KEYNOTE LECTURE TO THE FOURTH Al-Li CONFERENCE

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KEYNOTE LECTURE TO THE FOURTH Al-Li CONFERENCE

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First of all, I would like to express my gratitude to the organizing committee of this 4th Aluminium-Lithium Conference, that has given me the opportunity of addressing this distinguished audience.

Having been with Airbus Industrie for the past 12 years, I will obviously speak from a civil airplane manufacturer's point of view. I hope to be able to talk, to a certain extent at least, for our industry as a whole; an industry that has a reputation for its constant drive to produce better products in terms of technical capability, commercial viability and safety. Those who have failed in these areas are not present here today, which does not necessarily mean, that those who are not present have all failed.

Although most of you, ladies and gentlemen, are devoted to metallurgy and the development of advanced alloys, let me first refer to the basic environment in which we, as aircraft manufacturers, have to operate.

What our airline customers rightly expect from us is a product that is:
- technically sound
- cost effective or commercially viable
- well timed to meet market demand.

These are in a way constraining factors which put limits to our freedom of action; but they are inherently linked to success, which in this highly competitive field with its narrow margins have led to the "Sporty Game" which we have witnessed for a number of years.

The basic factors which govern our activities are of course fully applicable to the ingredients contributing to the construction of our airplanes, and in this context materials have a major importance. This obviously includes aerospace aluminium, for which also the market is narrow and subject to increasing competition from other materials.

Let me first analyse the situation from a technical, cost efficiency and timing point of view. I will naturally talk also about our expectations, leading to some conclusions and recommendations.

When we review Aluminium-Lithium as an advanced technology light-alloy, the first question to be asked is technical.
Which alloys can we use and in what form - that is sheet, plate, extrusions or forgings - and to what extent, with sufficient confidence to meet the technical requirements that our products have to satisfy? In addition, what will be available when, to be used reliably in an aircraft definition process?

Allow me at this point to move down the trails of history for a moment, and recall some of the major events in the eight decades of our common adventure.

It was metallurgy that made modern aviation possible, and it was a long and tedious process.

When the first Aluminium-Copper alloy was produced in 1909, it was too expensive to be used on a wide scale. The first applications in the construction of flying machines before and during the First World War were isolated efforts. It was only at the beginning of the "roaring twenties" that the advantages of the all-metal airplane were fully realized and that the search for the best possible application of the new light alloy, together with the evolution of the monoplane, became the issue. It was during these years that designers and their colleagues in the workshops began to learn how to use the still new material in a pioneering effort - those who didn't were soon to be out of business.

It was only in the thirties, however, that the all-metal cantilever monoplane with monocoque construction, as we still have it today, became the general rule. It came, in spite of the economic crises of the late twenties and early thirties, together with aluminium alloys with improved properties. Subsequent progress in the variety of alloys, the forms in which they could be used, treatments and processes, allowed the ever increasing demands from specific and more stringent requirements to be met.

Cladding, the development of zinc bearing alloys and higher purity materials were major events that have gone into history.

The aluminium industry over the years has proved to be a dynamic industry with outstanding capabilities to react to market requirements; it has won customers and made friends. We would like to have it as our partner in the future, in which it can have a firm place for a long time to come, even though competition from other materials may cause you concern.

I would not deny however that significant efforts will be required in innovative technical and industrial approaches in a world in which progress has become an increasingly self generating process. Right or wrong, these are facts with which we all have to live and with which we have to cope.

Under this set of circumstances permit me to look at your latest material from our point of view.

Announcements in the late 70's of the development of new Lithium bearing alloys with promising properties were received with great enthusiasm by the aircraft manufacturers. The initial goals of Aluminium-Lithium we perceived as a 10 - 12% density reduction while maintaining the other main characteristics of either the damage tolerant 2024 alloy or the high strength 7075 alloy.

Significant improvements in aircraft efficiency seemed possible while maintaining classical design and manufacturing techniques as well as established airline maintenance practices.
Of particular significance also, appeared the possibility of introducing the material by substitution into currently existing products with the possibility of performance improvement or/and widening the development potential for derivative aircraft types.

Fig. 1 shows the weight gains anticipated by our favourite competitor and ourselves in 1983 for the product lines, as then assumed; production deliveries being considered from 1988/89 onward.

### Al-Li weight reduction potential

*(preliminary estimates 1983)*

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>B737-300</td>
<td>1500 lb</td>
</tr>
<tr>
<td>B7-7</td>
<td>1900 lb</td>
</tr>
<tr>
<td>A320</td>
<td>2500 lb</td>
</tr>
<tr>
<td>B757</td>
<td>3100 lb</td>
</tr>
<tr>
<td>B767</td>
<td>4700 lb</td>
</tr>
<tr>
<td>A310</td>
<td>5700 lb</td>
</tr>
<tr>
<td>A300-600</td>
<td>6500 lb</td>
</tr>
<tr>
<td>A340(TA11)</td>
<td>8500 lb</td>
</tr>
<tr>
<td>B747SP</td>
<td>9300 lb</td>
</tr>
<tr>
<td>B747-200</td>
<td>11500 lb</td>
</tr>
</tbody>
</table>

(Fig. 1)

As a consequence of what appeared to be an encouraging situation Airbus Industrie proposed to its partners a combined approach to:

- define a joint material specification
- speed-up the evaluation process for an early introduction into the design of new or derivative airplane types
- encourage suppliers to minimize the number of alloy variants by standardization.

The organization for a common evaluation of Al-Li was established within the framework of the existing Airbus Industrie Materials Committee. A work-sharing was agreed with our partners, covering the whole range of Al-Li products from all potential suppliers, with the aim of obtaining first results at the end of 1984 and complete component testing in the following year.

Throughout 1984 and 1985 difficulties were however reported with procurement of test materials and the quality of those supplied remained unsatisfactory. In early 1986 we had reached results which appeared from a technical viewpoint to justify application to structural components of secondary importance only.

At about the same time new price indications began to reach us: instead of being twice that of current alloys as initially announced, factors of three and more were now quoted by the suppliers. This increased the doubts about the cost efficiency of the whole exercise.

Given the uncertainties which surrounded the new material, as to reliability of prediction, validation and cost, we had to revise our project studies and plans for its introduction.

In the meantime progress to produce consistent quality material with acceptable properties has been made and we would assume today, that at least thin products of the desired technical quality can be obtained.
Bear in mind, however, that the qualification or validation of damage tolerant material for use in large areas of our primary structures will still take some significant time.

Let me next deal with cost-efficiency, which now will become decisive.

There can be no doubt, that the price of a material is an essential factor in this respect. If a worthwhile return in terms of performance and/or economics cannot be shown by the aircraft to which it is applied, you can forget it. This is fundamental.

Cost-efficiency, however, also depends on aircraft size and on aircraft range (with a greater improvement to be expected for longer range aircraft), as well as the program stage at which the introduction of the new material is decided. Will it be within the framework of an all new aircraft program, for which it can be considered in the pre-launch phase, or during the development process of an existing aircraft type, of which significant numbers are around? (Fig. 2). In any case, the way the material is used is of importance, and this is conditioned by time relationships between the aircraft program and material availability.

Product scenario (civil)

(130 seats +)

A/C types capable of further development
Likely : A310, A320, A330/A340, 767, 747, MD-11
Possible : A300-600, 757, 737, MD-80

New types foreseeable
Likely : 7J7
Possible : MD-94

(Fig. 2)

I cannot deal with every possibility in detail here. Let me concentrate on the development of existing aircraft, the case which will be the most frequent until the end of the century. This should be of fundamental interest to this audience, since it fully exploits the substitution capability of Al-Li, a characteristic which is not shared by competing materials.

This substitution market with its high production volume, I believe, will be essential to permit recovery of investment within a reasonable time.

For illustration purposes I have chosen, as a datum, a typical 220 seat wide-body medium-range twin. This seems to me a good average. Relative seat-mile costs are used as the economic criterion. Four possible cases are considered (Fig. 3). In none of the cases have weight savings due to improved stiffness of Al-Li been accounted for, since this effect has shown to be small. Also, the improved crack propagation properties of the material would scarcely be visible in this type of diagram, though they would be helpful in airline service.
Case 1: The datum aircraft is modified by using Al-Li in secondary structure and limited areas (e.g. fuselage stringers) of the basic structure only.

Case 2: The aircraft geometry remains unchanged, but application is extended fully to the primary structure. This would require large scale structural testing.

Case 3: Maximum introduction of Aluminium-Lithium, as for case 2; the weight saving being put to profit by stretching the aircraft.

In all three cases approximately constant performance is assumed with minor adjustment of engine thrust.

Case 4: shows a classical approach to the same aircraft stretch by accepting increased take-off weight and engine thrust to achieve the same aircraft performance as in case 3 in particular.

Two extreme material cost situations are shown for cases 1 through 3:

(a) Al-Li costs the same as conventional alloys
(b) Al-Li costs an average of 3.5 times that of today's standard alloys.

From this a number of conclusions can be drawn:

Case 1 leads to an insignificant difference in terms of aircraft seat mile costs; barely visible in the diagram.

In Case 2 a wide scale application of Al-Li does reduce the index by two thirds of a percent if material costs are the same as for current material. However, when one takes the material cost at prices announced today, the index moves above the datum; which means, that substitution would be unattractive.

In Case 3 the index is significantly improved for the two cost situations.
However, this must be seen in conjunction with case 4, which is the "classic" stretch case to which we are used today. Compared to this the Al-Li airplane looks generally better, but the advantage achieved at the upper price level is clearly marginal.

Somewhat better results might be achieved with derivatives of long to very long range airplanes and also completely new types (snow-ball effect). Very few wholly new types, however, will appear before the end of the century (Fig. 3).

To catch the important substitution market is therefore a fundamental requirement for the aluminium industry in order to build up production of the new material. Strong emphasis on the damage tolerant alloy is essential in this context.

It must however also make every conceivable effort to get out of an extremely marginal situation through improving cost efficiency by all means. This is a very serious issue, which will not go away, even though the assumptions in the kind of analysis I presented here might be debatable to an extent or change with time.

My dealing with the timing aspect, as the third parameter in the equation, will be brief. There is no point anymore in expressing regret for lost chances - as for instance with our A320 or for early large scale introduction in our A340 aircraft. My message here can only be: take every necessary action, so that the new light-alloy in all its possible forms can be evaluated and qualified, to be available in time for developed versions of these aircraft. Freezing the material characteristics is urgent, so that we can confidently begin to consider using it on a larger scale. The market will not wait for technology to happen. Technology must be there in time for the market. Hesitation because of concern over competition from other materials might be understandable, but these materials also have their problems. For my part, I cannot see non-metallic wings and fuselages of big airplanes of the types being built or planned by the three large commercial aircraft manufacturers in a foreseeable timescale.

This being said, let me return to the key issue of cost efficiency. You may or may not agree with some of the things which I shall say. Please remember, however, that my sole purpose is an attempt to be helpful in finding a viable solution.

As regards material development, further reductions in density would translate directly into weight savings for the aircraft. In contrast, since increased stiffness can be used effectively only in limited areas of the structure, any improvements in that would not achieve very much.

Interesting opportunities could be opened up by the development of alloy variants suitable for superplastic forming and with good mechanical properties. This would allow us to make complex parts from a single piece of metal with consequent savings in weight and manufacturing costs.

Aside from the issue of material properties our deliberations must also include consideration of the different product forms required and manufacturing processes.

Limiting substitution to sheet and thin extrusions would ensure a minimum in waste of material, but impact on cost efficiency for many aircraft types would equally be limited. It would moreover drastically reduce the amount of Al-Li required and due to reduced
production volume would push even further downstream the point at which the suppliers break even. Thick products, such as plate, must therefore eventually become a vital element in your efforts.

Going back to sheet and thin extrusions, improvements, both technical and industrial, could result from a reduction of manufacturing tolerances.

It appears to me that the standards for materials in terms of geometrical tolerances have not changed for many years. The various skin thicknesses are still subject to relatively large tolerances, i.e. ± 10%. The airplane designer is forced to do the stressing of his components by using the lower limit whilst experience shows, that the material is generally delivered at the upper limit.

The question is whether advanced electronics - which we use very successfully to improve the efficiency of our latest aircraft by allowing it to operate much closer to the limits of its capability - would not permit in your case to further reduce tolerances to say ± 1 or 2% by better control of the process. In addition, an increase in the number of intermediate thicknesses by steps of perhaps 1/10 of a mm for skins ranging between 1.6 and 3.0 mm could become an interesting possibility. This would not only allow further weight optimization but also presumably a reduction in costs.

I have shown the significance of Al-Li price factors and to me there can be no doubt that a massive reduction in Al-Li costs is a major target towards which the resources and energy of the aluminium industry must be directed.

Let me finish with a last remark in this context.

To reach a market wide enough for economic viability, and to reduce the risks, while having a good chance to cope with the three basic factors I mentioned in the beginning of my address, we have seen in the aviation industry a pooling of technological and financial resources. This has resulted in collaborative efforts in a variety of forms, and these have allowed quite a few of the aircraft manufacturers to stay in business. We in Airbus Industrie have gone a long way in this direction.

Your industry, it would appear to me, even though there are only a few actors on the stage, has now reached the point where the merits of cooperation should be very seriously considered.

I know from experience that this will require a great deal of soul searching. Difficult questions and even more difficult decisions would have to be faced. Nevertheless, I do suggest that these issues must be addressed. For example, how many foundries are required in Europe to meet anticipated demand, what kind of work sharing arrangement could make sense, etc. etc.?

If the obstacles and difficulties are great, so too can be the rewards. The game is worth the candle.

Specialization and collaboration throughout the ages after all have created our modern society and this has not been a dream.

Good luck and thank you.