AN IMPOSSIBLE DREAM

all-composite anatomy

With all-composite aircraft composites do not to deliver as anticipated and that is a sobering experience. Somehow, the most important of flying experiences - safety - has not been properly addressed. Composites are just not suitable for the construction of outer skin of civil aircraft that leaves it too vulnerable to impact and lighting strike and poses a serious threat to passengers and crew in case of crash landing certainly when the aircraft catches fire. Also inspection and repair pose still insurmountable problems. Despite all efforts including long delays and huge cost overruns, weight reductions have not been achieved - that was what all-composite was all about - to the contrary these planes might turn out to be even heavier than their aluminium counterparts and still pose a safety risk. It has to be recognized that these aircraft will never achieve the safety record attained with aluminum aircraft - but that was already known before the project started. It seems, that all what is to be obtained with all-composite aircraft is some improved travel experience through higher cabin pressure and higher level of humidity - one has to await cabin noise and vibration - and of course that bigger window that was also promised with the Comet.

By 2000 Airbus found itself in a rather comfortable position. They had the better engineering and were on sales about to take over the lead from Boeing. Any visionary would have opt to continue on this course and focus in particular on the development of more fuel-efficient lightweight aircraft, that is, continue the step-by-step approach that been successfully practised until then -*'lentement mais sûrement'* - with gradual increase of new materials for primary structures. This approach made the A380 possible - the world's first composed aircraft. Not so at Airbus, where the seats in the boardroom were now occupied by sales driven

managers - likewise at Boeing - pushing aside the engineering driven management that had brought them early success to please shareholders. It was now about winning the championship decided each year by deliveries and net orders - Airbus beat Boeing with *triple seven* net orders in 2008.

Already in the 1990's Boeing and Airbus started joint feasibility studies for the development of a *Very Large Commercial Aircraft* but then departed to work on their own designs. Boeing was still successful with its 747 and new management at Airbus apparently could not resist the temptation to fight Boeing's last Jumbo stronghold with a Super Jumbo - some kind of Titanic in the sky - and December 19th 2000, the supervisory board of the newly restructured Airbus voted to launch the A380 - a € 8.8 billion program with 55 launch orders from six customers.

Now real fear struck at Boeing. The successes of the earlier visionary management with the 707 and the 747 were engineering driven achievements - with the first 747 delivered about exactly according the original schedule. With the success of the 747, sales reps took over control and management changed to sales driven – and the trouble began. Technical superior, the 747 pushed other Jumbo's - DC10 and Tristar - out of the existence, leaving Boeing monopoly. Confronted with Airbus' successful innovative approach management at Boeing choose not to fight but to compensate for lost market share by taking over of MacDonnell Douglas in 1997 to become The Boeing Company. When they kept loosing out on technological grounds they again dodged the technical confrontation with Airbus and opted for other practises by trying to bribe the U.S. Air Force for orders.

Now confronted with interest in the market switching form 747 to A380 management at Boeing had to come up with an answer - the sales reps now weighed technical options. Initial reaction was to fight the A380 with an enlarged 747X but the market did not show interest and Boeing choose to develop a derivative for the 400 to 500-seat market, instead of matching A380's capacity. The new design did take some time and November 2005 Boeing announced the 747-8 Intercontinental, planned to entry service in 2009. Initially not a success it gained more orders than the A380 by 2009.

In the meantime management at Boeing convinced themselves that something more drastic was needed to keep at pace with Airbus. Not constrained by technical boundaries management seriously considered a sonic cruiser that would fly at Mach 0.98 - not for long - the surging fuel prices forced them to focus rather on fuel efficiency than on higher speed. One of Boeing larges shareholders who was the driving force behind this project was not so pleased *'there's plenty of fossil fuel out there'* [410]. Then management envisaged another approach. Composites had been considered with the sonic cruiser so why not go all-composite - indeed why not - and December 2003 Boeing announced to go all-composite. The 787 Dreamliner was officially launched April 26th 2004 for which occasion Toray brokered the largest launch order ever in aviation history - 50 7E7's by ANA the first to be delivered May 2008. Boeing estimated that development would cost them some $6 billion - based on large subsidy expectation - but analysts from the University of Buffalo were quick to point out that these cost would double - to $ 13.4 billion to be precise [409] more than the A380.

Blindly taking lightweight plastic for lightweight aircraft - leave that to the sales reps - soon the 787 became the fastest selling civil aircraft in aviation history. Now it was to the engineers. But they did not have the expertise and that led to huge outsourcing and soon management and engineers completely lost oversight - but it took them quite some time before they found out the real mess they had created. But the show must go on and on the 8th of July they rolled out some carbon copy Dreamliner - first flight was promised within two months that would become two years.

Initially Airbus - still full of confidence about the A380 - tried to play down the virtues of all-composite, then their engineers warned their counterparts at Boeing that they were pushing the envelop too far. They were serious - back in 2004 - but the industry took it as marketing offensive when the engineers labelled carbon composites 'black aluminum' providing little advantage over conventional materials, but that would change. April 28th 2005 the A380 made its first successful flight, no doubt one of the greatest achievements in aviation history. Then completely out of

the blue came the shock announcement, June 2nd 2005, that due to a wiring problem - two wires being short - the A380 program had ran into some trouble - eventually resulting in seventeen months delay and more than € 5 billion cost overrun. All of the sudden Airbus found itself in desperate position. Reaction of management was three fold. First they sold their stock in Airbus, then they fired their Chief engineer and then they ordered their engineers to come up with a swift and cheap answer to confront the 787. October 6th 2005, Airbus shareholders gave the green light for the €3.5 billion A350. Not well received in the market in 2006 - it was an excellent design except may be for the lithium aluminium but that could be changed - the plane would have been a success when introduced in 2009.

Now also struck by fear at Airbus where management choose to ignore their engineers' respected opinion and let the market decide - some key customers by now all-composite indoctrinated. That became the $10 billion A350 XWB - a 787 with panel instead of barrel fuselage to fly in 2013. Then September 2007 - within months after its festive inauguration - Boeing had to face the truth and to admit that the Dreamliner had also run into troubles - something to do with shortage of fasteners - soon more delays had to be announced with no end in sight yet by 2009. Cost overruns have not been made public but total costs are estimated to be still ahead of the A380. A major set back no doubt but the belief of the market in all-composite was again strengthened by Airbus' dramatic switch and orders for both 787 and A350 XWB kept rolling in. Early 2009 the ticker was at 879 orders for the 787 and 483 orders for the A350, which recently took over the title of fastest selling civil aircraft in aviation history from the 787.

These Olympic Cooperate Games were initially driven by sales - then by fear well known to be the worst of advisors as development illustrate. When Airbus had refrained from Super Jumbo they would have been a very successful and profitable company by 2009, way ahead of Boeing - when Boeing had not reacted to the A380 with the 787 they would have been a winner with the 747-8 and even with the 747-400 by 2009 - when Boeing had studied composites just a little bit they would have never decided for all-composite and believe that outsourcing would bring the

missing know how and expertise - when Airbus had not reacted to the 787 they would have been a winner by 2009 with their traditional further improved 300 series - and when Airbus had not reacted to customer demand and stayed with the original A350 they would have had a winner by 2009. Instead of devoting their last resources to more promising projects both companies choose to keep struggling with all-composite. Now development of the 747-8 lags behind because the 787 requires all engineers' hands on deck and at Airbus ramping up of the A380 is still causing great headache and the A350 requires so much attention that engineers apparently don't have time to tackle the problems with the A400M.

Then something unexpected happened. December 2008 an internal Airbus document surfaced that contained quit embarrassing information about the 787 - now the problems were officially in the open - Boeing did not even try to deny. Intentionally or not this is going to backfire and affect both companies. To make things worse Boeing announced that test flights will go ahead with planes held by numerous improperly placed fasteners and a temporarily fastened wing box. With the price for oil tumbling - the main drive behind all-composite - market starts loosing faith and indeed early 2009 Boeing received first cancellations - by May 2009 Boeing faced 57 cancellations for its 787- undoubtedly also instigated by the sharp downturn in global economy. Also the A350, to be delivered from 2013 faced its first five cancellations. Is the industry now heading for the fastest cancelling plane in aviation history?

The A380 - A400M - 787 - A350 - A350 WXB all face an uncertain future. Total costs for development - for these planes originally estimated at some 50 billion - reached $ 75 billion by 2009 and will further increase. And what has been achieved - the 13th A380's was delivered ultimo 2008 and ramping up is far more complicated that anticipated and proceeds much slower than planned, the A400M is delayed indefinitely, a patched up and heavily overweight 787 is about to make its first test flight by the middle of 2009, the A350 was cancelled and with the A350 XWB engineers are struggling with huge overweight. The plane is to be delivered from 2013, but that has yet to be seen. In addition to that, the companies have to

deal with some $65 billion late and lost revenues and this will only get worse.

The all-composite 787 was a step too far too soon - an impossible dream. First delivery now planned for early 2010 might not take place before 2011 - if ever - some four years behind schedule and ramping up will develop at much slower pace than aimed for. One can only feel sorry with the airliners involved - all-composite's inspection and repair will turn out to be a nightmare. Lessons learned - engineers at Airbus are no doubt better suited to tackle problems and management seems to have adapted a more engineering driven approach with the development of the A350. Engineers are again encouraged to come forward but with all good intentions there is not much they can do about plastic - so who will come forward and tell management - that composites are just not suited for primary structures exposed to the extremely harsh conditions that apply to aircraft.

So far, the structural limit with large-scale application of composites involves the already mentioned blades for wind turbines. Wind blades are heavily loaded indeed but with civil aircraft loading is magnitudes higher - far more complex and extreme - ways beyond what plain composites can deliver. But the know-how gained here has been most valuable, most noticeable on lightning strike protection. Large composite wind blades would explode upon lightning strike when not properly grounded - most worrisome blades do frequently break due to lighting strike. Reliable lighting strike protection is complicated with wind blades but far easier than with all-composite aircraft.

Also cars can be built all-composites, easier than aeroplanes and the pro and cons are much more in favour with cars. Somehow all-composite did not make it in the automotive industry, most notably not in Japan. But the car industry was most successful with selective application of composites and proved that composites' lightweight, non-corrosiveness, stiffness and high strength can be successfully exploited for parts that can be easily exchanged. That is through selective application of composites that can also applied with aircraft - as one

Airbus engineer put it before management allowed customers to interfere with technical matters *'We want to have aluminum and composites both working together in parallel, so we can make use of the best material for a given structural application'* [65]. That is in good composite tradition where the selective combination of materials provides the structure as a whole with unique features that can't be achieved with one of the materials on their own - the future is composed aircraft for which the A380 is paving the way and where aluminium reinforced composites will play key role together with monolithic aluminium, titanium and plain composites suited so well for the large indoor primary structures like wing box and so on. Airbus has here an unbeatable advantage over Boeing in that aluminium reinforced composites can be relative easily adapted for the panels of the fuselage of the A350 - but cannot be applied with the barrels of the 787.