Aviation Products Pricing Working Party
Subgroup of Aviation Pricing Working Party

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1. Introduction

The Aviation Pricing Working Party formed three subgroups. This paper documents some of the work of the Aviation Products Pricing subgroup. The paper briefly describes the Aviation Products market, gives feedback on interviews with Aviation Products underwriters, begins to look at rating techniques and approaches, and provides some details of the analysis of large Aviation Products losses.

The data and analysis contained in this paper are for illustrative purposes only and should not be relied on. The data we based the analysis on is known to be incomplete and may contain errors.

The views expressed in this paper are the views of the individual members of the subgroup. They do not represent the views of our employers or any organisation which the individuals are associated with. “We” in this paper refers to the subgroup.

The subgroup did not start work until February 2005 and due to work commitments has not made the progress we would have liked. We view this paper as “work in progress” and would like to continue to review Aviation Products pricing in the future. Over the next year, one of our planned work-streams is to develop a generic exposure-rating model to price Aviation Products business.

The data used in this paper was complied from information provided by major brokers.

The subgroup was aware of recent heightened focus on EU anti-competitive regulations. We do not believe that we breach these regulations. By publishing our work, we are providing more information about the Aviation Product market and as such it could be argued we are helping a more competitive market by lowering barriers to entry to the market.
2. Aviation Products Market Overview

2.1 Coverage

Aviation Products Liability insurance protects manufacturers of aircraft and aircraft components against legal liability in respect of property damage and bodily injury. Typical liability limits would range from $1.5bn to $2bn for major manufacturers, $1bn to $1.5bn for large component manufacturers and $250m to $1b for smaller component manufacturers. The coverage is usually on a “losses occurring during” (LOD) basis.

In practice, various additional covers have often been included in Aviation Products insurance. These will normally be covered under different sections of the policies and will have their own sub limits. These covers include:

- Manufacturer’s hull and liability (covers accidents involving aircraft in the possession of the manufacturer, e.g. test flights.)
- Grounding risks – business interruption due to the grounding of a fleet for safety reasons. Often $125m sub limit is given.
- Hangarkeepers – Liability arising from damage to aircraft/property in the assured’s care, custody or control.

The following are examples of the wider covers that are sometimes given. These will be excess of underlying insurance policies and often there is a $25m sub-limit:

- Excess motor, e.g. for vehicles transporting components.
- General liability

These additional coverages were generally removed in the hard market post September 11 2001 although now some of these are being added again.

2.2 Categorisation

There are a very wide variety of purchasers of Aviation Products cover. Risks are often divided into the following categories:

- Airframe manufacturers
- Engine manufacturers
- Subcomponent manufacturers

Further, for some of these groupings, risks can also be categorised by type of aircraft to which they relate, for example:

- Commercial aircraft
- Military aircraft
- General aviation (often defined as aircrafts with less than 50 seats, although many other definitions also exist)

Other risks that are sometimes regarded as subsections of Aviation Products include:

- Air traffic control (ATC)
- Airports
- Refuellers
- Maintenance, Service and Repairs

Categorisation of individual insureds can be very difficult. It is common for individual insureds to fit into a number of the above categories. Airframe manufacturers will regularly
also sell subcomponents and maintenance services. Pricing often only focuses on the major activity of the insured.

2.3 Market premium and claims

Figures 1 to 3 below summarise total premium (London lead terms, net of commissions, excluding ATC/Airports/Refuellers) and large loss incurred claims figures over the last 23 years. We have added illustrative estimates of IBNR claims and attritional claims to obtain an example of estimated ultimate claims and loss ratios. The IBNR was derived using benchmarks, which may not necessarily be appropriate. Accurate estimates of market attritional claims are very difficult to obtain. It is generally easier to obtain information on large claims than to compile the information for attritional claims. We have shown, for illustrative purposes, attritional claims of $175m for 2004, reducing by 5% p.a. for each prior year. We note that estimates of attritional claim amounts vary considerably and one market practitioner informed us that he estimates attritional claims to be of the order of $300-350m per year. However, there is no clear definition of attritional.

Figure 1: Aviation Products Market Premium and Claims Summary

<table>
<thead>
<tr>
<th>U/W Year</th>
<th>Net Premium</th>
<th>Incurred Large Claims</th>
<th>Large Loss IBNR</th>
<th>Ultimate Large Claims</th>
<th>Attritional Claims</th>
<th>Total Claims Incl Attritional</th>
<th>LR</th>
<th>Total claims trended Ult (5% p.a.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>230</td>
<td>175</td>
<td>0</td>
<td>175</td>
<td>60</td>
<td>235</td>
<td>102%</td>
<td>687</td>
</tr>
<tr>
<td>1983</td>
<td>250</td>
<td>150</td>
<td>0</td>
<td>150</td>
<td>63</td>
<td>213</td>
<td>85%</td>
<td>593</td>
</tr>
<tr>
<td>1984</td>
<td>320</td>
<td>240</td>
<td>0</td>
<td>240</td>
<td>66</td>
<td>306</td>
<td>96%</td>
<td>812</td>
</tr>
<tr>
<td>1985</td>
<td>690</td>
<td>540</td>
<td>0</td>
<td>540</td>
<td>69</td>
<td>609</td>
<td>88%</td>
<td>1,540</td>
</tr>
<tr>
<td>1986</td>
<td>1,150</td>
<td>210</td>
<td>0</td>
<td>210</td>
<td>73</td>
<td>283</td>
<td>25%</td>
<td>680</td>
</tr>
<tr>
<td>1987</td>
<td>1,100</td>
<td>250</td>
<td>0</td>
<td>250</td>
<td>76</td>
<td>326</td>
<td>30%</td>
<td>748</td>
</tr>
<tr>
<td>1988</td>
<td>810</td>
<td>550</td>
<td>0</td>
<td>550</td>
<td>80</td>
<td>630</td>
<td>78%</td>
<td>1,376</td>
</tr>
<tr>
<td>1989</td>
<td>550</td>
<td>310</td>
<td>0</td>
<td>310</td>
<td>84</td>
<td>394</td>
<td>72%</td>
<td>819</td>
</tr>
<tr>
<td>1990</td>
<td>340</td>
<td>280</td>
<td>0</td>
<td>280</td>
<td>88</td>
<td>368</td>
<td>108%</td>
<td>729</td>
</tr>
<tr>
<td>1991</td>
<td>460</td>
<td>325</td>
<td>0</td>
<td>325</td>
<td>93</td>
<td>418</td>
<td>91%</td>
<td>788</td>
</tr>
<tr>
<td>1992</td>
<td>500</td>
<td>340</td>
<td>0</td>
<td>340</td>
<td>97</td>
<td>437</td>
<td>87%</td>
<td>786</td>
</tr>
<tr>
<td>1993</td>
<td>525</td>
<td>320</td>
<td>0</td>
<td>320</td>
<td>102</td>
<td>422</td>
<td>80%</td>
<td>722</td>
</tr>
<tr>
<td>1994</td>
<td>575</td>
<td>990</td>
<td>2</td>
<td>992</td>
<td>107</td>
<td>1,100</td>
<td>191%</td>
<td>1,791</td>
</tr>
<tr>
<td>1995</td>
<td>550</td>
<td>570</td>
<td>7</td>
<td>577</td>
<td>113</td>
<td>689</td>
<td>125%</td>
<td>1,070</td>
</tr>
<tr>
<td>1996</td>
<td>530</td>
<td>780</td>
<td>23</td>
<td>803</td>
<td>118</td>
<td>921</td>
<td>174%</td>
<td>1,361</td>
</tr>
<tr>
<td>1997</td>
<td>475</td>
<td>530</td>
<td>30</td>
<td>560</td>
<td>124</td>
<td>684</td>
<td>144%</td>
<td>963</td>
</tr>
<tr>
<td>1998</td>
<td>400</td>
<td>390</td>
<td>35</td>
<td>425</td>
<td>131</td>
<td>555</td>
<td>139%</td>
<td>744</td>
</tr>
<tr>
<td>1999</td>
<td>420</td>
<td>340</td>
<td>56</td>
<td>396</td>
<td>137</td>
<td>533</td>
<td>127%</td>
<td>680</td>
</tr>
<tr>
<td>2000</td>
<td>440</td>
<td>525</td>
<td>135</td>
<td>660</td>
<td>144</td>
<td>804</td>
<td>183%</td>
<td>978</td>
</tr>
<tr>
<td>2001</td>
<td>500</td>
<td>720</td>
<td>180</td>
<td>900</td>
<td>151</td>
<td>1,051</td>
<td>210%</td>
<td>1,217</td>
</tr>
<tr>
<td>2002</td>
<td>825</td>
<td>380</td>
<td>206</td>
<td>586</td>
<td>159</td>
<td>744</td>
<td>90%</td>
<td>821</td>
</tr>
<tr>
<td>2003</td>
<td>850</td>
<td>5</td>
<td>276</td>
<td>281</td>
<td>167</td>
<td>448</td>
<td>53%</td>
<td>470</td>
</tr>
<tr>
<td>2004</td>
<td>950</td>
<td>0</td>
<td>431</td>
<td>431</td>
<td>175</td>
<td>606</td>
<td>64%</td>
<td>606</td>
</tr>
<tr>
<td>Total</td>
<td>13,440</td>
<td>8,920</td>
<td>2,244</td>
<td>10,301</td>
<td>2,479</td>
<td>12,779</td>
<td>95%</td>
<td></td>
</tr>
</tbody>
</table>
At this stage, it is very difficult to comment upon the profitability of the 2003 and 2004 years. For these two years, there have not been any major US catastrophic Airline events and generally there is the belief that they should be quite low loss years. However, 2002 also had no major US airline events, but nevertheless has had some significant late developing claims for significant amounts. For the 2004 year there is still unexpired exposure at the time of writing this paper.

Figure 3 Market Underwriting Results

<table>
<thead>
<tr>
<th>U/W Year</th>
<th>Net Premium</th>
<th>Ultimate Claims Incl Attritional</th>
<th>U/W Result</th>
<th>LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982-89</td>
<td>5,100</td>
<td>2,996</td>
<td>2,104</td>
<td>59%</td>
</tr>
<tr>
<td>1990-93</td>
<td>1,825</td>
<td>1,646</td>
<td>179</td>
<td>90%</td>
</tr>
<tr>
<td>1994-2001</td>
<td>3,890</td>
<td>6,338</td>
<td>-2,448</td>
<td>163%</td>
</tr>
<tr>
<td>2002-04</td>
<td>2,625</td>
<td>1,799</td>
<td>826</td>
<td>69%</td>
</tr>
<tr>
<td>Total</td>
<td>13,440</td>
<td>12,779</td>
<td>661</td>
<td>95%</td>
</tr>
</tbody>
</table>

Figure 3 illustrates the huge difference in profitability of the market over different periods. Estimated ultimate loss ratios range from 59% (1982-89) to 163% (1994-2001). Due to the verticalisation of the Aviation market (leaders often get better rates than the following market) the net premiums for the following market will be lower (up to 15%) than those indicated above.

Figures 1-3 above illustrate the extremely cyclical nature of the market. Market premiums fell by a factor of three between 1987 and 1990. Premiums more than doubled over the four years from 2000. There had been a general deterioration in products claims arising from air disasters in earlier years and this was compounded by insurers’ need to recoup losses from the September 11th terrorist attacks in the US. Hence, rates rose rapidly. We estimate that the
market premium for Aviation Products is now in excess of $1bn following several years in which the market has suffered significant losses.

Figure 4 below shows the estimated ultimate claims from 1982 to 2004, trended to current values at 5% p.a.. The fitted linear trendline shows a slight downward trend in ultimate claims over the years. Clearly, this trendline is influenced by the choice of trend factor. Rising or falling trendlines could be produced if the chosen trend rate was lower or higher than the 5% figure. Average liability awards may be rising faster than 5% p.a.. However, market claims figures will be influenced by a number of factors, such as: improving safety, changes to the cover purchased and any change to the share of claims borne by manufacturers. The trendline is also affected by the assumptions made in deriving the IBNR estimates. Figure 4 also illustrates the volatility in ultimate claims from one year to the next. The downside volatility (chance of higher claims) is clearly much greater than the upside volatility.

Figure 4: Trended Ultimate claims
3. **Underwriter Questionnaire**

3.1 **Introduction**

We decided to meet with Aviation Products underwriters to gain a deeper understanding of the Products market, the way business has been priced historically and developments in pricing techniques. In order to compare and contrast one insurer from another we decided to structure our discussions around a set of standard questions. We provided a copy of these questions to the underwriter in advance of the meeting. The questionnaire is shown in the Appendix of this report. However, many of the interesting points and issues discussed came from general conversations.

A total of seven underwriters were interviewed. The underwriters represented insurers with Aviation Product premium income that ranged from less than $10m to over $200m. While this represents a substantial share of the market, it certainly does not account for the entire market. We estimate that the seven insurers combined have well in excess of $350m of Products premium income and a cumulative maximum line size of greater than $1b.

There were some insurers we approached who decided not to participate in this study due to anti-competitive concerns. Also, of those who did participate, there were two insurers who did not answer questions regarding achieved market rate rises in 2003 & 2004, changes in terms and conditions over the past three years and estimated market capacity as at 1/1/2005 for US critical, US non-critical, non-US critical and non-US non-critical, for similar reasons (critical part is one whose failure is highly likely to lead to an accident).

Some market practitioners have pointed out that in interviews it may be more likely to identify an underwriter’s aspirations of the elements they wish to include in the rating of risks. It is only by a detailed review of models, files and practices that one could determine which factors are generally, as opposed to only occasionally, taken into account. We note this potential bias.

Section 3 provides a brief overview of our findings.

3.2 **Use of models to price risk**

The use of models to price risks has become increasingly popular with five out of seven insurers using a standardised spreadsheet based model. Of these five insurers, three use a model to price more than 60% of their total Product premium. The pie chart (Figure 5) below shows the percentage of each insurer’s Product premium income that is rated using a standardised model (only 7 respondents so 14%=1/7, 29%=2/7):

Figure 5: Percentage of Product income rated using standardised model
Four out of the five insurers that use models to price risks have been doing so for the past 1-3 years, while one insurer has been using models for over six years. Model output is used as a ‘broad guide to rates’ for all five insurers, i.e. the model helps the underwriter to assess the rates but there is no compulsion to quote the model rate (or above model rate). None of the insurers questioned regularly used a stochastic model to price risks. Although, one had built stochastic models on a bespoke basis to allow for quotes with varying levels of SIR’s.

The five underwriters who use pricing models also get actuarial assistance in pricing risks. The other two underwriters interviewed do not get actuarial assistance. Of the five underwriters who get actuarial assistance, three underwriters get actuarial assistance for over 60% of total premium income. When looking at the business by policy count, only one underwriter gets actuarial assistance for more than 60% of policies. The chart below (figure 6) shows the percentage that is actuarially rated by premium income and by policy count:

Figure 6: Percentage of book actuarially rated

3.3 Rating factors

All seven underwriters interviewed use claims history and units in operation as rating factors. Six out of the seven interviewed also use sales, while only two insurers use flying hours.

Other rating factors used include the following:
- Passengers per airport (for airports)
- Limits, self insured retentions (SIR)
- Military/civil split
- Product type critical/non critical
- Short/long tail split
• Overhauls
• Duration/life expectancy of the product
• Fixed wing/rotor wing split
• US/non US exposure
• Legislative environment
• Past production details
• Contractual benefits such as indemnifications
• Space rated separately
• Use of aircraft – e.g. Private business & pleasure v airline v commercial v etc.
• Technology used in manufacturing
• Qualitative factors such as company’s risk management, quality of the product, materials used, product design and safety controls

3.4 Rating approaches

All seven insurers use a combination of experience and exposure rating.

Six out of the seven insurers interviewed develop historic losses to ultimate where development factors are obtained from a benchmark. Two of the insurers also use account specific development factors.

Six out of the seven insurers trend claims to current levels. For bodily injury claims the majority of insurers use a trend rate of 5%-6%. Trend rates are derived from a number of sources including, market data, underwriter judgement, ad hoc studies, and analysis of liability court awards.

The majority of insurers do not have a set level for which they define a large loss. Six of the seven insurers use historic losses to rate for attritional claims, while two use benchmark rates. The majority of insurers use historic market losses to rate for large/catastrophe claims.

3.5 Market segmentation

All seven insurers split the market into mainframe, engine and sub-components. Six insurers also split the market into engine repair and service, other repair and service, refuellers and general aviation. Five insurers also used ATC as a market classification.

3.6 Market rate rise and capacity

Five underwriters commented on perceived rate rises in 2003 and 2004 and estimated market capacity as at 1/1/2005.

In 2003, two underwriters believe the rise was 6%-10%, one underwriter believes the rise was 11%-15% and two underwriters believe the rise was 16%-20%. The range of answers was even wider for 2004, where one underwriter thought the achieved rate rise was 6%-10%, two underwriters thought it was 11%-15%, one underwriter thought it was 16%-20% and one thought it was 20%-25.

Figure 7 shows estimated market capacity for US critical, US non-critical, non-US critical and non-US non-critical:
The underwriters generally estimated that there was greater capacity for Non-US than US business and greater capacity for Non-critical than critical business.

### 3.7 Summary

We found a wide variety of different approaches to rating business across the seven insurers interviewed. Some were very technical, used a lot of actuarial input and had developed a range of pricing models and approaches. While two insurers had no rating models at all (including one major Products market insurer). One insurer only wrote business where it was possible to technically rate it and as a consequence had pulled out of Component Manufacturers’ business due to difficulties in building a credible rating model.

The majority of the pricing models used by the insurers are relatively new and have been developed in the last three years. Most insurers agreed that the future of Aviation Products pricing was going to involve greater attention to technical analysis and use of pricing models.

We discussed a range of views with underwriters regarding their opinion on the impact of the Montreal convention. Some underwriters believed that the removal of the upper legal liability limit for airlines (which existed under Warsaw) would ease pressure on manufacturers. Others believed that the Montreal convention will lead to greater claims since there is now greater choice on the jurisdiction and more claims will end up in US courts.
4. Some Aviation Products Pricing Considerations

4.1 Long-tail class

Sharing agreements for initial loss settlements are often set up between airlines and manufacturers. The operation of these agreements can be a factor which contributes to the long tail nature of manufacturers’ liability. The claims process may progress as follows:

- After an accident, a provisional sharing agreement is set up to enable claimants to receive payments in a timely manner. Initial court proceedings deal with determining the financial cost of individual awards and not the allocation to airline/manufacturer, this has been dealt with by the sharing agreement. The claim settlement process can take several years.
- A trial/agreement to establish the final apportionment between an airline and a manufacturer is usually not started until most of the victims have received their settlements. If it is decided that the share of liability should differ from the initial agreement, subrogation occurs between the parties involved. This can involve a substantial change in liability for the different parties.

Initial sharing agreements tend to involve the airline and the airframe manufacturer. It is possible that a subcomponent manufacturer may also be implicated, but this often occurs very late in the process.

We note that some insurers may write both the Airline assured and Product assured involved in an accident. In this case, if the line size is similar for both assureds, then a switch in liability from the airline to the manufacturer may not materially affect the insurer. However, it is often the case that the insurers have very different participations in each assured.

4.2 Claim narrative

Below is a claim narrative from an accident to illustrate this process.

*Initial court proceedings started within days of an air crash in which all passengers and crew died. These initial proceedings served not to determine the party responsible for the accident, but merely the extent of the damages. An initial sharing agreement was struck up between the respective insurers of the airframe manufacturer and the airline whereby any resulting claim would be shared in a given ratio. Over the course of the next few years, liability payments were awarded to relatives of the deceased and paid in the aforementioned ratio by the insurers.*

*Only six years after, when the bulk of the claimants had received their settlements, was there a trial to determine the party liable for the accident. At this point, the airline alleged that a faulty PCU (power control unit), affecting the navigation of the aircraft, had been the cause of the accident. For the first time since the air crash, the subcomponent manufacturer, who manufactured the PCU, was brought into the trial.*

*Two years later, the court found the subcomponent manufacturer liable for a share of the total loss in excess of $150m, even though many parties still believe that a pilot error might be the true cause of the accident, and therefore that the airline should have been fully liable. The insurers of the subcomponent manufacturer were forced to reimburse the airline’s insurer for this share of the loss.*
In this specific case, it took six years before the subcomponent manufacturer was involved in the settlement and another 2 years before the claim was settled.

The graph overleaf shows the incurred development for two large subcomponent claims, one corresponding to the above narrative and another with a similar pattern.

Figure 8: Illustration of Aviation Product’s claims characteristics

The graph (Figure 8) shows characteristic “jumps” of incurred amounts corresponding to a late involvement in the litigation process. In both cases the insurer of subcomponent manufacturer saw very low incurred claims four years after the date of loss. Even after 6 years the incurred position was well below the ultimate claims amount. In these 2 cases it is very unlikely that the insurers of the subcomponent manufacturers would be adequately reserved, at development year 6 for these very large claims, which settled well in excess of $150m. Potential for under-reserving of historic claims should be considered in the rating process.

4.3 Loss development factors

The graph below shows example loss development factors for mainframe, engine and component manufacturers.
Component manufacturers can show longer development than mainframe or engine manufacturers. One of the reasons that can explain this late development is the extra time it takes to name a subcomponent in a litigation process, as illustrated above.

These development profiles have been deliberately chosen to show that the profiles for different types of Aviation Products business can be very different. They are not designed to illustrate average development profiles for each type of business. For pricing it is important to choose a development profile that is appropriate for the account being considered.

### 4.4 Legal environment

#### Montreal Convention and the 5th Jurisdiction

The Montreal Convention eliminates airlines’ limits of liability with respect to passengers, which existed in the Warsaw Convention. In addition it introduces a 5th jurisdiction where a victim can claim, the domicile of the passenger. The other four jurisdictions are: destination, domicile of carrier, place of business of carrier and place of contract. The victim/victim’s family has right to choose the jurisdiction from the five options. Some changes that the Montreal Convention may have is as follows:

- Victim/victim’s family may be less likely to file a suit against an airline manufacturer directly, because high compensation is now available from the airline. Hence, manufacturers may not be named in initial proceedings, so in the absence of sharing agreements the manufacturers may not get involved until later, if at all.
- Airlines/Airline insurers are more likely to subrogate against the manufacturer.
- There may be a change in the type of lawyers manufacturers face. They will be less likely to be facing lawyers working for victims families and more likely to be facing lawyers hired by the airlines’ insurance companies. These companies are often large and well funded, and legal advice will normally be obtained from leading law firms that specialise in Aviation law.
- American residents are more likely to bring their case to the US where court awards are the highest.
**Minor subcomponents**

Smaller “nuts and bolts” manufacturers, which are two or three levels down in the manufacturing chain, may seek protection contractually from the main manufacturer (hold harmless agreement, i.e. the main manufacturer will not seek to recover from the smaller manufacturer in the event of a products claim) but they are still exposed to third parties. Some of these smaller manufacturers may effectively be too small to buy Aviation Products insurance on their own and are added under the main manufacturer’s policy.

**GARA (General Aviation Revitalisation Act) 1994**

This was mentioned in the underwriter interviews as a change to the legal environment. This is US legislation. Broadly, GARA sets a time limit of 18 years for actions against manufacturers of general aviation aircraft. We do not think that this act will have a significant impact on the totality of Aviation Products insured claims. Many of the airframe manufacturers continue to provide services and parts to their older airframes and thereby weaken their protection under GARA.

### 4.5 Claims management

We have heard suggestions that some companies are now quickly settling claims even if it is unclear whether there is any liability. Early settlement of claims prevents litigation spanning over many years, consequently reducing the associated legal costs, avoids bad publicity and does not set precedents. Awards can potentially escalate if cases are not settled quickly. If there is this change in companies’ claims management then historical data may not be a good guide to reporting patterns or settlement amounts.

### 4.6 Other Items

The increased exposure with larger aircrafts like the A380, may require greater insurance limits for airlines/manufacturers. Rating adjustments will be needed to allow for the increased limits. Such an allowance is difficult due to the lack of previous experience and therefore adds to the uncertainty regarding an appropriate catastrophe loading for Products insurance.

Liability sharing agreements are sometimes put in place when manufacturers work jointly on an aircraft part. These define how the manufacturers will share liability in the event of products liability arising from the part. They are often seen in relation to engines. They differ from the agreements discussed in section 4.1 above, as they are set up in advance of any accident and bare no relation to the circumstances of any accident. These need to be allowed for in pricing. However, they are difficult to explicitly allow for as one manufacturer may have dozens of these agreements covering different parts and different periods of manufacture.

Lawyers acting for Non-US victims on Non-US flights attempt to get their cases into US courts to try and achieve higher awards. Bringing action against a US manufacturer is a way lawyers try and get cases heard in the US courts.
5 Exposure Measures

A number of different exposure measures are in common use in the market. A few of them are listed below.

- Passenger kilometres
- Passenger voyages
- In-service seats
- In-service aircraft or engines
- Aviation related turnover

It could be argued that passenger voyages is a better measure of risk than passenger kilometres as studies have found that the majority of accidents occur on take-off or landing. A 10,000-kilometre voyage would therefore be a lot less than 10 times riskier than a 1,000-kilometre voyage.

Unfortunately, the exposure measures that best reflect the risk are often the most difficult to obtain figures for. For manufacturers of airframes and engines on large commercial aircraft, there is data available to the insurance market relating to most of the above measures. However, for smaller subcomponent manufacturers, it is almost impossible to track the whereabouts of all products sold.

For these companies, turnover is often the most readily available exposure measure, and is therefore probably the most commonly used measure in the market. However, this measure is flawed as turnover is not an accurate measure of the risk associated with insuring a manufacturer. For example, a manufacturer could have zero turnover in a policy year and yet still have significant exposure as coverage is based on accident year, irrespective of when the aircraft was manufactured or sold. Therefore previous years’ turnover can give rise to claims on the current year’s policy. In fact, older aircraft are generally more likely to have accidents than newer ones. Some underwriters see past production as a key exposure measure.

A better measure might be a rolling average turnover. For example, if an aircraft spends an average of 15 years in service, one might consider using the average (or equivalently total) turnover in the last 15 years as an approximate measure of exposure. Or the historic annual turnover could be weighted by a risk profile. This profile could be derived from age of aircraft in accidents.

The main problem with these exposure measures is their lack of uniformity. For example, a jet engine as one of four on a wide-bodied airliner represents a very different risk to turboprop engine on a cargo aircraft. All of the exposure measures used need large adjustments derived from rating factors (some are discussed in the next section) before they can be of any use for rating.
6 Rating Factors

There is no standard rating methodology used across the Aviation Products insurance market. Therefore, a wide range of rating factors is in use by different insurers. Some of these factors are built explicitly into actuarial rating models. Other, sometimes more subjective factors are commonly used by underwriters as part of the rating process. The underwriter questionnaire/interviews provided an interesting insight into the diverse array of rating factors in use in the market.

This section lists a selection of key rating factors in use today, along with descriptions of how each factor is likely to influence the premium charged.

6.1 Loss history

For large companies with a significant amount of historic data, premiums are often based heavily on the actual claims history of the company.

6.2 Type of component

Most insurers have separate sets of rates for airframe, engine and subcomponent manufacturers. Subcomponents are often split into critical/non-critical, although finer splits than this are sometimes used. Data sources available to the working party, including large loss lists compiled by brokers, these suggested that historically global aviation products claims were split between airframes, engines and subcomponents in a ratio of roughly 70%, 10%, and 20% respectively.

6.3 Type of aircraft

Another key rating factor is type of aircraft, since a small company manufacturing parts for large commercial aircraft can be subject to very large liability claims. Also, the accident rates vary considerably by type of aircraft.

For Aviation Products pricing “type of aircraft” is normally taken as a broad differentiation of type. For example, jets v turboprop v rotor wing. Rather than a detailed make and model differentiation.

Different premium rates tend to be charged for commercial, military and private aircraft. The commercial category tends to be split further according to size of aircraft. Some companies have different rates for narrow-bodied and wide-bodied aircraft.

Insurers tend to charge lower rates (per aircraft) for military aircraft. This is due to hold harmless agreements that insureds obtain, stating that the military operator will not sue the manufacturer. Manufacturers are still liable for claims from third parties, but it is expected that the third party would normally seek compensation from the military operator.

Satellites and missiles are sometimes considered as categories of Aviation Products. Insurers often use separate rates for these risks.
6.4 The manufacturing process

For larger risks, underwriters sometimes visit the insured’s premises in order to weigh up factors such as the standard of safety controls and the use of technology in the manufacturing process. One of the underwriters we interviewed mentioned that credit was given to companies who had automated certain processes as it reduced the risk of human error.

6.5 Use of aircraft

Consideration can be given to the use to which aircraft are put. For example, passenger aircraft may be considered higher risk than cargo aircraft, as large awards can be made for passenger deaths from aircraft accidents. Different rates may be charged for business jets that are only used occasionally.

6.6 Geographic region

The jurisdiction within which litigation takes place has an enormous impact upon the amount of any liability settlements. Plaintiffs may have a degree of freedom to choose which country to sue manufacturers in. Therefore, they will try and get cases heard in the jurisdiction where they expect to receive the greatest settlement. In the period from 1996 to 2002, settlements for passenger fatalities averaged $2.9m in the US, $1.1m in Europe and $0.5m in Africa.

As a result, higher rates may be charged to manufacturers for whom a high proportion of sales are in the US. For Aviation Products, it is often very difficult to obtain a breakdown of exposure by geographic region. Insurers often rely on approximate figures, and sometimes only differentiate rates for US and non-US exposure.
7 Rating Approaches

There are a very wide variety of different Products Liability exposures. Therefore, different rating approaches are needed for different types of business. There is not one general rating model that can effectively be applied to all accounts. For example, a major mainframe manufacturer may provide full development triangles for a 30-year period and a detailed breakdown of active units. By contrast, a sub-component manufacturer may have had zero claims and just provide sales figures for the last two years. For the mainframe manufacturer experience rating may help with pricing, but this would be of little value for the sub-component manufacturer. Also, the exposure measures will be different for each account.

The sections below look at how a “loss pick” for the “pure premium” could be developed, i.e. just the expected claims element of the premium. This would then need to be loaded for items such as expenses, profit, cost of capital, reinsurance costs, etc. Some sort of credibility approach could be used to combine experience and exposure rate estimates.

7.1 Experience Rating

Standard actuarial experience rating approaches can be applied to Products business. However, due to the catastrophe element of Aviation business (one accident could easily give rise to insured claims in excess of $1b) experience rating is often only applied to lower layers. For example, an account with $1b limits could be experience rated to $50m and a Cat load added x $50m. The experience rating could be as follows:

- **Develop to ultimate.** The appropriate development factors must be applied. As shown in Section 4 the development profile varies considerably for different types of Products business. For large accounts, account specific development factors should be selected and compared to benchmarks, before the final development factors are selected. Large losses should be analysed separately. Development may not be necessary for large losses as current incurred value may represent the amount the claim was actually settled for, or the best estimate of ultimate for that claim. For more recent years a Bornhuetter-Ferguson approach could be used. An “a priori” amount per exposure unit could be selected based on average ultimate selections for prior years allowing for trend to the year being considered, or taken from an exposure rate estimate.

- **Cap large losses at a chosen level.** For example, $50m in current day values but trended down for each prior year.

- **Exposure adjust** to projected exposures for the insured period.

- **Trend** to insured period values.

- **Select experience estimate** of losses. Each year of loss data would provide an estimate of the experience rate. Averages over different periods should be considered. Oldest years may be of little value as a lot of adjustment may be required for trend and exposure. Most recent years may be of little value as they may be too immature, but they may give an indication of presence/absence of Cat losses.

7.2 Catastrophe Loading

Some possible approaches to Cat loading are set out below:

- **Products Large Loss Curve** – Broker information on large losses can be used to create a market large loss curve. As this is being used to price individual accounts each manufacturers’ contribution to an event can be treated as an individual claim. Hence, there can be multiple Products claims from one event. The large loss data can be trended to current values. From the trended data, historical empirical frequency and severity market large loss curves can be obtained. Statistical distributions can be...
fitted or the size banded empirical data can be used for pricing. Separate curves can be directly created for different classes of account, e.g. mainframe / engine / components, by categorising the large loss data by class. However, this approach has the problem of lack of historical data for some classes. One approach could be to develop a Products market large loss curve and then sub-divide this curve to class. This would be best performed in size bands, as the percentage by class would vary by size of loss, e.g. >$750m 90%/7%/3% mainframe / engine / components, $250m- $750m 75%/10%/15%. The percentages could be estimated from historical data and judgement. For an individual account an estimate of the market share of the class is needed so a cat load can be derived from the class large loss curve. For example, for each engine manufacturer units in use are known, split by airplane type. Weighted factors could be applied to obtain market share. This market share can be applied to the large loss curve to get a cat loss pick.

- **Scenario assessment.** For some accounts any market share assessment could be difficult. Here one subjective approach is to estimate representative large losses and return periods. For example, an account requiring cat loading from $100m to $750m may estimate two losses, one of $200m and one of $500m with return periods of 1 in 50 years and 1 in 250 respectively. Clearly, this is very subjective and a good knowledge of historic market large losses is required.

- **Market Cat Loads.** Market cat loads can be assessed for each product segment and allocated down to accounts using a risk scoring system. So that if the market was written then the market Cat load would be added.

- **Reinsurance EAM’s** - Some insurers have analysed their exposure adjustment mechanisms (EAM’s), which are on their outwards reinsurance programmes, as an initial guide to catastrophe exposure weights.

### 7.3 Exposure Rating

Some insurers have developed exposure rating models. These tend to be spreadsheet based models. A base rate is often obtained for a given level of cover and unit of exposure. This base rate is then adjusted for various rating factors e.g. those shown in Section 6 above. Generally these models are difficult to develop, as there is no uniformity of exposure measures across different accounts, and the very low frequency of claims (e.g. compared to Motor/Property). Thus, statistically credible models are difficult to produce. Correlations between rating factors are hard to allow for, as there is often insufficient claims history. There is insufficient data for effective generalised linear model (GLM) analysis. However, we believe it is important that insurers try and help develop these models even if subjective judgements are required in the parameterisation. The working party would like to develop a generic exposure rating model if the sub-group continues its work in the future.

### 7.4 Rating Issues

Here is a list of some of the rating issues that the working party sub-group has discussed over the year:

- **Trend rates.** These are very difficult to estimate but vital in the experience rating.
- **Safety improvements.** Generally there have been significant improvements in aircraft safety over the last 20 years. This needs to be understood and allowed for appropriately in rating. For example, safety improvements have been far greater for Airlines than for Helicopters.
- **Manufacturer’s hull and property damage claims need to be separated from bodily injury claims for developing to ultimate and trending to exposure period values.**
- **Legal changes.** For example, what impact will Montreal Convention have on Products claims?
- **Is there an increasing contribution from Products insurance in large aviation claims?**
• Has there been a trend for an offering of an early settlement figure from manufacturers even if there is no clear liability? See Section 4.5.
• Discounting claims. Some types of Product business have a very long delay from receipt of premium to expected time of payment of claims. The underwriter interviews indicated that some insurers do explicitly discount as part of the rating process and others do not. One underwriter said that they used to discount when interest rates were higher but they no longer do.
• Large aviation claims are more likely to have a Products involvement than small claims.
8 **Large Loss Analysis**

The working party had access to aviation large claims databases maintained by major brokers. These showed the insured market loss for each event, split by contribution from each insured. We classified each insured e.g. airline/mainframe manufacturer/engine manufacturer/etc. This enabled us to analyse the incidence of large claims by market sector.

We performed an analysis of large losses between 1984 and 2003, based on data held at 31 December 2004. The data contained details of 309 events during this period (excluding September 11th 2001 losses). Our findings are set out below.

When interpreting our analysis, it is important to bear in mind the following:

- Losses stem from Manufacturer’s Hull, Property Damage and Liability classes
- September 11th 2001 losses related claims have been excluded from the analysis
- All claims were revalued as at 2005 using an inflation of 5%
- Claims have been taken at their incurred market loss. No development factors have been applied.

8.1 **Claim frequency and severity**

Due to the infrequent nature of aviation catastrophes, it was not always easy to identify frequency, severity and other trends. We found that due to the data limitations, it was helpful to analyse the data in five-year blocks. Figure 10 below shows the split of aviation claims in each five-year block.

<table>
<thead>
<tr>
<th>Period</th>
<th>No Events</th>
<th>Amount of Claims ($m)</th>
<th>% of Total Amount of Claims</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Airlines</td>
<td>Airports</td>
</tr>
<tr>
<td>1979 - 1983</td>
<td>23</td>
<td>3,890</td>
<td>171</td>
</tr>
<tr>
<td>1984 - 1988</td>
<td>33</td>
<td>6,009</td>
<td>1</td>
</tr>
<tr>
<td>1989 - 1993</td>
<td>81</td>
<td>7,321</td>
<td>39</td>
</tr>
<tr>
<td>1994 - 1998</td>
<td>80</td>
<td>6,271</td>
<td>253</td>
</tr>
<tr>
<td>1999 - 2003</td>
<td>92</td>
<td>6,358</td>
<td>191</td>
</tr>
<tr>
<td>1979 - 2003</td>
<td>309</td>
<td>29,850</td>
<td>656</td>
</tr>
</tbody>
</table>

Figure 10 shows that there was a significant increase in the overall products liability share of all aviation large losses during the mid-1990s, from 19% to 38%. Given the long-tailed nature of aviation products business, the ultimate share of the overall claims for 1999-2003 may be well in excess of the 18% products share to date.

The largest individual revalued claim is $1.3b. This is from a 1988 event with airline involvement of about $550m.

The graph and table overleaf (Figure 11) illustrate the severity of individual claims split between airlines, airports and the five products sub-categories. These claims have not been aggregated, they represent an individual assured’s contribution to an event losses.
Figure 11: Severity of individual claims

<table>
<thead>
<tr>
<th></th>
<th>All claims</th>
<th>Claims above $10m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Claims</td>
<td>Average Value ($m)</td>
</tr>
<tr>
<td>Airlines</td>
<td>355</td>
<td>85</td>
</tr>
<tr>
<td>Airports</td>
<td>36</td>
<td>18</td>
</tr>
<tr>
<td>Boeing/Airbus</td>
<td>155</td>
<td>29</td>
</tr>
<tr>
<td>Airframes</td>
<td>42</td>
<td>23</td>
</tr>
<tr>
<td>Engines</td>
<td>50</td>
<td>27</td>
</tr>
<tr>
<td>Subcomponents</td>
<td>53</td>
<td>15</td>
</tr>
<tr>
<td>Others</td>
<td>109</td>
<td>11</td>
</tr>
</tbody>
</table>

One observation is that there have been far more large airlines claims than products claims. Within Aviation Products, Boeing and Airbus have suffered the highest frequency and severity. The ‘Subcomponents’ figures show that manufacturers of minor components can suffer very large claims.

Companies who make subcomponents for Boeing and Airbus can be liable for huge amounts in the event of a crash. Some such companies have relatively low turnovers, and based on this have had very low insurance premiums in the past. This demonstrates one reason why turnover may be a misleading exposure measure to use in the rating process.

8.2 Large losses

The graph overleaf (Figure 12) provides a graphical representation of the large loss data. It plots the total value of claims aggregated by event.
Figure 12: Large Losses

For illustration purposes, the arrow in the above graph indicates a major 1994 accident, which settled for about $475m ($810m inflated at 5% p.a. to 2005 values). In most cases, the loss per event is shared between several parties. Figure 13 overleaf shows the losses relating to Products only (aggregation of products claims by event).
It is important to note that most of the losses in the above graph represent the accumulation of several individual products claims. For example, in the case of the 1994 accident, the revalued overall total cost of $810m is split roughly between the airline ($60m) and the manufacturers involved ($750m) indicated by the arrow. The products loss ($750m) is roughly split between the airframe manufacturer ($435m), a component manufacturer ($310m) and four other subcomponents manufacturers ($5m).

There is evidence from the graph that the frequency of Products’ very large losses has increased over the period. We further investigated this apparent trend, see below, by considering “significant” claims (defined to be above $5m) within large events (defined to the above $50m), both in terms of frequency and total claim amounts.
8.3 Significant Products Involvement

The table below (Figure 14) shows the number of significant products claims (above $5m) divided by the number of large events (above $50m). This could be interpreted as the empirical probability of having a significant contribution from products claims when a large event occurs.

Figure 14: Number of “significant” claims

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total No Events</td>
<td>21</td>
<td>29</td>
<td>60</td>
<td>53</td>
<td>37</td>
<td>200</td>
</tr>
<tr>
<td>No Events with significant involvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airlines</td>
<td>21</td>
<td>27</td>
<td>55</td>
<td>47</td>
<td>36</td>
<td>186</td>
</tr>
<tr>
<td>Airports</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Products</td>
<td>5</td>
<td>12</td>
<td>22</td>
<td>22</td>
<td>13</td>
<td>74</td>
</tr>
<tr>
<td>Percentage with significant involvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airlines</td>
<td>100%</td>
<td>93%</td>
<td>92%</td>
<td>89%</td>
<td>97%</td>
<td>93%</td>
</tr>
<tr>
<td>Airports</td>
<td>5%</td>
<td>0%</td>
<td>3%</td>
<td>6%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Products</td>
<td>24%</td>
<td>41%</td>
<td>37%</td>
<td>42%</td>
<td>35%</td>
<td>37%</td>
</tr>
</tbody>
</table>

Note - The percentages add to more than 100% as a large event may have a large involvement from 1, 2 or 3 of Airlines/Airports/Products.

The figure shows clearly that there have been far more large airlines claims than products claims. However, the likelihood of having a significant products contribution has increased from 24% in 1979-83 to about 40% over the rest of the period. Due to the long-tail nature of products liability claims, it is possible that the 35% figure for 1999-2003 could rise further.

37% of large losses during the 25-year period had a large products contribution. Why are products claims so common in the event of major air catastrophes? One factor could be that Boeing, Airbus and other manufacturers operate at much higher profit margins than most airlines. This may lead plaintiffs to see manufacturers as a more lucrative target than airlines. Also, under the Warsaw Convention airline liability was limited so the manufacturer may have been cited in an attempt to recover more than the limit.

The table below (Figure 15) shows the figures computed on the amounts of claims.

Figure 15: “Significant” claim amounts

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of Claims ($m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airlines</td>
<td>3,798</td>
<td>5,870</td>
<td>6,607</td>
<td>5,628</td>
<td>5,061</td>
<td>26,963</td>
</tr>
<tr>
<td>Airports</td>
<td>167</td>
<td>0</td>
<td>37</td>
<td>203</td>
<td>160</td>
<td>567</td>
</tr>
<tr>
<td>Products</td>
<td>170</td>
<td>1,403</td>
<td>1,573</td>
<td>3,704</td>
<td>1,060</td>
<td>7,909</td>
</tr>
<tr>
<td>Total</td>
<td>4,135</td>
<td>7,272</td>
<td>8,217</td>
<td>9,534</td>
<td>6,280</td>
<td>35,439</td>
</tr>
<tr>
<td>Percentage of Total Claims</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airlines</td>
<td>92%</td>
<td>81%</td>
<td>80%</td>
<td>59%</td>
<td>81%</td>
<td>76%</td>
</tr>
<tr>
<td>Airports</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Products</td>
<td>4%</td>
<td>19%</td>
<td>19%</td>
<td>39%</td>
<td>17%</td>
<td>22%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

As highlighted previously, the Products’ involvement has increased during the mid-1990s. In order to analyse more specifically the Products’ claims, we have categorised all the Products’ claims in the data as one of the following subcategories:

- Boeing or Airbus
- Airframes - Other
- Engines – Major
- Subcomponents – Major
Figure 16 below shows the number of significant involvements (above $5m) for each product sub-category divided by the number of large events (above $50m).

**Figure 16: Number of “significant” Products claims**

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total No Events</strong></td>
<td>21</td>
<td>29</td>
<td>60</td>
<td>53</td>
<td>37</td>
<td>200</td>
</tr>
<tr>
<td><strong>No Events with significant involvement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boeing &amp; Airbus</td>
<td>3</td>
<td>7</td>
<td>11</td>
<td>13</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>Airframes</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Engines</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>SubComponents</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td><strong>Percentage with significant involvement</strong></td>
<td>14%</td>
<td>24%</td>
<td>18%</td>
<td>25%</td>
<td>16%</td>
<td>20%</td>
</tr>
<tr>
<td>Boeing &amp; Airbus</td>
<td>5%</td>
<td>3%</td>
<td>7%</td>
<td>6%</td>
<td>14%</td>
<td>7%</td>
</tr>
<tr>
<td>Airframes</td>
<td>5%</td>
<td>10%</td>
<td>8%</td>
<td>6%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Engines</td>
<td>5%</td>
<td>3%</td>
<td>5%</td>
<td>11%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>SubComponents</td>
<td>5%</td>
<td>10%</td>
<td>5%</td>
<td>15%</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>Others</td>
<td>5%</td>
<td>3%</td>
<td>5%</td>
<td>11%</td>
<td>3%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Note the numbers within Figure 16 are higher than the 74 Products claims in Figure 14, as the Products element has been split into the finer subdivisions. For example, you could get Airframe, Engine and Sub-component significant claims for one event.

Figure 17 below plots the above percentages using the mid year of the 5 year-bands.

Figures 16-17 above show that on average, the historical probability of Boeing/Airbus category making a significant contribution towards large events is about three times higher than other Products Manufacturers’ categories. Boeing/Airbus make the largest passenger airplanes, so it is perhaps not surprising that overall they have historically made a large contribution to large events. There may also be an element of “deep pocket syndrome” as to why Boeing/Airbus have made significant contributions.
We show below an analysis of the amounts rather than the numbers. Figure 18 below shows the proportion of significant products subcategories claims (above $5m) within the total value of products claims of large events (above $50m).

Figure 18: “Significant” Products Claims amounts

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Boeing &amp; Airbus</td>
<td>76</td>
<td>1,154</td>
<td>559</td>
<td>1,785</td>
<td>694</td>
<td>4,268</td>
</tr>
<tr>
<td>Airframes</td>
<td>47</td>
<td>7</td>
<td>153</td>
<td>345</td>
<td>196</td>
<td>749</td>
</tr>
<tr>
<td>Engines</td>
<td>16</td>
<td>127</td>
<td>669</td>
<td>243</td>
<td>0</td>
<td>1,055</td>
</tr>
<tr>
<td>SubComponents</td>
<td>9</td>
<td>15</td>
<td>73</td>
<td>637</td>
<td>21</td>
<td>755</td>
</tr>
<tr>
<td>Others</td>
<td>22</td>
<td>89</td>
<td>95</td>
<td>683</td>
<td>133</td>
<td>1,023</td>
</tr>
<tr>
<td>Total Products</td>
<td>169</td>
<td>1,393</td>
<td>1,550</td>
<td>3,694</td>
<td>1,045</td>
<td>7,850</td>
</tr>
</tbody>
</table>

Percentage of Total Claims

| Boeing & Airbus | 45% | 83% | 36% | 48% | 66% | 54% |
| Airframes      | 28% | 1%  | 10% | 9%  | 19% | 10% |
| Engines        | 9%  | 9%  | 43% | 7%  | 0%  | 13% |
| SubComponents  | 5%  | 1%  | 5%  | 17% | 2%  | 10% |
| Others         | 13% | 6%  | 6%  | 18% | 13% | 13% |
| Total Products | 100%| 100%| 100%| 100%| 100%| 100%|

Figure 19 below plots the above percentages using the mid year of the 5 year-bands.

Figures 18-19 above demonstrate the extent to which Boeing and Airbus dominate historical large losses. These two major airframe manufacturers have generated 54% of the Products large losses in the last 25 years. Perhaps surprisingly, major engine manufacturers have only generated 13% of the losses, while major subcomponents accounted for 10%.
Appendix

Aviation Working Party – Products Sub Group
Questionnaire for Underwriters – May 2005

Aims

- To meet with Product Underwriters to discuss Aviation Product Market and Pricing approaches.
- The questionnaire provides a framework to structure discussions and also analyse answers.

Questionnaire results individually confidential

Underwriter Questionnaire

Account

- Roughly what was your Aviation Products premium income in 2004?
  Less than $10m, $10m-$25m, $25-$50m, > $50m
- What was your maximum line size in 2004?
  <$25m, $26m-$50m, $51m-$100m, $101-$200m, >200m

Rating

- What type of rating models do you have for Product business?
  Spreadsheet/Programmed model/Other/None.
- Do you use stochastic models? Yes/No
- What percentage of Products premium income is rated using a standardised model?
  0-20%, 20%-40%, 40%-60%, 60%-80%, 80%-100%
- How long have you been using rating models for?
  Don’t use, less than 1 year, 1-3 years, 3-6 years, more than 6 years
- How do you generally use the output of rating models?
  Broad guide to rates, price from model always quoted, rarely quote below model rates, other.
- Do you get actuarial assistance in rating? Yes/No
  What % of your Products book is actuarially rated?
  By income - 0-20%, 20%-40%, 40%-60%, 60%-80%, 80%-100%
  By policy count - 0-20%, 20%-40%, 40%-60%, 60%-80%, 80%-100%
- What rating factors do you use?
  Claims history / Sales / Units in operation / Flying hours / others (please list)
- In rating do you develop historic losses to ultimate? Yes/No
  Where do you get development factors? Account specific / benchmark / other.
- Do you trend historic Product claims to current levels? Yes/No
  What trend rates do you use for bodily injury losses?
  0-2%, 3-4%, 5-6%, 7-8%, 9-10%, 11-12%, 13-14%, >15%
  How were the trend rates derived?
- Do you use:
  Experience rating (based on historic claims) – Yes/No
  Exposure rating – Yes/No
  If both approaches are used how are results combined?
- Is there a set level for which you define attritional / large losses? – Yes/No
  If yes what is it at 100% level? $5-$10m, $11-$25m, $26m-$50m, $51m-$100m, >$100m
Discussion questions:

- How do you rate for attritional claims?
  Historic losses / benchmark rate / other
- How do you rate for potential large/cat claims?
  Cat load derived from historic market large losses / min rate for limit / other.
- How do you allow for changes in exposures over time in rating an account?
- How do you allow for difference in exposure by territory in rating?
- Do you take an overall view on Product market losses and allocate to specific accounts in rating, i.e. top down approach?
- In 2004 did you monitor how achieved rates compare to modelled rates?

Products Insurance Market

- What market segmentation do you use to analyse your data?
  Mainframe / Engine / sub-components / engine repair and service / other repair and service / airports / ATC / military / GA / other
- What rate rises do you believe the market has achieved in 2003 and in 2004?
  2003 – <0%, 0%, 1%-5%, 6%-10%, 11%-15%, 16%-20%, 20%-25%, >25%.
  2004 – <0%, 0%, 1%-5%, 6%-10%, 11%-15%, 16%-20%, 20%-25%, >25%.
- How have terms and conditions changed over the past 3 years?
- What do you estimate the Products insurance capacity for an individual risk was at 1/1/05?
  US critical - $1.5, $2b, $2.5b, $3b, $3.5b, $4b
  US non-critical - $1.5, $2b, $2.5b, $3b, $3.5b, $4b
  Non-US critical - $1.5, $2b, $2.5b, $3b, $3.5b, $4b
  Non-US non-critical - $1.5, $2b, $2.5b, $3b, $3.5b, $4b
- What significant Legal issues have there been in the last 3 years?