1. AIMING FOR COMPLETE CONTROL OF THE MARKET

About an entertaining relationship

In aviation a sequence of dramatic events did unfold in recent years when Boeing and Airbus locked themselves in a dramatic arch rival battle that has all the ingredients of a next James Bond. In corporate history competition has never been so fierce and the stakes never been so high. At the same time, more possible disaster has never been looming at the horizon. At stake the market for all composite aircraft - with already some 1400 firm orders worth a staggering 200 billion. Aiming for complete control of the market both companies overplayed their hands and are now fighting for survival.

Founded in the late 1960's - May 29th 1969 exactly 40 years ago - Airbus achieved the 'impossible' by beating Boeing in sales by 2000. The success was largely based on creative technology with groundbreaking advances, a result of *French ingéniosité* and *German Gründlichkeit* that soon set new standards with aviation. Initially engineering driven - that led to the success - Airbus was by 2000 gradually transformed into a more sales driven business enterprise and the new management could not resist to contest also Boeing's 747 monopoly in the lucrative Jumbo Market - Boeing had by then delivered more than 1250 Jumbo's. This became the Airbus A380, launched in 2000, that transferred the dead weight 125 ton Jumbo into a 275 ton Super Jumbo - adding some 50% floor space - the first composed aircraft with about 22% of the primary structure out of composites that were supposed to bring some 15 tons of payload. The massive 11ton wing box - for the first time out of composite - saved alone some 1.5 ton. Other novelties include the thermoplast J-nose front edges and the application of aluminium reinforced composites - Glare - that make up some 3% of the weight to cover some 500 square feet of the upper fuselage. Composites were also applied for the keel beam, rear pressure bulkhead, most of the vertical tail, ribs and control faces. The wings and the remaining fuselage are out of traditional aluminium. The structure contains some145 tons of titanium - about 26 tons in the engines. Promised to be at least 20% more service efficient per seat, interest of airlines soon switched towards this plane.

Taking lightweight plastic for lightweight aircraft

Now Boeing started to become really nervous if not desperate and pondered about a response - driven by fear. This had to be technical superior to whatever Airbus was offering or had in mind and became the first all-composite aircraft - the 787 Dreamliner - launched in 2005 to be about 50% out of composites by weight or 80% by volume, probably the maximum that can be achieved. Boeing had only limited experience with primary applications of composites and didn't have the know-how and expertise to design and build a plastic airplane, which led to

outsourcing of some 70% of the activities - *'virtually everything except final assembly that would Boeing take only three days'* [311]. Suppliers became partners who *'would shoulder more than $9 billion of the project's $13 billion cost in exchange for lucrative, multiyear guaranteed contracts and a slice of the plane's sales'.* [311]. Other reports suggest that $6 billion came from Boeing and $4 billion form suppliers [315].

The 787 will also be *'a more electric plane'* [232] equipped with many new advanced systems that enable more efficient operation and improve on flying experience [78]. Boeing claimed that the 787 would be cheaper to manufacture, save 20% on fuel, needs 30% less maintenance - *'the corrosion and fatigue benefits are going to be astounding'* [9] - and passengers would love to fly it - amongst other, the composite structure allows for lower cabin pressure, higher relative humidity and much larger windows. The concept appealed to the industry. Nobody questioned safety, nor any other of the features claimed by Boeing and - taking lightweight plastic for lightweight aircraft - the 787 soon became the fastest selling civil aircraft in aviation history. By January 2009 more than 50 customers had placed more than 900 orders - worth a staggering $ 125 billion plus - but the project was by then already two years behind schedule with no firm date set for first delivery and the plane has now to be introduced in the midst of the worst recession ever. Outsourcing did not bring the success, nor the savings that were hoped for - too late it became clear that the partners were not as knowledgeable as anticipated. Problems mounted and Boeing had completely lost oversight when a copy of a copy of the first Dreamliner was rolled out July 2007 - *'the program was more than we could handle'* [311] - and this led to long delays and huge cost overruns.

Blunt talk

Initially very sceptical, the early success of the 787 took Airbus by surprise and they soon realized that they had to come up with a swift answer. But Airbus was by now short by cash because the production of the A380 had run into serious problems causing a two year delay. Now also driven by fear [132] Airbus launched the A350 - October 2005 - a balanced composed design about 30% out of composite

by weight. Development costs were estimated at a modest € 3.5 billion and the plane would roll out in 2010. The fuselage was based on the A330, but now out of the latest generation of aluminum-lithium - which was probably not such good idea. The wings were newly designed, largely out of composites carrying also the landing gear. Surprisingly, aluminum reinforced composites - so successfully applied with the A380 - were not employed. Confident that the A350 would challenge both the 787 and the 777 [133)] they were in for a bitter disappointment. For the first time an Airbus concept was not well received - not enough composites - criticized by a key customer who *'stunned a packed audience of some 700 aviation professionals here by calling on Airbus to scrap its existing A350 design and spend many additional billions on a brand-new airplane with a new fuselage and a new wing'* [10)]. Such blunt talk in public is rare indeed in this industry, where close relationships between manufacturer and customer are *'necessaire'* [306)] and management saw no other option than to agree to reconsider the design [11)] - as one Airbus official puts it *'I don't think it's ever happened before that an aircraft program has been launched and then there's been a public debate over the design'* [12)].

The customer is always right, right?

The customer is always right [13)] - or not. Engineers at Airbus had encountered serious problems with composites in recent years and were understandably reluctant to a sudden switch to all composite and had already publicly warned that Boeing was pushing the envelope too far too quickly – *'making a giant leap without fully comprehending the risks of swapping metal for a composite of plastic and carbon fibre'* [14)]. Most engineers at Airbus preferred to stay with their step-by-step approach - *'lentement mais sûrement'* - that had served them so well in the past and focus more on the further development of composed aircraft, others were bullish on all composite [15)]. Weighing the pros and cons Airbus management choose *'to listen to the customer'* [16)]. With good reason - may be - for the first time since 2000 Boeing outsold Airbus by a sizeable sum in 2006 [17)] - and it was now to Boeing to subtly remark *'Now it seems, Airbus is the company*

that is strategically confused' [131]. It took Airbus six major renditions to satisfy the market, when composites were gradually increased to a level about similar to the 787 - that is, also all-composite. But the engineers did not completely surrender and the design of what is now called the A350 XWB is - *still* - fundamentally different from the 787. Airbus decided with the fuselage for a panel approach instead of the barrel concept adapted by Boeing - this to the dismay of certain key customers. But Airbus managed to convince the market that the A350 XWB - extra wide body - was going to be even more fuel efficient than the 787 and by September 2008 more than 470 orders were received from some 23 customers - taking over the title from Boeing of the *'fastest selling aircraft in commercial aircraft history'* [224] in these Corporate Olympic Games. Airbus estimated the development costs of the A350 XWB at €10 billion - most probably far from enough - and first delivery was scheduled for 2013. 'Design freeze' was announced January 2009, but the structure is reported to be still significant overweight and needs major modification to lower weight [8]. This will be very difficult to achieve - once the design has been decided the trend is rather upwards than downwards with large aircraft - and it has to be awaited what weight reduction can be attained.

A380 - a giant airplane causing giant problems

The A380 made its successful maiden flight April 27th 2005, delayed by only three months. The target weight had been exceeded by some 5,500 kg (~12,000 lbs) - the equivalent of 55 passengers - regardless enormous effort, but the composed structure was a success and still saves considerable weight - it would have been impossible to fly the A380 without composites. Then - June 2005 - disaster struck when wiring problems surfaced - '*two wires being too short and not meeting'* [18] - which led eventually to a two year delay and made development costs soar to a staggering €15 billion, exceeding the budget by some €5 billion.

That the 530 km (330 ml) of wiring - including some 10,000 wires and 40,300 connectors - did not fit was quite a bizarre affair caused by two different computer programmes

that were not properly linked. The cabling was prepared in Hamburg for assembly in Toulouse. Sophisticated CATIA programs from Dassault were used, but in Toulouse the latest version and in Hamburg an older one - and these are really different programs. Disaster could have been avoided when Airbus had a program running to make up a 3D mock up that was available at that time and most probably would have detected the problem in time. It is surprising that the leading company in aviation famous for its innovations was not using state of the art design technology at that time with such complicated and ambitious project. Once new programs were installed it took the engineers quite some time to come to terms with the new tools, which added further to the delay. The role of Dassault is not clear, but they should have noticed.

With the A380 losses are still mounting due to further severe delays with ramping up, compensation for late delivery, underperformance and disappointing sales. April 2009 the A380 passed 200 orders of which 14 have been delivered. Break even was initially set for 270 aircraft XXX), increased to 420 planes XXX) when the delay surfaced and it now assumed to require between 600 and 800 aircraft [288)] - that is the equivalent of roughly half the global demand during the next 20 years. At Airbus there is serious worry that it might run out of orders within years [317)]. May 2009 *'Airbus proclaimed its A380 a success'* [384)] - that may be bit premature with only 41,000 revenue flight hours clocked by a fleet of 14 - but technically the A380 is an amazing achievement.

It appears that with the A380 ramping up is far more complicated and time consuming than anticipated and is still causing headache and long delays. Next to the huge extremely complicated construction of the aircraft and intricate wiring, some 23,000 individual parts are used in the cabin area alone – in very different configurations because of wide-ranging customization. This led to more than teething problems when the aircraft entered service. Problems included electric faults, on-board electronics, singed power cables, partially torn-off sections of panelling, defective parts of thrust nozzles in the engines and trouble with fuel pumps - at one instance two Qantas A380s were grounded simultaneously due to fuel problems - causing delays, cancellations and frequent grounding for several

days. The four jets operated by Emirates experienced some kind of problems about once every two days - according the frustrated airline due to *'shoddy work ethic at Airbus and its suppliers'* [290]. An embarrassed Airbus promised to do *'everything in our power to correct any reports of deficiencies as quickly as possible'* [290] and were quick to reassure that *'none of these issues are related to safety'* [288] - of course - but then listen to this.

> The A380 commenced service October 25th 2007 with Singapore Airlines. What has surfaced is that the A380 is lower on fuel than expected and everybody who has seen the aircraft at take-off or landing has been surprised by the silence of the aircraft - more than 6db below a 747-400 on takeoff and up to 3.7db quieter on arrival. Compared with the 747-400, the A380 requires 17 per cent less runway than the Boeing 747-400 to take off and 11 per cent less to land and cruises at a 4000ft higher initial cruise altitude, a 20 knot lower approach speed and 1100 nautical miles more range [384].
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> However, soon the A380 disappointed the world at large. In a shock announcement Singapore Airlines warned that when you have the privilege to share one of the private cabins in front of the plane provided with airborne double bed with your secretary, inappropriate activity is not allowed for. The isolation is so bad that such activity detracts pilots' attention - and that's the real problem with plastic.
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> And the world was shocked again when the A380 entered service with Emirates August 1st 2008. Operations were already ceased September 9th for some three days due to engineering work that was *'taking longer as expected'* [296]. Also here the private cabin was at the root of problems. With Emirates the A380 has two first class cabins each provided with a mile-high-shower - not exactly environmental friendly - requiring 2000 pounds of water or the weight of some 12 passengers. For safety reasons *'each activation of either shower is timed to provide up to 5 minutes of water'* [295], but this proved to be not safe enough. Undoubtedly ingeniously designed by Airbus, but apparently too complicated to handle for *'a determined female passenger who was unable to operate the showerhead and promptly tore out the entire fixture - and flooded the first class section'* [290]. Now just imagine, an Arab plane, a disrupted deactivation timer, a nude female screaming for help with 2000 pounds of hot water on the loose flooding the shower room and first class in an aircraft provided with hundreds miles

of wiring, thousands of connectors and highly sophisticated electronics all over and no male crew allowed to enter the area. Rumoured on the Internet - and probably true - the incident caused the burn out of an avionics panel. Fortunately the pilots managed to land the aircraft uneventfully, but this accident could have led to disaster – and possibly the end of the A380.

One can indeed wonder whether a structure so stuffed with electrical circuits and electronic equipment that nowadays completely controls the aircraft - including fly by wire - can still be sufficiently protected from accidents and shielded from lightning strike as will be discussed later.

To solve the problems, delivery projection for 2009 had to be reduced from 26 units to 21 [281] - to be further reduced to 18 by February when Airbus announced that *'The latest delivery target can be met, although it may be narrowly met just as what happened last year'* [280] - to be further cut to 15 by March [314] - to be further slashed to 14 by May 6th 2009 [341]. Note that missing eleven more deliveries means almost €3 billion in lost revenues during 2009 - but Airbus is probably holding down production down at 15 per year for the foreseeable future due to *'serious over inflation of the order book'* [317]. When orders don't pick up soon the A380 faces an uncertain future.

A400M - delayed 'indefinitely'

In the meantime EADS - the mother company of Airbus - decided also for the development of a military transport aircraft, a market new to Airbus that is still dominated by the Lockheed Martin Hercules C130 and the Boeing C-17 Jumbolifter. This became the € 20 billion A400M - also to be able to act as air-to-air refuelling tanker - commissioned by seven European NATO countries in 2003. The A400M is about 35% out of composites including the wings and 192 firm orders were received. Also this project ran into problems *'the A380 was a nightmare when it happened, but that's mostly out of the woods'* according to one analyst *'now they have a new major problem, the A400M, which is a nightmare not*

only for the company, but for shareholders' [392].

Starting development in 2003 a first delay of 6-12 months had to be announced November 2007 [196]. June 26th 2008, the A400M rolled out to make its first test flight September next - but it would never come to that. Engineers struggled for more than a year to control vibration problems but these proved to be uncontrollable. September 2008 it was announced that the project was delayed '*indefinitely*' [21]. According EADS the propulsion system is to blame. These were developed by a consortium of European partners, a political decision that overruled the preference of Airbus managers for Pratt and Whitney' [278]. But the consortium argues that large turbo prop engines did not cause problems when mounted on a converted Hercules C-130 transporter [287]. When that is the case, the composite wings might be at the root of problems - vibration and damping behaviour of composites are indeed very different form that of aluminium, as will be discussed later. Then it surfaced that *'a major error regarding software certification'* - whatever that may mean - *'was the main cause for the significant delay in the programme'* [385].

Another major problem is that the plane is presently reported to be some 12,000 kg (~26,450 lbs) overweight [6] causing further headache for the military - operation *'could become very problematic if payload falls below 33 ton/ 36 ton, as development of a number of armoured vehicle programs are already in motion that will depend on this capability'* [197]. The contract does not contain weight specifications but requires that the A400M achieves certain payload and range targets. Actually weight and size have to be considered.

EADS had to concede that they *'underestimated the complexity of the program'* [19] - according an insider *'Das ganze Program ist aus den Fugen geraten'* - *'Oversight has been completely lost'* [6]. A new start will be considered by EADS *'only once adequate maturity is reached, based on flight test results'* [20] and when *'the risks and opportunities are appropriately shared by the customer and the industry'* [288] - that means more tax payers money, who cares nowadays.

EADS admits that the A400M is a *'heavy lossmaker'* [197] - cost overruns on

the program could face as much as $6 billion [198] and Airbus has already taken 1.74 billion in charges since November 2007 [305]. The alternative is scrapping the project that would force EADS to reimburse € 5.7 billion [283], but that needs unanimous support of all countries involved. So far only UK is seriously considering abandoning the project [284], Germany is threatening to completely withdraw [288] and France announced to *'do everything to try to save this program'* [285] but is also reported to consider purchase of two C17 of Boeing as temporary alternative [286]. EADS now argues that they *'should never have signed the contract'* [288] - however - *'If we can manage to get the program back on course, the A400M will be a success story'* [288] and

Whatever the outcome, the aircraft needs complete redesign to try to solve the problems. For that, EADS needs many extra billions and at least another three years [287] - and it remains doubtful whether the target weight can be met. According EADS *'the original target was unachievable'* [289] but announces at the same time that they do not *'anticipate any reduction in capability'* [385] or more specific *'EADS says payload will remain at 37 tonnes'* [310]. To achieve that goal means that other performance has to be degraded - probably landing performance. For the moment it appears that also the A400M faces an uncertain future.

787 – still ambiguous to the extreme

So far first flight of the 787 has been delayed five times and first delivery four times - due to grove negligence as will be discussed in more detail later. Most important, possible advantages of composites were very much overestimated and disadvantages were underestimated or simply ignored. When the first 6 month delay was announced - October 2007 - Boeing said that *'it is still aiming to deliver 109 787s by the end of 2009, only three fewer than originally planned'* [307]. About 18 months later - March 2009 - Boeing announced that it *'continues to work'* [310] toward first test flight in the second quarter of 2009 - originally scheduled for September 2007 - and first delivery to take place in the first quarter of 2010 - formally scheduled for May 2008. That is a two-year delay and it is expected that

another delay will have to be announced during the second half of 2009 because certification will take much longer than anticipated.

Certification involves six flight test aircraft that are all considerable overweight - probably some 10.000 lbs (~4500 kg) - and have serious shortcomings that will be discussed in more detail later. Amongst others, a large number of fasteners are not correctly placed [229] nobody knows how many - also the wing box had to be provisionally strengthened [59] - the lighting protection system is not completely in place and the landing gears braking system has to be modified [300]. Difficult to understand Boeing's reasoning to deal with these shortcomings after the test flights have been completed - not to mention that important parts of the aircraft are being redesigned in an attempt to lower weight. Most worrisome, FAA had to loosen fuel tank safety rules [299] - February 2009 - otherwise certification wouldn't have been 'possible at all', so we are told.

Still ambiguous to the extreme Boeing plans a record certification timeline of six [297] to nine [298] months - where certification of the far less complicated 777 took eleven months. Airbus has scheduled fifteen months for certification the A350XWB. Given the history of the 787 some eighteen months is probably a more realistic figure.

March 2009, 787 watchers anticipated that the first test aircraft - ZA001 - could be flying by the end of June 2009. Engine start occurred May 21st - *'the first electric start of a turbo fan engine on a large twin commercial jet transporter'* [386] - when the six start generators on board of the 787 collectively supply nearly 1.5 megawatts of power, enough to power about 400 homes. ZA002 initiated power-on late February and will undergo vibration testing. Production work on ZA003, ZA004, and ZA005 is continuing. Final assembly of ZA006 started March 2009 and it has yet to be seen whether these aircraft will be ready to meet the certification time line. Production of the first standard aircraft to be delivered - ZA100 - has also commenced, which means that certification takes place along the production line.

One can only wonder what is the purpose of testing an aircraft of which the design has to be significantly modified to make it suitable for service. Boeing confirmed that the first batch of 787s that will be delivered - ZA100 to ZA119 - will be overweight [303], Boeing was not specific but overweight will probably be well over 5000 lbs (~2250 kg) which means a 10 to 15% range shortfall [342]. But Boeing reassured their customers that these planes will be provided with the definitive wing box. From ZA120 the planes will have newly designed wings and other features to save on weight - how much has to be awaited.

With the 787 costs related to development are mounting to a level that Boeing is *'not expected to make any money on the first 100 or so Dreamliners'* [311]. It is here assumed that the budget will be exceeded in a way similar to the A380 - if not beyond; that is, when the aircraft does indeed fulfil expectations, and that has yet to be seen. Airlines are particular concerned about overweight that limits the either the range or take off load [342]. Undoubtedly, safety, inspection and repair will soon become other issues of concern. Moreover, the problems with the 787 take up so much of the engineering capacity that other projects at Boeing lag behind, most noticeably the 747-8 freighter program that is delayed by nine months, announced November 2008 [135]. Also financial resources are affected - Boeing's cash reserves plummeted during 2008 from $7 billion to $3 billion.

Deliveries - taking a last lead

In the meantime the Olympic Corporate Games continued. Boeing regained the lead in the market during 2006 and 2007, but Airbus did beat Boeing again in 2008 on both deliveries and orders - taking a last lead - but total numbers fell sharply from 2007. Due to the 58-day machinists strike deliveries at Boeing declined 15% to 441 from 375 - Airbus delivered 483 jets, 30 more than the previous year. More dramatic, sales dropped at Boeing in 2008 with 53% - to 662 units from 1413 in 2007. At Airbus sales fell with 42% - from 1341 to a lucky *777*.

Already in 2008 analysts forecasted aircraft deliveries to fall worldwide by *'as much as 50% from 2009 to 2013'* [25]. January 2009 Airbus had still has hopes for deliveries at *'the lower end of 300-400'* [136] - by May the expectation was *'that number was likely to fall to fewer than 300'* [393] - that is, when governments are willing to provide support with financing [302]. Boeing and Airbus insist that the shortfall with financing is 'only $4 to $5 billion' but analysts estimate a shortfall of $10 to $20 billion [305]. But even with such help it is now doubtful whether the Airbus and Boeing will achieve 500 deliveries together in 2009. Projections for 2010 are even worse [305]. April 2009 Boeing was forced to park first brand new commercial jets [293] in the desert awaiting delivery, and announced cut backs in production rates for all models.

A different game

January 2009, Boeing and Airbus each had a backlog of about 3700 aircraft, including some 1400 all composite aircraft, totalling more than $ 700 billion - that is about the package President Obama asked Congress in 2009 to simulate the US economy. The $700 billion backlog is however a relative figure. Already July 2008, at the Farnborough Air show, analysts warned that *'There are about 2,000 too many aircraft in backlog at the moment'* [57]. A further sharp drop in sales is expected from 2009 and many customers may not be able to take their ordered planes because of the present credit crunch [151]. During the first four months of 2009 Boeing net orders totalled a negative 1 shipment mainly due to the cancellation of 787s. During the same period Airbus booked a total of 11 orders net of 19 cancellations. Even on figures almost 100% down from the previous year, the press still made it *'Airbus leads Boeing in slow race for orders'* [387].

More airlines are signalling that they may pull back on orders. April 2009 Boeing revealed 60 aircraft deferrals from 2010 and 2011 and at least another 60 more in discussion - all aircraft types are affected [388]. The 787 might suffer most, facing possibly 100 cancellations during 2009 [391]. In April 8 orders were received for the 787, the first for 2009. With the A380 *'There are already rumours abound*

that Airbus will suffer a dozen or more A380 cancellations in 2009' [280] - other reports suggest that *'of the 200 outstanding orders Airbus claims, at lest 20% (40 aircraft) are likely to be deferred....while a further 40% (80 aircraft) could be cancelled outright'* [317].

Aiming for complete control of the market

Aiming for complete control of the market, Airbus and Boeing are now fighting for survival. Confronted with the worst economic crises ever and shaken confidence of both customers and investors due to continuous delays, the companies have now to deal with the enormous - still mounting - cost overruns with the A380, A400M, 787 and the switch of A350 to A350 XWB. A conservative estimate - *taking one US Dollar for one Euro* - shows that with the A380, where cost for development were originally set at 10 billion that increased with an additional 5 billion due to the two year delay have been confirmed, present delays and problems with ramping up are expected to add another 2.5 billion to the losses. The 20 billion A400M needs at least an additional 6 billion to try to solve problems - 10 billion is probably a more realistic figure - charges may total as much as 4 billion euros in 2009 [392]. Development costs of the B787, originally estimated at 10 billion, must already have consumed an additional 5 billion if not closer to 10 billion - so far Boeing did not release exact figures – but compensation payments for late delivery and underperformance as well as cancellations are expected to add another 5 billion. Development of the 10 billion A350 XWB will most probably need another 2.5 billion - that is to say at least. This means that the development costs of these aircraft, originally estimated at about 50 billion, will be exceeded with more than half to surpass 75 billion and this might indeed turn out be a conservative approach indeed - *the total costs associated with Apollo project amounted to about 135 billion in 2005 US dollars and included 15 launch vehicles.*

The situation is even more dramatic with late and lost revenues due to delays and cancellations. The assembly facility for the A380 was originally designed to maintain a production rate of 4.4 planes per month by the end of 2008, to be able

to deliver 40 to 48 aircraft per year from 2009 [309]. When the delays surfaced in 2005, the company slashed the delivery schedule from one plane in 2006 to zero, from nine planes in 2007 to one and from 25 planes in 2008 to 13 [316]. This revised schedule has been met but only 14 deliveries are expected for 2009 instead of the originally scheduled 30. Assuming also 15 deliveries for 2010 instead of 40 that could have been produced means that production lags behind 54 planes by the end of 2010. At a list price of 250 million this mounts to almost 14 billion in lost revenues - with probably numerous cancellations in the pipeline as was indicated before. With the A400M - listed at about 150 million - estimate of lost revenue is difficult because partner governments have already contributed more than 5 billion [309], that EADS might have to pay back as indicated before, and the company has already taken charges of 1.74 billion in 2009. Lost revenues are here set at 2 billion by the end of 2010. Most dramatic is the situation with the 787. Total aircraft to roll out was set for 40 in 2008, that is, during testing for certification. Assembly rate was to be steadily cut short to just three days to be able to roll out 112 aircraft by 2009 to increase to 168 by 2010. Boeing now expects to start deliveries in 2010 - but that might be delayed to 2011 as indicated before - which means that by the end of 2010 production could be 328 behind the original schedule - at list price of 150 million almost 50 billion. This brings the total of late revenues at staggering 66 billion by the end of 2010 excluding numerous cancellations - about the size of the jet market at its height in 2007.

Cancellations and deferred deliveries add further to the burden. A leading analyst estimates that *'between 30 and 70 percent of all orders for jets worldwide will at least be deferred, if not cancelled. In his worst-case scenario, 630 orders would be postponed or dropped, a potential loss of $126 billion in revenue'* [311] - may be not so much in 2009 - *'it's 2010 when we'll begin to see a shift'* [137]. As indicated before, the A380 might face large cancellations during 2009; the 787 up to 100 and the A440M might be scrapped. The fate of the A350 has to be awaited.

Joining forces

Self imposed - no question about that - all this puts Boeing and Airbus in a very awkward if not impossible position. To a certain extend it is possible to reduce production of long running models. But with the new models most of the know how and expertise is in the minds of the people, including suppliers and partners, and one has to be very careful to avoid a brain drain that makes it extremely difficult if not impossible to continue with the project. It is however 'virtually impossible' to slow development of new models - this would mean the end of the 787. Further reducing the production rate of the A380 would effectively also end this project. Also the position of suppliers has to be considered - at Boeing and Airbus up to 80% of the value of a plane comes from outside companies. With the 787 the partners take a lot of the burden, but a failure of one of them could bring the project to a long standstill - some partners are in need financial support. Development of the A350 could still be halted but losses would amount some 5 billion and cause serious embarrassment. For the moment the project is proceeding - may be some headaches and may be somewhat short by cash - January 14th 2009, Airbus launched the new A350 final assembly line, a €140 million facility including a 74.000 m^2 production hall in Toulouse and still predicts that 480 aircraft will be delivered from 2013 [294)]. Whether it is worthwhile to make a fresh start with the A400M is for the politicians to decide - but one can wonder whether EADS is capable to succeed a second time.

Somehow the companies have to deal with both the technical challenges and the enormous losses, which couldn't come at a worse moment. One can criticize Boeing for outsourcing of some 70% of the 787 becoming fully dependent on know how and expertise of partners [389)]. Airbus is spreading production facilities globally and is reported to face serious espionage at its Tianjin plant in China where the A320 is built [390)] - which comes not exactly as a surprise. What exclusive know-how and expertise will be left for Boeing and Airbus in a couple of years - on both traditional and advanced aircraft technology - not much probably.

For Boeing and Airbus to survive the present crisis there appears to be no

other way out than to join forces, otherwise other countries - already waiting in the sidelines - will soon take over initiative. Important to note in this respect is that regarding the $35 billion US Air Force contract for new refuelling jets, Airbus signalled - April 17th 2009 - that it is *'willing to consider splitting US Air force contract with Boeing'* [304] and Boeing signalled back - April 27th 2009 - that *'it will support splitting the contract when the pentagon chooses that approach'* [308]. The military transporter would be an obvious next choice for cooperation. But even more important is to join forces on the development of composed aircraft - instead of all composite aircraft.

Facing also an uncertain future

April 16th 2009 Boeing delivered its 6000th 737 - a milestone - unfilled orders for the next generation 737 exceed 2200 planes valued at some $160 billion at list prices. Not much ado when Airbus announced its 40th anniversary May 29th 2009 with the A320 nearing its 4000 mark. Can the same success be repeated with the 787 and the A350 - most probably not. Development of the technology to manufacture the enormous composite section involved extreme engineering - let there be no doubt about the immense achievements. The engineers involved with the 787 did a magnificent job coming to terms with a new construction material - never tried at this scale before - not even near. So many problems had to be solved - and have been solved - technology had been stressed to its absolute limit, most probably beyond. When the 787 finally takes of for its first test flight Boeing has written aviation history again. No doubt the plain will fly all right, probably better than any plane before, but problems affecting safety will surface, which means that also the 787 and the A350 face an uncertain future - composites are just not good enough - but they could have known as will be discussed in more detail at the following pages.