? So why not go with a smaller engine and make it a four engine airplane? Well, if you look at the operating costs of four engine or three engine airplanes versus two engine airplanes, you'll find that about five to nine percent of the operating cost of the airplane is wound up in the difference between a four engine and a two engine airplane depending on the range that you fly that airplane. And you'll see that the twin engine airplane weighs less and therefore burns less fuel. Two engines cost less to purchase than four engines. Two engines cost less to maintain than four engines. A large percentage of the airlines cost of operation is wound up in their engine maintenance.

One of the things that's near and dear to a lot of people's hearts is the issue of noise, airport noise. And if you compare this airplane with previous airplanes and you look at their noise footprint, you'll see that if you take a DC1030 and you look at its noise footprint for a fifty-five decibel area, you'll find that the reduction is about fifty-one percent over the DC10 and you'll see that it is very comparable to the 767 today. So it's essentially the same as today's engine and that's a 1991. By the time this engine services in 1995, they are predicting that it will come down. So we're talking about a bigger engine that's as quiet and by the time it goes into service, it will be even quieter.

One of the other issues, that is I'm sure near and dear to a lot of litigators here, is the extended twin operations or ETOC. ETOC is the buzz word that's been around quite some time. The major concern is that you have three engines on this airplane versus four. Where if you lose one engine, you only have one left and on a four engine airplane or three engine, obviously, you have two or three left after that one failure. But you'll find that with the advancement in technology, these engines are as reliable if not even more reliable than their predecessors. Again I mention that the engines have the same core as the engines on the day sixty-seven and forty-seven models. They're going to use that information to argue the point that these engines will be as reliable if not more reliable from the lessons they have learned from the previous engines and they'll take advantage of that. So that's what they're trying to do is to utilize all the information that they've gathered since 1985 with respect to twin engine operations.

The next topic is avionics. One of the things the airlines wanted was an advance flight deck. Many airlines classify the 767, which is fairly new technology, as steam driven technology. So we knew we were in trouble when they classified it that way. What you're looking at is the 777 flight deck. It is extremely similar to the 747 flight deck. There have been some advances made and there will be more by the time this airplane goes into production. But currently this is its design. One of the things that they wanted was to optimize the quiet airplane situation and what we've done is we've compacted an awful lot of information into a one-eighth inch square tube. A pilot can look at one instrument and get his attitude, altitude, his speed, his direction. You can just glance down at it.

In previous airplanes, he would have to hunt around for several different dials, several different instruments, to be able to get that kind of information. Now he can get it at a glance. And with a lot of reference tick marks on that instrument, he can figure out exactly where he is and where he should be. So at a glance he can pick this information out. Again, that will minimize the heads down time. He will be able to look down at a glance and figure out the situation especially in the terminal control areas where most of your pilot awareness is keen.

They also wanted to design for future expansion of flight operation. One of the future advances is that they're going to add in another eight inch tube. Although they'll be flat plate displays by that time, which is another new technology we're working on. Over here on the side, you'd want the basic airplane information to be at the pilot's command right away. Other information that is not essential to the operation of the airplane, but you'd like the pilot to be aware of it, will be put off on the side tubes. Any type of communication between the airline and the airplane itself, that you don't want to have go through the control tower, you'll be able to send through these separate tubes. One of the big keys for the airlines.

Again, to tell you a little about the avionics package, the 747 package with an expansion from there. You'll be able to have satellite communications again that gets into separate amounts of information from the pilot.

You'll have a global communication system which is more accurate than what they have in current airplanes.

One of the things I wanted to mention as well is the microwave landing system.

There has been a lot of talk in this past day and a half where they're worried about airport congestion, being able to get airplanes in and out. I've sat on the Chicago O'Hare tarmac, where one time, it was well over an hour wait for all of the airplanes ahead of me to take off and they have to wait for subsequent airplanes to land in between. With a microwave landing system, currently you can land two airplanes parallel to each other with a 1,500 foot distance between them. With a microwave landing system, because of its accuracy capability, we're talking about being able to have that. Also you have to land two minutes apart. They're also talking about stacking them up even tighter than that because of the accuracy of this, as well as, some other advances. Then we also have some imbedded software in our airborne information and maintenance system.

On previous airplanes we have had several black boxes or separate computers to do all sorts of different things on the airplane. On this airplane we are going to combine them all in one. And that's the airplane information and management system. What we're going to do is we're going to reduce the weight of the overall system by twenty percent, not the weight of the airplane. We used to have all these separate boxes and now they're combined into one, that's where most of the weight reduction comes from. A thirty percent power reduction requirement again because we don't have all these separate boxes, we only have one that's going to require a certain level of power. Again, with the separate number of boxes you have more failure of individual boxes now we're going to only have one. We're going to try to increase that reliability factor.

One of the keys that the airlines wanted was that we consider when we design a box, when you design an airplane, that it's about five years before it actually flies. There's a lot of design activity. You design a black box or a computer to be able to handle a certain amount of information. Well, as the airplane progresses through its development, you'll find that the airlines want more and more and more information to be able to be processed through these computers. And what we're doing is that in its initial design we're allowing for that thing to double in size as to the amount of information that is processed. Key to the airlines is a lesson learned in the 767 and 747 which are right up against their limit right now as to how much information they can process. The airlines are not very happy about that . . . . As you're about to backup away from the gate, they unplug the power from shore power and you're now on ship power or airplane power and you find the lights flicker. Well, for all of you who own digital computers, you know what a power surge does to the digital box.

It makes it go haywire. They are going to make this less susceptible to those power surges. So that it will operate right on through a power surge. Again, all of the flight crew functions that were associated with instrumentation for the pilot will be able to operate on either engine power or standby power which is extremely important. A pilot has the capability of selecting what source of electrical power he requires and he can set it to standby power if he wishes.

The cabin management system is another big key for the airlines. This is all information that has come back to us from the airlines. We're making it modular so that what Boeing will provide to the airlines is dispatch critical and non-dispatch critical items that will be built into the airline. The one thing about buyer furnished equipment is all the video entertainment. With this capability, they'll be able to buy anybody's peripherals, anybody's video tape machine, anybody's audio entertainment, anybody's cameras or whatever, and be able to plug into the system. With the way they've done it in the past, every airline had its own way of doing things. They have their favorite video entertainment supplier, etc. Very rarely will we find two airlines that have the same supplier.

Let's give you a little gee whiz picture here. Imagine a flight attendant here at the cabin management system terminal. She has a keyboard where she can enter all sorts of information that will allow her to understand the health of the system as well as any other information that she may require, telephone, everything is available to her at one easy station. She can then operate all of the video, all of the audio, everything from one terminal. One thing we are going to offer to the airlines is the ability to put the screen on the seat back in front of you This way you'll be able to watch it right in front of you.

The next thing to get into is the interior flexibility, a real key Boeing has to offer and the other airline manufacturers have to offer. Not that I'm trying to sell this airplane. One of the key features of this airplane is that one day you may want to fly this airplane in an all coach or all tourist setup and within twenty-four hours you might want, because of the way you are routing your airplane, to go with a large business class or a large first class and a smaller tourist class. So you'll want to be able to remove seats and replace it with a lavatory or a galley depending on how long your trip is if you need more galley or any combination thereof. In the past, and on our competitor's airplanes, you're going to find that in order to make those kind of changes, your airplane would be down for a matter of days if not on the order of a week. And for all you economists out there, that costs on an order of $100 million on the ground for seven days, you've lost a lot of revenue. We're not going to allow them free reign on the airplane because as you can imagine if you have a seat and you're going to replace it with a lavatory, one of the things you have to do is you have wastewater management and you know it's kind of tough to leave a hole in the floor underneath somebody's seat.

So, what we're offering is a foot print where you can put your galleys in a certain area and these areas are key areas. It allows you to have that capability of enlarging your first class or shrinking your business or vice versa to be able to handle the galley. Also, in the lavatory are the capabilities where you can locate your lavatories in regard to how you want to arrange your interior. Certain areas are fixed, there are certain fixed galleys. And that's pretty standard. You're not going to want to stuff somebody, a passenger, way back here in the back. So we feel fairly safe about that. Certain areas are fixed lavatories on the airplane. But again the difference is the middle of the airplane where you make all of your interior changes.

The last thing to talk about, as far as technology is concerned, is the composite structure material that we'll use on board the airplane. This is nothing new. Composite structures have been used on airplanes for quite some time. The one thing that will be new for the 777 airplane is that we will use an extensive amount of composite in the horizontal and vertical tails. We have used, in the past, almost every other area that you see here highlighted by the different types of lightweight composites we have used on the fifty-seven and sixty-seven, and subsequently, on the 747-400. One of the things that has come up, especially in the recent past, is structural durability and one of the things that Boeing is pretty smart at is learning their lessons and we're now going with the thicker skin than we had in the past. We have improved damage drainage to reduce corrosion. One of the things you'll find is that you go through the service of the airplane, through taking off up to altitude and back down, you're stretching and shrinking the airplane over and over again. As a result of that, you're always going to have a certain amount of fuel leak either through your wastewater management or any of the hydraulics or anything. All airplanes have that. One of the things that's key is to be able to get into these areas where this fluid will get caught and be able to remove it. Again, parts and features, better accessibility to trouble prone areas, again that's the same thing that fluid tends to be trapped in certain areas of the airplane and you want to be able to get in there and remove it.

Just a recap. What we're looking at is we're going to twin engines instead of the prior four, again for lower fuel burn and the lower noise. We have improved the avionics and aerodynamics to be able to lessen the cost for the airlines. We're looking at a better design through the digital preassembly and also through the use of components. And we're also offering a tremendous interior flexibility for the airline as well as the spaciousness for the airlines. Just to give you one indication of direct operating costs. Direct operating cost for the airlines that use the fuel are maintenance, engine maintenance, insurance, and flight crew costs. If you look at the regional markets, the dual class on a 1,000 nautical mission although 1,000 might be a little on the short side. It was just chosen as an example. If you look at the 767-300 which Boeing builds today versus the new airplane, you can see that through our use of technology we were able to lower the operating costs quite a bit. The difference here is just nine abreast or ten abreast seating. Ten abreast is a little bit tight and nine abreast is our standard. So if we look at nine abreast versus our present technology, we're that much improved. And we are improved over the MD11 and MD-8330 which is our counterpart twin. If you look at our international market, the big jump here was fairly bold here and the reason that they've fallen off here is the four engine airplane. That's one of the big increases that there is the extra cost for the extra two engines.

Just to give you one final cap here on the now and in the future we're going to introduce in May 1995, United Airlines is our first customer, All Nippon Airways bought our airplane a couple of months ago. They have not chosen an engine as of yet. United Airlines chose Pratt & Whitney, so there's a bit to do between Rolls Royce and General Electric as far as who gets that second engine. There's big money for that. December of 1996 we're going to go to the higher airplane. That was the one you'll be able to fly to Tokyo and Bejing. We're going to stretch the airplane, we're not sure on a date on that. We're still negotiating with Cathay Pacific out of Hong Kong who is very interested in our stretch version and then the future growth of the airplane as we mentioned earlier which is a bit further off in the distance. And what that amounts to is what Boeing offers is the full family of airplanes now. We go all the way from 110 passengers all the way to about 450 passengers and we've got everything covered. So as our Vice Presidents like to say, we have one stop shopping. Whatever you want, we got. And with that, I'll say thank you.

JOHN M. SWIHART[2]

I'd like to start where Mike left off and talk about growth for a second because that's extremely important. He mentioned the broad analysis of growth. One of them very optimistic, one very conservative. Boeing tends to be in the middle. But all of them predict that in the year 2000, traffic relative to today is going to nearly double. Right now there are 1,200 million revenue passenger miles being flown in the world. There is going to be nearly double that number by the year 2000 and by 2005 it will be more than double. And what that really means is that there's going to be nearly 9,000 new aircraft come into the system by 2005. That combination of replacement aircraft, which is going to be approximately 3,000 of the 9,000 aircraft, and the new aircraft is a market of $617 billion between now and 2005. About $423 billion new and $194 billion for replacement overall. Now the interesting thing about the Boeing study which was just released in February 1990, is that the largest share of those new aircraft are going to be in airplanes of over 350 seats. Now there's a very good reason for that. The biggest problem we have in the world today is between runway capacity and air traffic control. In fact, the lack of runways and the lack of global positioned satellites and combination is really keeping things below what they should be if we could get them done. Mike mentioned MLS. MLS and all of its combinations will only increase runway acceptance by twenty-five percent, but we're going to double. So you need more runways and that's pretty soon.

There are twenty-five countries waiting for landing slots at Narita Airport in Japan right now. The internal Japanese lines are turning six million passengers a year over to the railroads because there are not enough runways, even though they fly 747-SR's at 550 seats and they fly every half hour. There is not enough runway capacity to handle the traffic traveling between Tokyo-Sapporo, Tokyo-Osaka, Tokyo-Fukuoka and Tokyo-Naha. They're turning six million passengers over to Bullet Train (Shinkansen). That's just on the main four trunk routes, that's not the other part of the domestic system.

Airports, as you must well know, in Denver, bring thousands of jobs once they get put in place. So we've got to have more concrete around the world. That's all there is to it and it's a great mistake, and I'll go on record with this, to close Stapleton when you make the new airport. Because if you are going to double capacity within ten years, what are you going to do? You are going to have the same problem you've got today.

2. John M. Swihart is currently President of Swihart Consulting, Inc., President of the National Center for Advanced Technology, and President of the American Institute for Aeronautics and Astronautics. Previously he was a vice President of Beoing.

There are twenty-five airports under constraint in the United States right now. By 2005 that number will be over fifty which is a serious problem.

Let me talk about technology for a moment. I'm fortunate to have retired from Boeing and I'm the President of the National Center for Advanced Technologies, which is a non-profit foundation of the Aerospace Industry Association. We got together a group of senior vice presidents of research and engineering here in 1987 and we looked at all of the technologies which would affect our international competitiveness by the year 2000. We used some very selective criteria, but we picked a bunch of them and I'm only going to mention those that apply to airplanes at this particular moment. We picked air breathing propulsion, advanced composite structure, advanced metallic materials, computational sciences. We got a lot of commonality with what Mike had to say. Ultra reliable electronics and optical information processing.

The process we used is that we appointed one of those senior vice presidents to be the sponsor of each one of these technologies. He, in turn, went to his company, he got a senior person from engineering, and a senior person from manufacturing and said, "you go out and get one third of the number of people you need to build a road map from industry, you get one third from government, you get one third from academia and you start building a road map with that technology for the next ten years." As soon as you get that road map built, go back to the central authority, so to speak, we'll review it, and then we'll start doing a national technology development plan for each one of these things. So we'll lay out ten years worth of very detailed technology development plans that will ensure that several things happen. One, we will double the productivity of our manpower in aerospace. We will cut the time from idea to product in half, and we will leap frog our international competition.

Industry leads the process of making these national technology development plans. The government participates and academia participates. If they want to join the team, if they want to put their money in that technology, that's fine because industry is putting their money in. A large share of their internal research and development is going into these eleven key technologies that we have identified.

I want to talk about each one of those a little bit with reference to some of the things that Mike had to say. For example, air breathing propulsion. The goal is to double the thrust to weight ratio of those big engines that you see that Mike had there in the first part of the twenty first century. Now that roughly means that their thrust weight ratio right now is about five to one. This would mean that they go ten to one. We could do that by using metal matrices for the turbine wheels. We could use ceramic matrices for the combustion chambers. We could use advanced composites for the frames and the blades. Just to put that into context, if you could double the thrust to weight ratio of the two engines on Mike's new airplane, you could do several things. I'll put it in terms of passengers; you could increase the passenger capacity by eighty passengers. You wouldn't do that. What you'd do is take the savings in weight and put it immediately into range or higher initial cruise altitude. Also, the second goal of air breathing propulsion is to reduce the specific fuel consumption by twenty five percent. This, in that same frame of reference, would increase the passenger capacity of the 777 by sixty eight passengers. Between those two, you see there's almost half of the payload in advanced technology. You could run the gross weight down and increase the range. You could reduce the ticket price because the direct operating cost would go down a very substantial amount.

Advanced composite structure. We're talking about structures that are designed right from the beginning not as black aluminum, which is a lot of what we do today, but taking advantage of the strengths of the advanced composite structure and making new material, new manufacturing methods, lower cost. If we could do that and actually apply it to the entire airplane, you could probably reduce the operating empty weight by between twenty five to thirty percent. That's about 7,500 pounds of the 777 airplane. What a terrific affect that would have when you integrate that back into the total airplane. Engine size goes down, fuel burn goes down, landing fees go down, everything goes down very substantially.

Advanced metallic structure. There are new ways of manufacturing metallics today that are being talked about. For example, you might make the wing in two pieces. You might make the front spar on the lower surface, the rear spar in the upper surface and put it together. A very simple two piece wing in other words. That could result a ten percent reduction in operating empty weight and substantial reduction in cost.

Computational science, computational fuel dynamics are the new thing. Mike showed you a lot of wonderful things. The three dimensional mockups. All of that material. The aerodynamics that he mentioned. All of that. There could be some tremendous advances made in computational science. For example, today we could probably run computers at an average speed of maybe a billion of operations per second. What we're looking for is a 100 billion operations per second. So when we can do the type of computations it takes to get the complete analysis of the airplane which now takes twenty four to thirty six hours and costs hundreds of thousands of dollars, in a couple of minutes, then we could look at the result and say let's make that change. Let's try that out. Two minutes later you would know if it was right or wrong. Then you could get to the stage where you make one wind tunnel model and that particular model is the one that you use to guarantee United what their performance should be.

Now, a couple of others things you might get with new computational science. Laminar flow. For example, laminar flow is a very smooth flow of air one-fifth of the drag we get with an airplane today. The 757 has run a test in this past year when they achieved laminar flow over the upper surface of the wing from the leading edge to the seventy percent chord. A very substantial amount of laminar flow. They achieved it 100% of the time on ninety one flights. Properly applied to the wings, the nacelles, the vertical and horizontal tails of the 777, this would result in a thirteen to fifteen percent fuel savings below the numbers that Mike already showed you. This also will do a couple of other things. With laminar flow of that kind you can reduce the engine size. You wouldn't do that probably. You would run the initial cruise altitude up 2,000 or 3,000 feet because that helps promote more laminar flow and the engine likes to fly higher and faster anyway. Therefore, you get reduced maintenance cost on the engine. Overall it would be a very large improvement. You'd get better airframe engine integration by using computational science than we have today without a lot of wind tunnel testing.

Ultra reliable electronics. I just want to mention very quickly that the goal is to design and build an electronic suite that never fails in the lifetime of either a civil or military aircraft. That's the goal of the technology. Never fails. Think of the reduction of life cycle costs if United bought an airplane and expected it to last for 60,000 - 70,000 hours and never have an electronic failure. That's the goal of the ultra reliable electronics, very powerful reduction in life cycle costs.

Let me just summarize quickly and then we'll get to some questions. If you combine all of these technologies into a new series of airplane, you obviously make obsolete our current product. Those things would lead you to do some other things. Remember I said there are not enough runways? One of the ways you take care of not enough runways is to build bigger airplanes. An airplane that should be on the design board, at this particular moment, and with these advance technologies will probably do it before the end of the 1990's is an 800 passenger, three class airplane that would fly 7,500-8,000 nautical miles. It will solve most of the runway problems to probably the year 2025.

The second one that I'll mention quickly, because George mentioned it, is high speed civil transport. The high speed civil transport has some environmental problems that have to be solved first Arnold Goldberg and I worked on this most of our lives I think. You have to show that you don't wreck the ozone layer. You have to show that you can meet those nice noise requirements that Mike showed and you have to show that you do not make a *startling* sonic boom. The technology is available right now to very probably accomplish every one of those three things. But even if you couldn't solve the last one, the non startling sonic boom, the use of these technologies would allow us to build a high speed civil transport and probably cruise between 1,500 and 1,800 miles per hour, seat 300-350-400 passengers and fly from Denver to Japan in four and a half hours and have a ticket price that was within ten percent of the 747-400. Thank you.