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NEW TECHNOLOGY FOR THE NEXT GENERATION OF COMMERCIAL TRANSPORTS - REAL OR IMAGINARY?

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Abstract

Financial survival of many world airlines is precarious. Continued use of ageing aircraft with associated poor fuel efficiency, high maintenance cost, poor load factors, low utilization and low yields are major factors in their problems. In some cases, questions of safety also arise. The preferred alternative of acquiring aircraft incorporating the improved technology of the next 20 years will be hampered by high capital cost and interest rates, technical and operational complexity and financial and marketing health. If the present climate continues for an extended period, the scientific and engineering efforts to produce still further improvements may be wasted, since the opportunity to apply many of them may not arise - they will become imaginary! The potential advancements are outlined and the situation is examined in some detail.

Introduction

Dealing realistically with a subject of such scope, complexity and implication as the next twenty years of commercial aviation technology is a challenge indeed. As will be shown, there are a considerable number of major advancements which are imminent and others which will be available in the long term. There are, however, serious storm warnings and a need exists to examine clearly and objectively the direction that commercial aviation is really going.

There are some ominous and fundamental questions involving the ability of our industry to survive in the coming decades. The response to such concerns is normally - "don't worry, we'll pull through, we always have." The situation is, in fact, so concerning that there are genuine possibilities that some contributors to our total business will not survive.

I propose to take off the rose tinted glasses and try to portray the real life situation that the researchers, scientists, designers, builders and operators in the aeronautical world are facing.

The degree of survivability of the airlines and the manufacturers, under today's chaotic economic conditions, will be a major influence on whether or not much of this impressive technology will, in fact, ever come about.

Such statements can come as a shock to many here today who perhaps believe that our industry will simply go on forever. If anyone has doubts about the seriousness of the situation, they need only look at the collapse of Laker Airlines and Braniff, and the termination of the L-1011 program for which, incidently, several innovative new advancements were planned by Lockheed. Consider the enormous financial losses that almost all of the major carriers of the world are facing and the postponing or cancelling of new airplane orders that are taking place. The manufacturing and operating side of our business is in as bad or worse a condition as it has ever been in. Many areas of it are very close to collapse.

In the examining of these fundamental questions, which involve the survivability or otherwise of our business, I am acutely aware of the risk I take in deviating, somewhat, from the objectives that Dr. von Kármán laid out for ICAS some twenty-four years ago. There was, then, no doubt that ICAS was to be a forum for the exchange of scientific aeronautical information covering all countries of the world. I am, therefore, very conscious of the dangers of treading on sacred ground by introducing concern, caution and doubt into an otherwise dedicated world of scientific confidence, challenge and integrity. I sincerely believe that from a realistic and practical point of view, many of the incredible and much needed technical advancements in aviation may not happen.

The tremendous progress in aviation has always had the impetus of adventurous spirit and response to technological challenge. There was growth, expansion, profitability and stability.

There was really never a question of not solving a problem but only how long it would take.

Today, our industry is feeling the difficulties of having reached maturity - many of the forces that drove it there have dissipated.

In order to try to see where the many technological advances really fit in the world of tomorrow, I propose to address the following general areas:

1. A brief review of the factors that, since 1977, have been placing tremendous pressures on the major airlines of the world to make significant changes in their airplane fleets.

2. A review of what the airplane and engine manufacturers have done to respond to the needs of the airlines to upgrade their fleets.

3. A look at the advancements that will be available between now and the turn of the century to further the safety, efficiency and profitability of commercial airplanes.

4. Lastly, an attempt to look realistically at where all of these technological and scientific benefits are going and whether there are serious deterrents to their successful and useful implementation.

In retrospect, we began to see some of the handwriting on the wall with the Supersonic Transport developments of the 1960's. At that time the world was in a race for the moon and there was an atmosphere of scientific exhilaration surrounding our industry.

The Concorde, despite the technological problems that had to be overcome, was, and still is, an incredible advancement in civil aviation. For many and varied reasons the program stopped.

The U.S. SST program collapsed in 1971 mainly because of environmental extremism and the enormous economic implications involved. Although today's SST would be of substantially better design, indeed, the question of its ever really happening in this century is uncertain and controversial. Despite the incredible aerodynamic, structural and engine developments that many people took part in, complex forces at play caused the demise of the first efforts on this side of the Atlantic.

The Need to Re-equip

It was not until early 1977, that the major airlines began, seriously, examining the mammoth implications that would soon be associated with the needed replacement of their technically and economically obsolete fleets of old aircraft. Approximately one-half of the commercial jet aircraft operating today are made up of relatively new widebody transports and, the more recently built, narrow body and standard body transports that meet up-to-date technical and operational standards.

The remaining half of the western world's fleets consist of old, first generation airplanes that are becoming of increasing concern to the airlines for a number of reasons:

1. Many are old or are fast approaching old age. They are, or soon will be, suffering from varying degrees of fatigue and corrosion. They are reaching high flight cycles and flying hours. They are becoming progressively more difficult and more costly to maintain.

2. Most of them do not come near to meeting reasonable community noise standards at airports. By the mid-1980's, it is expected that, even tougher, noise legislation will be introduced in many countries and this will virtually bring an end to their practical use.

3. The interior design and seating layout of most of these old aircraft is not, by any stretch of the imagination, up to the standards of passenger appeal, comfort, service, efficiency and interior noise level of the new airplane designs of today. Similarly, the flight deck layout and instrumentation, the electronic and mechanical systems, the structural and aerodynamic designs do not contain anywhere near the substantial technological improvement and systems redundancy and reliability that is an integral part of today's newer designs.

4. The operating economics of most of the older equipment is poorer than what is achievable with current designs. This of course, tends to worsen as the cost of fuel continues to rise and as maintenance costs increase due to airplane ageing.

5. By far the most singly important driving force is the energy situation. Since the fuel crisis of 1973, the severe escalating of the cost of fuel has become an economic and operational factor of major concern in commercial air transport. The old, first generation aircraft are just not fuel efficient by the current standards of today's wide-body airplanes and compared to the new airplane/engine designs that will soon be available.

Thus, for several years there have been tremendous pressures to retire and replace outdated equipment.

We must bear in mind that during the decade of the 1970's, the growth of air transport, all over the world, was extremely high. The available seat miles doubled in that 10 years. The most remarkable thing though, is the fact that all of this growth was accomplished with the technology of the 1960's!

The Concorde and the 747 were developed in the 1960's as were the other wide-bodies. The L-1011, the DC-10 and the A-300 were all variations of that same technology - they even use the same engines. The DC-9 models of today are simply extended versions of their 1960's predecessors. The Boeing 727 is still, basically, a 1960's airplane with a bit of 1970's added here and there.

Prior to 1973, an airplane such as an L-1011 or a 747 would, over an assumed 20 year life span, consume in fuel an amount equal to its, then, first cost. How things are indeed changing! If we assume a probable fuel price, in the next few years, of $2.00/gallon, a DC-10 and 747 will, over their lifetime then consume some six times their first cost in fuel.

Some believe that jet fuel could conceivably go up to $4.00/gallon by 1990. At these rates, the lifetime cost of fuel for an airplane could quite well go to ten times the original cost of the airplane - a cost in fuel <u>per year</u> equal to one half the new price of the airplane! A new 747, by then, will probably cost $100M and that single airplane will burn $50M worth of fuel in one year!

In the past two or three years, a number of the major airlines have recognized that to make this enormous equipment transition will require the maximum amount of available time and they have been quietly moving up on the program. This is true not only for the costs of acquisition but is very necessary for any sound program of old aircraft disposal. Some airlines spend a lot of time thinking about new aircraft acquisition and sometimes forget or put off the properly planned disposal of older outdated fleets.

From a close-at-hand viewpoint, it is well to remember that there are a considerable number of 707's and DC-8's still flying and it is these airplanes that are presently under the gun from a noise point-of-view. It is these aircraft that will be most immediately affected by the FAR-36 noise regulations which will call for the older noisier aircraft to either meet the regulations sometime in the mid-1980's or be retired.

Added to this, nearly all of the older, first generation 727's, 737's, DC-9's, BAC 111's, Tridents and Caravelles are noisy, relatively fuel inefficient, are quite unappealing from a passenger viewpoint and are economically and technologically obsolete. The technology that exists today is considerably in advance of that early jet era - improved aerodynamics, better propulsion and even the use of some composite materials.

Most of these older aircraft will continue to be progressively retired between now and the mid 1980's. Many major carriers are, today, disposing of their smaller 100 passenger jets and will continue to do so as the "bottom of the fleet" tends naturally to the 130 to 140 passenger size.

The loss of capacity associated with this massive retirement of obsolete aircraft will throw up a correspondingly large re-equipment program. This has, in fact, been going on slowly for the past several years. Widebody airplanes are replacing many of the older medium and long range jets. Updated and more efficient narrow body and standard body short-to-medium range aircraft are replacing the old first generation ones.

The potential scale of this overall replacement activity is very large. It will require some $50 billion by 1985/86 and an additional $50 billion by 1990. With the financial situation that exists in the airlines today, one may well ask if such an enormous rebuilding program is even remotely possible. The counter question is "What are the alternatives?"

In today's environment the situation is fraught with difficulties. The airlines cannot go on using their ageing first generation aircraft with poor fuel efficiency, high operating cost, poor utilization, high noise levels, fatigue and corrosion and inability to provide a continuing safe, competitive, profitable operation. Especially difficult, however, is the alternative of acquiring new efficient competitive fleets. Inflation, high interest rates, high capital cost and inability to generate the needed capital funds are causing very serious difficulties. Safety, profitability, image and even survival are very real challenges - for many, the situation is critical.

Manufacturers' Response to the Need

For several years now, in anticipation of this costly re-equipment program, and in the face of considerable uncertainty, the major airframe and engine manufacturers have been working on, and displaying to the world, a whole array of new and derivative designs of narrow body, standard body and wide-body commercial aircraft and new efficient engines to power them.

This activity has produced, over the past few years, an infusion of impressive new technology, the degree of which has not been witnessed since the late 1960's when the 747's, L-1011's and DC-10's first came upon us as paper airplanes. Aviation technology, despite the outpourings of the somewhat unenlightened pundits, has not, by any means bottomed out.

What are the things that are special on the new and derivative airplanes that are being offered to the airlines for the 1980's? By far the most important challenge facing our industry in the next ten years is, I repeat, the overall implications of the fuel situation. Fuel, throughout the history of aviation, has probably been the most underdeveloped of all airline technologies, and now, it is the key to our future.

The long range wide-body airplanes such as the 747, DC-10 and L-1011 are actually quite a bit more fuel efficient than the older DC-8's, 707's and VC-10's that they are replacing and they will improve even more. This is basically due to the scale effect of their size, to the use of high by-pass engines and to a small amount of airfoil section improvement. The new big engines, alone, are some 25% to 30% better in specific fuel consumption than the older engines on the earlier aircraft.

The point really is that the older, smaller 727's, DC-9's and BAC 111's, Tridents, Caravelles and 737's are the ones that are now relatively inefficient on a fuel per passenger basis. The cause is again part out-of-date airplane design, part their relatively small size and part engine. The new breed of 757's, 767's, DC-9-80's, A-310's and others such as the proposed A-320 will be very substantially more fuel efficient than the older airplanes they will be replacing.

The improvements in overall efficiency are being achieved by the use of more fuel efficient high by-pass engines, the better aerodynamics of the super-critical airfoil with its associated reduced sweep and higher aspect ratio, and the use of some light weight composite materials plus improved aircraft systems and performance monitoring.

We expect, too, that further fuel efficiency improvements will be accomplished within the next five or six years on the existing widebodies. This will come about from a myriad of small things. Another 15% of overall efficiency will be gained by such things as active controls with extended wing span, further engine S.F.C. improvements, further airfoil modifications, active controls on the horizontal tail and a further small, but helpful, use of composites.

Further into the 1980's and early 1990's more improvements, again, could come along on the big airplanes. The stretching of the fuselage, some redesign of the wing to a fully supercritical high aspect airfoil, and further engine improvements would add, conservatively, yet another 25% or more to the overall fuel efficiency of these airplanes.

The smaller new airplanes, too, will gain further in efficiency through the 1980's. The use of a new third generation series of high bypass engines will come to fruition by the mid 1980's - the Pratt and Whitney PW 2037, the Rolls Royce RJ-500 and the GE-SNECMA CFM-56. All of these smaller high-bypass engines are in various stages of production by their respective companies. They will be yet another step forward in technology over the existing big engines that are flying today with SFC improvements of about 10%. The 737-300, with the CFM-56, in development today, perhaps best represents this interim step in the short term progress of the 130 to 140 passenger airplane. The fuel efficiency improvement alone on this airplane is about 20%.

I have cautiously mentioned composites. I do not believe that composites will provide a significant technical breakthrough for the aircraft of the early and mid 1980's - but they will provide some gains.

The big benefits from composites do not result from their application as substitute materials nor from their employment in secondary structure. The real benefits will be realized only when they are able to be used in primary structure. For example, in the case of a wing, the structure will be considerably lighter. Because of this, the airplane gross weight to perform a given mission is reduced and therefore the required engine size is reduced. But now that a smaller engine is needed, the wing can again become smaller.

There will be tremendous improvement when this total wing re-sizing phenomenon can be implemented. The scaling down of the aircraft resulting from the use of composites will probably not be available in commercial airplanes until the mid 1990's.

During the 1970's significant advances were made in airfoil design. It is now possible to get a much thicker airfoil to go just as fast as the thinner ones that were formerly used. This thicker wing reduces airplane weight and aeroelasticity and increases fuel capacity and overall structural efficiency of the wing. The newer airfoils will be used on the coming generation of aircraft to reduce weight, increase aspect ratio and to reduce sweepback. These improvements will be used to gain further fuel efficiency. Normally, to add wing span for increased aspect ratio increases the wing bending loads with an associated added structural weight and higher cost.

Active aileron controls can provide the ability to increase in span without the need for major wing redesign. This increased span will provide a significant fuel efficiency improvement. This system is on the L-1011-500's and alone, provides a 3% fuel saving. The outboard ailerons are automatically deflected symmetrically, responding to a manoeuvre load. The centre of airload is forced to move inboard because the outboard wing is unloaded. To compensate for the loss of outboard lift the airplane is rotated to a slightly higher angle of attack which increases the loading of the inboard wing. Wing bending moments are thus reduced. Wing span can now be added to restore the original wing bending moments - a drag reduction occurs and the result is a saving of fuel.

The new breed of short to medium range airplanes, 767's, A-310's and 757's, will provide an immediate 30% to 35% saving in fuel by the mid 1980's. I confidently expect that these airplanes will also go through further changes which, by the early 1990's, will add another 15% to 20% of fuel saving. We won't see the big dramatic changes of the 1950/60's such as the emergence of the jet engine or the swept wing - what we will see, will be a series of relatively small changes - the total of which will be quite significant.

Having said this, however, the real challenge of the fuel crisis in aviation cannot be met with a 30% increase in fuel efficiency of the forthcoming generation of jets! An alternative to conventional fuel at reasonable cost simply must be found. Our industry must, for its survival between now and the end of the century, take much of the lead in the effort to break the "fuel barrier".

The present fuel "glut" and the corresponding slight reduction in cost, while a welcome breather from the spiraling price increases, should not be considered as long term.

While the world thinks of nuclear energy, solar energy, biomass, tidal power, wind energy, etc., these are things that are not readily usable in air transport as we know it.

A tremendous effort will be needed to solve the problem, the solution of which will cost many billions of dollars and it will take considerable time to get to a point of adequate day-in day-out supplies for the airlines. It is unquestionably the biggest single technological challenge facing us.

It is quite evident that, with the help of a significant amount of research, the airplane and engine manufacturers have made a very positive and impressive response to the serious technical and operational problems of the airlines. They have designed and produced airplanes to replace many of the 3000 or so old airplanes that must be retired and they have improved fuel efficiency by some 30% to 40%.

The results of these efforts have produced the L-1011-500 and DC-9-80, both of which are in airline service. The 737-300 is committed to production and the 757, 767 and A-310 are in the certification process and will soon be in operation.

What Lies Ahead

When we look ahead to the later 1980's and early 1990's we see a great many areas of technological advance that are being examined in detail today and which will, hopefully, bear fruit tomorrow.

In the complex world of advanced aerodynamics, there is much going on in still further advanced wing design, including high lift development, design for higher lift to drag ratios and the application of various different wing tip devices.

The active controls, that I mentioned earlier, show considerable promise, not only to improve fuel efficiency but they will be available for various forms of load alleviation, stability augmentation, reduced fatigue, flutter suppression, flight envelope extension and even for the provision of a smoother ride for passengers.

One of the areas that has made very impressive progress over the past few years has been that of digital electronics. It is, of course, becoming basic to all high technologies, but its application to air transportation has been spectacular. Much more capacity is available today in electronic systems at considerably less cost and with far greater reliability than ever before. All of this is helping in the development of the, so called, advanced flight deck - the use of sophisticated electronic displays, digital avionics and the accurate management of thrust and performance.

Some of these advancements are on the 767, 757 and A-310 aircraft - coloured CRT sets instead of conventional instruments - literally colour TV flight instrumentation, including coloured weather radar. There will ultimately be a complete integration of future airline requirements to exploit, fully, the inherent flexibility of the CRT presentation - including map display documentation, communications and navigational data, MLS and traffic situation displays and integrated avionics management. This will provide for reduced pilot workload, increased safety, reliability and dispatch capability as well as reduced weight and cost.

In propulsion, we will see further incremental improvements toward better propulsive efficiency. This will include the continued use of light weight materials, improved manufacturing methods, still higher component efficiencies as well as higher temperatures and pressure ratios. Also, there will be further efforts to reduce engine performance deterioration, and reduction in leakage around ducts, seals, compressor tips and turbine tips - also improvements in fan and compressor erosion.

Much is going on in structures and materials. We will see continued efforts in the use of composites and improved metals. Slowly this effort will be applied to primary structure and that is where the real benefits lie. Costs will be reduced and manufacturing technologies will improve.

In the areas of systems and equipment, we will see continuing trends toward improved performance, lower weight, greater reliability and a lower cost of ownership and operation.

Because of the complex interrelation of the benefits mentioned, stemming from all aspects of advanced technology, it is very difficult to put precise figures against each technology in isolation.

Some approximate feel for the situation may be gained if we start from a datum of an early 1970's level of widebody technology, including the use of high bypass engines. Through to 1990, improvements in structures and the use of active controls will show improvements of a 12% to 15% reduction in fuel consumption. Further advances in systems, aerodynamics and engines will show progressive benefits of up to 20% in fuel efficiency. The use of composites in some primary structure will add yet another improvement. In 1990, as I mentioned earlier, I can see a further overall 30% to 40% improvement in fuel saving - well worth going after - worth billions of dollars - particularly if the costs of fuel continue their upward trends.

It is, of course, becoming increasingly difficult to finance new advancements. The possibilities that are seen to be available in the 1990's and beyond are in many cases "mega-projects" and many of them may stumble badly on financial grounds when it comes to practically developing, producing and operating them.

In the past, improvements in productivity and operating economics came about from progressive developments in airplane size and speed. In many cases, spin-off from military research produced the very impressive and necessary boost to commercial programs. Such welcome assistance is very much reduced today.

The costs of new development programs is unbelievably high today - and will be even more difficult in the future. Compounding the problem is the fact that the length of time required from the conceptual stage to the final design, manufacture, certification and entry into service can be very long indeed.

This problem is not new, and in order to reduce or minimize these effects, the manufacturers have tried their best to extend the capability of their existing products. Stretching the fuselage, increasing the engine thrust and gross weight and updating the systems technology has been going on for many years, quite successfully and is being done today. In nearly all cases this has benefitted all concerned.

The 737-300 aircraft with the CFM-56 engine is a good example of this principle. It is committed to production by Boeing and will be a significant step forward in fuel efficiency, due mostly to the application of the new advanced propulsion system. The DC-9-80 is, similarly, a major extension of the basic DC-9. The 747 has been ordered with the extended upper deck. It is possible, also, to lengthen the fuselage, add a new high aspect ratio wing with improved airfoil characteristics and very substantially improve the fuel efficiency and operating economics of the airplane. Improvements due to still more fuel conserving engines have been improving today's basic 747 - by quite a bit.

Other near-term considerations that have some degree of probable success are the re-engining with two engines of the 727-200 and, a bit further out, the stretching of the 767. There are many advanced 727-200's that are young enough to take full advantage of this re-engining possibility. Airbus Industrie have examined a number of plans for derivatives of the A-300 and the A-310 which may well come along when the world is ready. All of these near-term things <u>can</u> happen. Whether they <u>will</u> happen with conditions as they are in the airline business today will remain to be seen.

Fuel efficiency will continue to be the singly most important design parameter beyond 1990. The advent of the use in primary structure of composite materials and the consequent ability to resize the engine and wing will be a major step forward. The extended use of active control technology for load alleviation and flutter suppression as well as the so called, control configured vehicle, will assist in the design for aerodynamic and economic efficiency. A major gain of perhaps 20% in overall efficiency could be achieved with the development of laminar flow control to reduce wing drag. Also aft CG control and relaxed static stability show promise of incremental improvement.

In the area of propulsion, there will be, as previously mentioned, continued improvements in existing designs. In the 1990's the continuing pressure to improve fuel efficiency may well create a need for an airplane designed around a prop-fan which, alone could better existing propulsion effectiveness by perhaps another 20%.

In all of this it is important to realize that the airlines of the Western world are consuming fuel at a rate of over 20 billion gallons per year. At an average cost of over $1.20/gal. this costs well over 20 billion dollars per year. A change in efficiency or the price of fuel of 1%, alone, changes this annual fuel bill by more than 200 million dollars.

There is no doubt that, by the turn of the century, technology improvements, alone, could well provide gains in fuel efficiency, for long range operation alone, of at least 50% over today's widebody airplanes. Similar improvements, to a somewhat lesser extent, can be expected on short to medium range operations.

Work has continued by research organizations and by the aircraft and engine manufacturers on the design of an advanced Supersonic Transport. Since the designs of the Concorde and U.S. SST, which had supersonic L/D's of 7 to 8, much as been done to improve this somewhat high level of supersonic drag. The latest wing technology shows promise and other areas such as off-design performance and structural materials have made progress. It must be remembered that on a typical flight from New York to London a wide bodied airplane such as a 747, DC-10 or L-1011 burns about one third of the fuel per seat as does the Concorde.

There is considerable controversy on whether or not the advanced SST will ever, from a practical point of view, emerge as an airline airplane. There is general agreement that, even if substantial progress can be made to reduce shock drag, the sonic boom, the noise and improve the relatively low fuel efficiency, it is still unlikely that such a program could put an SST in airline operation before the year 2000. There are just too many other important things to be developed and too little development money available.

Our industry must be very careful that it doesn't allow itself to be carried away by the euphoria of some of the way-out technology that appears to be ahead. There is no question that things such as advanced prop-fans, laminar flow control, variable cycle engines and supersonic transports are important, but they will only have meaning and effect when they are in operation and are performing efficiently and economically. But they are far away and they will be extremely expensive to develop. In this regard there are two important considerations that emerge.

Firstly, I suggest that, for the well-being and stability of the scientific and research community, there is an important need, on an international basis, to create a well-though-out priority list of items for development that will be truly beneficial and that have a good change of success. There are undoubtedly many areas of research activity which can be shown to have substantial technological advantage, but for which there is no real chance of their becoming a reality in the commercial airplane world. I believe we are at a technical and financial crossroads. Major surgery is going to be required to list carefully and carry out, only, the worthwhile things that can be made to happen. Not only are the funds for research very sparse but the financial conditions of the manufacturers and operators and the risk involved will only allow new developments at a slow to moderate rate.

Secondly, I suggest that great care be taken to ensure that the low profile bread-and-butter elements of today's real-life airline operations be continuously examined, developed and improved. It is vital that items such as the overall safety, operational integrity, maintainability and reliability of airplanes and the ability to take harsh equipment usage as well as air traffic control improvements be given a high priority in all research and development activity. Today's financial, technical and operational problems are real and they are hurting. Tomorrow's highly advanced technological improvements will only come about if our industry can systematically solve today's difficulties.

A random look at the past ten or twelve years clearly indicates the fragility of the commercial side of aviation.

- The Concorde program terminated after tremendous expense to the public purse.
- The U.S. SST program stopped after considerable expense.
- Rolls Royce went bankrupt in 1971.
- Subsequently, Lockheed nearly went under and was resuscitated with a $250M loan from the U.S. government.
- The Douglas DC-10-twin, ASMR, DC-X-200, ATMR, DC-10 stretch and recently the MDF-100 programs were initiated, developed and subsequently cancelled.
- The YC-14 and YC-15 STOL programs have, so far, yielded no commercial STOL progress.
- All of the engine and airframe manufacturers have had a number of recurrent cash flow and production problems, involving large cutbacks of personnel and serious financial losses. Some have been able to lean on parent companies - others have not.

- Last December, Lockheed took the decision to terminate production of the L-1011 because of the state of collapse of the commercial transport market. It is probable that the losses that would have been incurred in riding out the storm would never have been recovered.
- Laker Airlines and Braniff have gone into oblivion.
- Pan American, United, American, Continental, British Airways and others are on the brink of disaster after several years of enormous losses; 1982 will be the worst ever. The big question is "Who will survive and who will join Laker and Braniff?"
- There have been large cut-backs on orders for new technology airplanes. In addition, there is an overall vacuum in the market for new airplanes.
- The list goes on ----------

Our industry is facing the immediate and long term future from a severely handicapped position. We have a long way to go just to get up to the abscissae.

The well of financial resources for research is not, by any means, infinitely deep. A further set-back because of political and technological ineptitude could be devastating and we should all be cognisant of the consequences of bad judgement.

I can still sense the atmosphere of non-belief by many of the seriousness of the overall situation.

Real or Imaginary?

A question of enormous implication for the next two decades is "how much of the apparent progress in the technology of commercial airplanes will actually find its way into useful application in airline operation? How much is real and how much is imaginary?"

A very major factor in answering this rather worrisome question is going to be the recoverability and readjustment capability of the world's airlines. The problems that surround most of the airlines today are deep-rooted and complex. They all boil down to serious financial ill-health. This has been going on progressively for the last few years and has now reached epidemic proportions. The continued operation of some major airlines has been dependent upon massive loans by the banks or, by taxpayers' money, in the case of government owned airlines.

When we examine the difficulties, it is apparent that the road back to financial stability will not be easy - some won't make it.

At the risk of imposing a list of mundane airline problems on such an august scientific assemblage, I would point out that the manufacturers' health is very dependent on the stability of their customers - the airlines.

Let's look at a list of some of the airlines' problems:

<u>Continuing Fuel Cost Increases</u>

- $2.00/gal.in 1985, $4.00/gal. in 1990? - Despite temporary flattening.

<u>Serious Inflation</u>

- No end in sight today for most countries.

<u>Economic Recession</u>

- No indication of short term recovery.

<u>High Interest Rates</u>

- Severely affecting ability to undertake much needed aircraft replacement.

<u>High Capital Costs</u>

- Also seriously affecting badly needed aircraft upgrading programs. Some airlines are desperate.

<u>Diminishing Yields</u>

- For many and complex reasons.

<u>Limited Capital Resources</u>

- Low profits or high losses.

<u>Cash Flow Uncertainty</u>

- Many airlines on edge of bankruptcy.

<u>Poor Fleet Utilization</u>

- Aircraft age, condition, fleet size, route structure - small airlines particularly.

<u>High Maintenance Cost of Old Aircraft Fleets</u>

- Aircraft age, condition, complexity, labour cost.

<u>Small Inefficient Fleets of Smaller Airlines</u>

- Lack of flexibility and dispatch reliability
- Small fleets create expensive ASM's.

Technical Obsolescence of Many Old, Tired Aircraft

- Aircraft age, condition, 1960's technology and design, high cost, old structure, systems, materials, electronics, etc.

Structural Inefficiency of Old Generation Aircraft

- Design, materials, strength/weight ratio, fracture toughness, life limitations, high cost, cycle sensitivity.

Operational Obsolescence of Older Jets

- Old flight decks, outdated aids, old ATC methods, safety, reliability, old navigation and communication methods.

Use of Ageing Aircraft

- 1960's technology, low cycle life, image, noise, safety, reliability, high cost, etc. - serious problem.

Noise Legislation

- Becoming progressively more difficult to meet. If proposed legislation upheld, by 1985 many aircraft will be grounded.

Aircraft Corrosion

- Major problem on old aircraft - high cost - sophisticated inspections required - for many small airlines no facilities or experience exist to properly handle - airworthiness affected - serious problem.

Aircraft Fatigue

- Old aircraft - high flight cycles - high/time - high cost-safety implications - airworthiness - difficult to cope with - serious.

Aerodynamic Inefficiency of First Generation Aircraft

- Old 1960's wing technology - affects fuel consumption - poor L/D - inefficient structural weight, etc.

Propulsive Inefficiency of Old Jets

- Old technology engines - low bypass or non-fan - low pressure ratios - leaky ducts - poor tolerances - high SFC - high maintenance cost.

Inadequate Maintenance Capability

- A problem for some airlines who have poor facilities, poor training, poor inspection capability, poor product support, etc.

Excessive Labor Demands

- Want same or better living standards, exhorbitant contract settlements - low productivity - is moderating in some areas.

Declining Profitability

- Diminished yields - low productivity - increasing costs - reduced cost effectiveness.

Heavy Debt Load & Servicing Costs

- Assets vs. debts
- High losses, new airplane purchases, high first costs
- High interest rates.

Excessive Rate Competition

- Overall effects of deregulation - inability to properly compete - rate wars - image - fare abominations.

Severe Market Uncertainty

- Due to many and complex factors.

Sparse Route Networks

- Affects airlines with thin routes - wrong use of equipment - low load factors, etc.

Narrow Market Penetration

- Poor equipment - poor image - many airlines can't compete.

Deregulation

- An overall contributor to todays marketing, economic and financial problems of all airlines.

Lack of Competitive Image

- Old aircraft - old standards - old methods - old service - old technology - old systems.

Airport/Airspace Capacity Problems

- Old airport design, larger aircraft, inadequate ATC equipment, crowded skies, poor equipment maintenance - budget cuts, old airport equipment, etc.

Reduced Discretionary Income

- Less money available for pleasure and trade - high cost of basic air transportation - other ways of now spending vacation savings.

Manufacturers' Uncertainty

- Market uncertainty - high financial risk - overextension-bankruptcy or financial uncertainty - high cost of new programs - low commercial backlog.

Inadequate Governmental Budgets for Needed Improvements

- Navigation aids, ATC, safety, high user costs, inefficiency - overstaffing, etc.

Limited Staff

- Small airlines do not have trained professionals to undertake special financial, technical, operational and marketing analyses - inadequate long range fleet planning.

Increasing Dependence on Government Subsidies

- Hand outs - inefficiency - loans - use of taxpayers' money, etc.

Airline Shrinkage Instead of Growth

- A bad sign if over an extended period.

Fear of Competitive Modes

- Auto - bus - electronic conferencing, etc. vs. air.

Increasing Break-Even Load Factors

- Diminished yields - higher costs.

Directional Cargo Imbalances

- One way cargo traffic - low profitability.

Mismatch of Old Aircraft to Improper Routes

- e.g. use of old DC-8/707 aircraft on short routes only - inefficient - high cost, etc. - serious problem - not cost effective nor competitive.

Uncertain Traffic Growth

- Reduced growth rates - in many cases negative growth.

Small Fleet Sizes and Too Many Aircraft Types

- High costs, serious operational inefficiency, difficult training, operational spares coverage, etc.

Effects of U.S. Controllers Strike

- Still having its side effects.

The effects of this mélange of difficulties is causing havoc among the airlines. At best, recovery will be slow even if the world comes out of its recessionary phase within a relatively short time. The acquiring of heavy debt, the need for new airplanes and the continued high financial losses will leave long-term wounds to the industry which will be some time in healing. Some airlines will not survive.

There are many optimists in aviation who feel that the present difficulties are a mere passing phase. Optimism and an adventurous spirit have always been an ingredient of aviation progress, but it has always had more than its share of financial risk. Today it is mature, and the expansive growth that propelled it through other troubled times is no longer there.

If the next two decades of commercial aviation are as turbulent and as fraught with risk as the last, there will be a very real need for cool heads and a stabilizing influence. This does not mean that research and progress must stop. It does indicate, though, a requirement for a most thorough analysis of what is important versus what is merely desirable or preferred. There needs to be an international cooperative program to spend almost as much effort in determining what should be done as is spent on the research to determine how best to do it. It almost seems as if the easy part is designing the airplane - the hardest is finding out how to make it happen.

If we do not take stock and find a way to get out priorities right, much of the research and development that our industry has thrived on either won't be financed or, if it is financed and moves forward, it may never find its way into an airline operating system. Being optimistic is a great driver but the future of scientific advancement in commercial aviation lies in being realistic - very realistic indeed - and I commend you to it.