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RESERVING FOR CATASTROPHE REINSURANCE

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ABSTRACT

The paper sets out the method required to be followed when estimating reserves for a Company or a Lloyd's Syndicate which has accepted reinsurance treaties that have given rise to catastrophe losses, sufficiently large to upset the normal development pattern and to affect the gross account quite differently from the net account. The losses may be caused by single factors such as aircraft crashes or oil rig disasters, or by the aggregation of claims resulting from a windstorm or an earthquake. The paper discusses two possible approaches to estimation of the gross losses; via exposure totals or via statistical modelling techniques.

KEYWORDS

Reserving; Catastrophe Losses; Gross to Net Reserving

1. Subject Matter

1.1 A company or Lloyd's syndicate which accepts catastrophe reinsurance business faces the problem, where a catastrophe is known to have occurred, of deciding on the provision it should set aside for meeting the resulting claims. The claims resulting from catastrophes do not conform to the normal pattern of claims development found elsewhere, particularly those in recent years where settlement is often much faster than it has been in the past. Nor do they form a uniform pattern amongst themselves, for each catastrophe is unique to itself in the rapidity with which it gives rise to the claims stemming from it.

1.2 Hence, arriving at reasonable figures for the reserves required on the overall account is particularly difficult. The probable amount of loss may be ascertainable, albeit with some difficulty, in regard to the gross account, but the net account is so heavily influenced by the outwards reinsurance protections that an uneven and even a zig-zag pattern of development results, which is impossible to analyse statistically if examined only on an overall account basis. This paper sets out a method for handling such problems. It conforms, in general terms, to methods devised by actuaries as they have come to face the type of problem depicted herein.

1.3.1 Throughout the paper, where the term 'gross' is used in regard to the inward account, what is actually meant is usually described in the reinsurance market as 'gross net', which is the gross account less risk-related reinsurances outwards, that is, less proportional reinsurances arising from either the facultative reinsurance of individual risks or else proportional treaty reinsurance outwards of classes or of specific risks, a defined part of each of which is being allocated to the treaty.

1.3.2 By 'net' is meant net absolute, i.e. net after the excess loss protections have been brought into play, but before provision is made for any subsequent whole account subrogations net of the excess loss protections, if such exist.

1.4 The reserving problems apply specifically to those offices and Lloyd's syndicates which specialise in catastrophe risk, mainly through LMX underwriting, but also apply to almost any office in the reinsurance market, as today most offices have to carry a certain amount of catastrophe risk in order to obtain other business and to assist in a wider placing of such risks. They also apply, to a much more limited extent, to direct insurers as a result of their outwards reinsurance protections and the need to estimate the amounts they will recover from their reinsurers.

1.5 There are two possible paths of analysis available for estimating the ultimate effect of catastrophe losses:

exposure analysis, and
statistical forecasting.

Exposure analysis is the tool that must always be used by the underwriter when setting up the portfolio of business written. As to forecasting the ultimate top amounts of catastrophe claims known to have arisen, exposure analysis is the obviously available tool and should always be pursued as an indication of the top limits possible. Unfortunately, it usually gives rise to not inconsiderable problems in seeking to set levels of reserves.

2. Inwards Reinsurance

2.1 *Exposure*

2.1.1 The exposure limit is sought by examining the records of each risk written for the year of account concerned, deciding whether the line written is exposed to the catastrophe under examination and, where there is exposure, adding up the amount of cover made available under the contract.

2.1.2 It is often not possible to determine the quantum of exposure under proportional facultative or treaty business accepted, and normally the search is restricted to excess of loss contracts of reinsurance.

2.1.3 In the case of losses arising from specific events such as aircraft crashes, rig losses, ship losses, oil spills and large fires, it is normally relatively easy to see what contracts will be involved, although there will usually be 'fuzzy edges' in respect of contracts which may be dragged into the picture if claims should arise from sources other than expected.

2.1.4.1 In the case of catastrophe losses arising from the accumulation of a large number of individual policies, such as after hurricanes or earthquakes, somewhat more difficulty exists in determining which contracts may be involved and to what extent.

2.1.4.2 In the case of American losses, the direct insurers involved are normally in a position to judge very rapidly what their losses are expected to

amount to, but may not be very willing to provide them. Where direct advices are not provided, recourse can be had to data provided by bodies such as *Best Insurance Review* in order to obtain a measure of the relevant class of business written by each company, taken as a percentage of business written by all insurers in the area covered. Those percentages are then multiplied by the amount of overall loss so expected to provide the figures concerned.

2.1.4.3 In other countries somewhat similar methods can be employed, using, perhaps, figures available from returns made to regulating authorities, but less precision is likely to be obtainable.

2.1.5 For retrocession treaties, the quantum of catastrophe exposures of any type is likely to be much more difficult to track, and upper limits become almost indeterminate.

2.1.6 In the case of spiral business arising from LMX business on LMX, further difficulties arise and the picture becomes even more difficult of analysis. Currently LMX on LMX business has virtually disappeared from the market, but earlier underwriting years are deeply involved.

2.1.7 In all types of catastrophes and for all types of contracts it would seem to be necessary to obtain an estimate of the total cover that may be involved on each risk written, and then to multiply it by two factors:

(a) the probability of the risk being involved at all, and
(b) the percentage of the total cover provided that may be involved.

2.2 *Statistical Forecasting*

2.2.1.1 As a starting point, it is necessary to have available a computer system which can provide, at very least, quarterly development figures of each catastrophe by source of business (see §2.2.3). Monthly development figures would be preferable—even weekly for very large catastrophes.

2.2.1.2 Inwards business will include reinsurance covers arising from treaties with different start points and different durations, so that any catastrophe may have affected two or three years of account, although the figures from one year of account usually predominate. It will be found to be advisable to start from totals of losses from all years of account added together.

2.2.2.1 The inwards business may well contain losses relating to any one catastrophe arising from:

Facultative reinsurances of individual insurances,
Proportional treaties,
The specific reinsurance of a cedant protecting one proportional treaty,
Generals, protecting all business written by the cedant, but limited to one or a few classes of business,
Whole account protections,
Top and drop protections, and
Other more unusual types of reinsurance, such as so-called franchise cover,

where the reinsurance depends on total market losses being in excess of a specified minimum amount.

Also, the claims may come from each of several different layers with different excess points and limits, back-up covers and other acceptances of which different percentages have been written. It may be argued that the catastrophe statistics are better analysed on a ground up basis for claims arising from each cedant, perhaps all on a 100% acceptance basis, to produce uniformity, but ground up losses amalgamated for a large number of cedants do not necessarily give the same pattern as will be produced for the inwards business as a whole, owing to the effect of different types of reinsurance and different percentage acceptances for each layer and each cedant.

2.2.2.2 A more effective division might be between low-level and high-level reinsurance acceptances. The low-level reinsurances will have been affected at an early stage by any large catastrophe, but claims notified may not breach higher-level protections until a later stage, when sufficient notifications have been accumulated.

2.2.2.3 Most treaties define catastrophe losses as those caused by a specific event and occurring within a period of 72 hours. Where a particular event, perhaps a windstorm, causes losses during a longer period, the cedant has the right to define the period and to divide the losses, if required, into two or more catastrophes.

2.2.2.4 The treaties of reinsurance normally specify the rates of exchange applying between U.S. dollars (and Canadian dollars) and pounds sterling for purposes of checking the effect of excess points and limits. Currently this is normally 2:1, but other rates have applied at times in the past, and there may be variations between different treaties in the same year. The outwards treaties similarly carry stated rates of exchange, but the rates can differ from those on the inwards treaties. Other currencies are normally converted into £ sterling or dollars when claims are settled with outstanding claim advices converted at the rate of exchange applying at the time of advice. The result may produce distortions, but they are usually minor and may be ignored. Outwards reinsurance recoveries are called for in the main currencies in the ratio that results from the inwards business, but precise practice varies from office to office, and the resultant effect can be very complicated.

2.2.2.5 The losses themselves will stem from the date of the catastrophe, and hence the quarterly statistics should start from the end of the first quarter during which the catastrophe occurs.

2.2.3 The type of business being insured and the insuring channel through which the advice has come are of importance. Wide variations in rates of advice are found in practice, and these variations have considerable effect on the estimates of ultimate claim amount.

2.2.3.1 In the U.S.A., when there has been a catastrophe such as a hurricane that has caused extensive damage on the coast, the direct writing companies

virtually all have claims adjusters at their disposal who are sent immediately to the area concerned, to live in mobile homes or caravans where necessary and to settle the smaller claims on the spot. Even with larger claims the claims adjusters can obtain a very close estimate of the amounts of loss concerned, and there remain only miscellaneous claims from unexpected sources or of amounts arising because the damage was more extensive than first appeared. Hence the U.S. CAT account, as it is usually called, will develop very rapidly indeed and will show reasonably completed figures in a short period of time.

2.2.3.2 In Britain and on the Continent the advices are rapid, but not as quick as in the U.S.A. The worldwide CAT account will take somewhat longer to develop, particularly if the catastrophe has been in a part of the world where immediate response services are not available.

2.2.3.3 Thereafter the losses begin to circulate through the market, and hence advices in respect of retrocessions and LMX accounts are a good deal slower and can be affected by spiralling when the account includes the reinsurance of LMX business itself.

2.2.3.4 Slowest of all will be the marine part of non-marine losses such as Hurricane Hugo. The cause stems mainly from the acceptances of so called 'incidental non-marine business' by marine syndicates. Within syndicates writing such business, the non-marine parts of the catastrophes are not covered by marine excess of loss covers, and must wait until they have extended into the whole account protections. Hence there may be a very considerable delay, and in practice one finds that there are almost no advices at all for periods of up to 2 years; very rapid development continuing for some time thereafter. In some cases the overall claim cost may remain relatively small, but in others it is large, particularly in the cases of Hurricanes Hugo and 90A.

2.2.4 Once the development figures have been obtained by catastrophe and by source in the form of a development pattern of claim amounts at quarterly (or more frequent) rests, it is possible to move towards an estimation of the ultimate figure that is expected. It is preferable to work with incurred losses, provided care has been taken in recording outstanding claim advices and they have been provided by reasonably reliable sources. The paid claims sometimes are small for so long that they do not provide a reasonable basis for extrapolation, particularly where one is trying to estimate the ultimate effect of a catastrophe at a fairly early stage of development. Perhaps extrapolation should be made on both bases.

2.2.5 Provided all the figures used in setting up the development pattern have been converted at the currency exchange rates specified in the treaties, there should not be much difficulty arising from currency exchange rates. If substantial amounts of claims are advised in currencies with fluctuating exchange rates, then the analysis may have to be carried separately by currency.

2.2.6 In the estimation process the traditional chain ladder methods are of little or no assistance, for there is no pattern developed by one catastrophe or one set of catastrophes that can be used for another. Each is unique in itself. At best some link ratio factors can be developed for the catastrophe itself and then

smoothed by a fitting process which will give rise to a tail factor, but great care is necessary in order to obtain reasonable results. The size of the tail factor will be crucial to the results and may not be easy to establish.

2.2.7 A method which seems to work in most cases is that of modelling with a double set of parameters by use of a double Gauss curve (see 'Techniques of Reserving—The London Market', by D. H. Craighead, *J.I.A.* **113**, 411).

The curve is of the form:

$$I(t) = A(S)\{1 - e^{-(t/B(S))^2}\} + A(L)\{1 - e^{-(t/B(L))^2}\}$$

where:
$I(t)$ is the losses advised at point of development time t,
$A(S)$ is the ultimate total of short-tail losses,
$A(L)$ is the ultimate total of long-tail losses,
$B(S)$ is the parameter determining the length of tail of the short-tail losses, and
$B(L)$ is the parameter determining the length of tail of the long-tail losses.

In practice a large number of values of $I(t)$ are available, the more the better (and hence monthly development figures are better than quarterly) and the values of $A(S)$, $A(L)$, $B(S)$, $B(L)$ are calculated as such values as will minimise the weighted sum of squares:

$$\frac{\Sigma\{I(t) - I'(t)\}^2 \times t}{\Sigma t}$$

where $I'(t)$ is the calculated value of losses advised as obtained from the curve defined by the parameters so estimated. The ultimate loss amount expected is then $A(S)+(A)L$.

2.2.8 In practice it is found useful to multiply each value in the numerator by t before summing so as to give more weight to the later values, and the sum so obtained is divided by Σt so as to obtain a mean weighted value which can be compared with other values obtained from different numbers of points used in other estimates of a similar nature, so as to provide some idea of the 'goodness of fit' so obtained.

2.2.9 A screen showing the curve so produced must be used to make sure that a reasonable fit has been obtained, and very often it is necessary to shift the start point backwards and forwards in order to obtain such a fit. A close examination of the closeness of fit of the curve to the development points over (say) the last 2 years will assist in a decision as to whether the ultimate figure is reasonable.

2.2.10 The greatest difficulty will arise in the early stages of development, where the points form a straight line upwards or even a concave curve to the left. Even then, a modelling curve of the shape usually found, obtained by presetting parameters $B(S)$ and $B(L)$, will produce results which can then be examined for rough credibility, perhaps against development patterns found for earlier catastrophes at the same duration of development, but bearing in mind the different development patterns found for different catastrophes and different channels of reporting.

2.2.11.1 Once an 'ultimate' figure is obtained for a specific catastrophe, the

figure can be disclosed to the underwriters and claim managers concerned. However, even with a 'feel' for the situation and assisted by general market talk, it may be difficult for them to express a reliable and well rounded opinion. More specific guidance may be rendered by producing further information via a graphical picture of likely further development.

2.2.11.2 The modelling curve should be shown, printed out against the actual development points. By using that point at which the long-tail portion of the curve reaches 98% of expected value as being twice the $B(L)$ value, it is possible to indicate on the curve a date at which that point will be reached. This percentage is obtained by putting $B = t/2$ in the long-tail portion of the formula, so that:

$$1 - e^{-4} = 0{\cdot}9817.$$

2.2.11.3 The graph can then be shown in that form to the underwriter and to the claims manager, who know how rapidly advices are coming in and from what sources. They can then judge whether the point of completion is reasonable. If it appears unreasonable, then the curve can be modified by pre-setting a new value of $B(L)$ and watching whether the fit is still reasonable. Sometimes, even with considerable changes in the $B(L)$ value, the final figure for the catastrophe will not be greatly affected, as the short-tail portion sometimes has a very large bearing on the final result.

2.2.12 Such a process is particularly valuable in respect of large aviation losses. If the loss is mainly hull and perhaps cargo with some liability in respect of the crew, then the $B(L)$ factor is likely to run at about 1·75, showing that the claims will complete within 3·5 years from the date of loss. If, however, there is a large passenger liability, then the $B(L)$ value is more likely to be about 4·25, or can be set at that value which produces a time factor of about 8·5 years before the full claim development is complete.

2.2.13.1 In the case of a large catastrophe such as Hurricane Hugo and Hurricane 90A (Daria), which have provided the largest losses to the reinsurance market in recent years, it is advisable to carry out the modelling process both on the catastrophe losses as a whole and individually by source of business. On adding up the figures obtained from the various sources and comparing them with the overall total, one can see whether the figures which have been obtained are realistic. The two results should be within reasonable distance of each other, in which case an average can be obtained and the final figures for the different sources can be averaged out. It may be safer, however, to use the higher of the two.

2.2.13.2 Alternatively, it may be decided, from an examination of the development patterns shown by the graphs printed out, that the estimate for the ultimate level of claims expected through one source is too low (perhaps, for example, the marine source of claims for Hurricane Hugo), then that figure is adjusted upwards to give the total figure expected. However, delays in the reporting channel can also cause large variations, sometimes of an unexpected nature, even in an aviation crash where a hull loss only is involved.

2.3.1 In the case of an LMX underwriting office there can easily be anything

from 20 to 50 catastrophe losses from the years 1987 onwards which give rise to such investigation, although a few will be of more importance than the others.

2.3.2 In the case of an office writing mostly other classes of business, there might still be 10 or 20 catastrophes needing attention. Such has been the pattern of losses in the last seven years.

2.4 The subsequent progress of the claims arising from each catastrophe and the new estimates of ultimate claim amounts should always be tracked against previous estimates, to see how reliable each original estimate was, and, if the new estimate differs considerably, what was the cause of the failure. It could arise from a source of claims not previously foreseen, for example business interruption claims in the case of the Phillips Petroleum Fire.

2.5 Where, on first analysis, it is reasonably clear from the statistical forecasting that the overall total of incoming claims from the catastrophe is very unlikely to reach the top limit of cover provided by the reinsurances outwards, then the exposure analysis may well not be pursued, involving as it does a large amount of time-consuming work. It is primarily where the margin is thin, or in the early stages of development of a castastrophe, that the exposure analysis becomes important.

2.6.1 There will, however, be a number of smaller catastrophe losses which have not yet reached a sufficient amount to justify individual treatment. For example, the incurred loss figures developed to the date of investigation may be less than, say, a million or half a million pounds in each case. In such instances it may be preferable to group all such small catastrophes by year of account, and within the year of account by the source of business, again taking overall totals to see whether they agree. Such a procedure can be used to give weight to the different sources of information of claims and the varying rapidity with which they develop.

2.6.2 Alternatively, the statistics for the smaller catastrophes may be left to fall in with the general residue of ordinary claim amounts, assuming that they will develop with roughly the same rapidity. Much depends on whether the smaller catastrophes are judged likely to trigger reinsurance recoveries.

2.7.1 Where it is possible to obtain a reasonably clear estimate of the ultimate claim amount expected from both exposure analysis and statistical forecasting, a comparison can then be made as to the relative sizes. Where a large difference results, each should be examined to see what adjustments, if any, should be made in the forecasting process.

2.7.2 A figure provided by exposure estimation will often not be available at all, or will be too indeterminate to be applied with any degree of confidence. On the other hand, where it is in excess of the figure provided by statistical forecasting (as it often will be) and the analysis provides some measure of reasonable expectation as to the ultimate outcome, there will be a strong argument in favour of using an experience rating between the two types of estimate, favouring initially the exposure track and then leaning more heavily towards the result provided by statistical forecasting as the development period

lengthens. This type of approach will be valuable, more particularly in borderline cases—see Sections 3.1 and 5.1.

2.8.1 The greatest difficulty will be encountered where the catastrophe has occurred only a short time before the date of analysis, for example Hurricane Andrew, which occurred on 26–28 August 1992 and had to be taken into account in estimating reserves as at 31 December 1992.

2.8.2 In such a case, the estimate will have to depend heavily on the exposure figure obtained, but it may be possible to obtain an estimate statistically by comparing such a development pattern as has been obtained with the development pattern of an earlier catastrophe of roughly similar nature; for example Hurricanes Andrew to Hugo, but taking into account known differences, such as deleting any LMX on LMX part and, probably, the claim notifications from marine syndicates.

3. Adjusting for Exhaustion of Inwards Reinsurance Treaties

3.1.1 Once an estimate has been made of the amount that each catastrophe will reach, a ratio of increase of ultimate to incurred losses can be set. That ratio of increase can be carried back into each of the reinsurance treaties accepted which show losses from that particular catastrophe. The percentage increase should be applied to the residual exposure from each cedant, as it is those exposures that will give rise to the IBNR. The ratio, however, is only an average. A strong case can be made for varying the ratio of increase by the level of reinsurance layer accepted, but such variations will be difficult to make in practice, as there may easily be two or three thousand inward treaties giving rise to losses under a specific catastrophe to examine. It is often not possible to try to obtain more than rough approximations by taking an overall average.

3.1.2 However, a type of double deduction can come into the picture. If the claims development of the catastrophe losses has been slowing down, it may be because most of the losses involved are already known to the market, but it may also be because some of the cedants have already reached the top limits of their coverage. The projection developed by means of the graph itself extrapolates the effect of this exhaustion. To avoid effective double deduction at a later stage, the effect of the capping of claims from those particular cedants should first be eliminated.

3.1.3 For example, suppose for a particular catastrophe:

Incurred loss	251,769	Ultimate loss	286,194
		Ratio 1:1·1367	
Deduct losses from cedants where top limit has been reached, say	65,426		65,426
	186,343		220,768
		Adjusted ratio 1:1·1847	

3.2 By applying the average back to incurred losses it is possible to obtain an IBNR figure for each catastrophe for each treaty accepted on inwards business, and then to examine for both horizontal and vertical exhaustion within the treaty.

3.3.1 If there is vertical exhaustion, then the losses will be capped at that point, but care has to be taken that there is not another acceptance from the same cedant at a higher level. The computer database will have to enable the computer to track through for higher layers from the same cedant and to carry excesses into those higher layers, making adjustments for the different percentage acceptances, before arriving at a cut-off figure.

3.3.2 The picture can be very complicated according to the variety of different treaties accepted. There may be 'second loss only' treaties, back-up treaties and parallel treaties. Once a layer has been exhausted, it may be possible to move to a higher layer or it may be possible to move from a class reinsurance to a whole account and then to a top and drop. All these may be at different percentages of acceptance. In practice, the only practical course may be to have the computer print out the details of other acceptances from the same cedant, and then for clerical intervention to be used to see the effect of each catastrophe on each treaty before a determination is made as to vertical exhaustion.

3.3.3 Nevertheless, vertical exhaustion is beginning to have a substantial effect on the inwards losses advised from the market on some catastrophes, particularly Hurricanes Hugo and 90A.

3.4.1 Horizontal exhaustion will occur where there are insufficient reinstatements available under the terms of the treaty to cover all the catastrophes impacting that layer in the year of account concerned and there are no back-up or top and drop treaties to cover the situation. Such a position often arises. For example, during 1989 there were several major catastrophes which gave rise to marine treaty losses:

Exxon Valdez,
Phillips Petroleum Fire,
Atlantic Richfield,
Arco B Platform,
Hurricane Hugo, and
Chevron Refinery,

yet many of the treaties provided for only two reinstatements, and could therefore cover only three catastrophes. The allocation of catastrophe claims to the treaty in such cases will depend on the date of loss, but, because of the layers accepted from various cedants, can still give rise to inwards claims relating to all the catastrophes.

3.4.2 Since excess points have to be breached before reinsurance recoveries can arise, it is possible for a payment to be made in partial settlement of losses arising from a specific catastrophe and for outstandings to be recorded, only to

receive later advices of claims from another catastrophe, which occurred earlier within the duration of the same treaty, that have breached the excess point. Although practice varies, and non-marine markets sometimes act differently from marine markets, generally the first settlement payment has to be refunded and the outstanding notification deleted from the record so that claims arising from the earlier catastrophe can take its place. However, with varying practice, this factor introduces an element of choice into the equation on the part of the cedant.

3.5.1 There may well be in existence treaties where claims arising are accumulating steadily, but the aggregate has not yet breached the excess point. In some cases the cedant gives warning advices of claims accumulating and the same percentage, obtained as indicated in Section 3.1, can be applied to see whether the claims are likely ultimately to exceed the excess point, but such warnings are frequently not given. Enquiries addressed to cedants may help in this regard, but not always. There is particular danger if the office has underwritten a number of high level treaties, particularly if some of them are of considerable amount each.

3.5.2 With a list of higher level treaties to hand, showing in each case the nature of the treaty and the limitations, it is possible to allocate a reasonable percentage of the total exposure of each treaty so as to build up a scenario of claims ultimately expected, based on general market knowledge and on experience and on each cedant—whether that office is likely to have exposure to the catastrophe concerned and, if so, what degree of exposure is likely as considered against the excess point of the treaty written.

3.6 If statistical methods of forecasting are used which show confidence limits, those limits may be wide indeed, particularly for recent catastrophes where estimates of ultimate claim amounts expected may be of extreme importance to the outcome of the year's trading. They may narrow quite dramatically as time elapses. In general great caution is required, but over-reserving for the sake of safety can be dangerous if it should lead to losses being shown of a magnitude considerably exceeding what ultimately eventuates. Much will depend on how large the margins are in the outwards reinsurance protections.

3.7 Once the inward business has been adjusted for any horizontal and vertical exhaustion and for the catastrophe claims arising from inwards facultative and proportional business, together with possible additional claims from sources not yet advised, the figures can be carried through to the net account to examine the effect of the outwards treaties; but see also Section 5.

3.8 If the outwards reinsurance excludes inwards LMX cover, then those inwards treaties must be excluded from the total tested against outwards reinsurance, and treated instead as net claims.

3.9 It should also be possible to estimate reinstatement premiums due, both on outstanding loss advices to the treaty and on IBNR estimates. Such estimations may well not be possible to carry out automatically by computer, in which case they will have to be calculated clerically from a print-out of treaties affected. Distortions can be caused by the years of account to which they are

allocated. An extra complication arises if reinstatement premium protection covers have been written.

3.10 Burning cost premium adjustments can also be sufficiently material to justify the calculation of expected extra premiums.

3.11 The outwards reinsurance treaties providing the cover will normally be the risk year in which the catastrophe has occurred, but any amount 'over the top' relates to inwards business, and hence may revert to the year of account governing the cedants' claims.

4. Outwards Reinsurance

4.1 By gathering together the figures for each catastrophe's loss from all the treaties in force on the portfolio, it should be possible to examine the totals against the effect of outwards reinsurance treaties. Usually only one year of account is involved in each case, as the outward treaties are seldom spread across a number of years of account, but there are exceptions, e.g. Catastrophe 90A is covered by two years of account in some offices.

4.2 The rate of conversion between dollars and pounds may cause a difficulty, as the standard conversion rate used may differ for outwards business as against inwards business, or there may have been varying rates of exchange between separate inwards treaties (see § 2.2.2.4). However, the London Market has tended to use a standard pattern over the years, and hence there may possibly not be as much difficulty as could arise. If variations do exist, then the calculation becomes even more complex, as it is necessary to determine the ratio of pounds to dollars that will apply to the outwards reinsurance protections before amalgamating them into one figure to be compared against excess points and limits, and so as to calculate net figures.

4.3 It will, then, be necessary, as in the case of inwards treaties, to examine for both horizontal and vertical exhaustion. If either occurs, then it means that the residual losses over and above the top limit or horizontally will be on a net basis.

4.4 The net losses in the IBNR field will then stem from a number of sources:

- —Losses still under the lowest excess point of the reinsurances outwards.
- —Parts of the outwards treaty which the office has not been able to place.
- —Self retention (also called 'co-insurance' or 'co-reinsurance'), particularly within the non-marine treaties. They are less frequent in the marine treaties.
- —The effect of any horizontal exhaustion.
- —The effect of any vertical exhaustion.
- —Reinstatement premiums which will become payable. The reinstatement premiums would depend both on the percentage of ultimate loss and on the terms of payment of reinstatement premiums. Against these it will be possible to deduct reinstatement protection premiums recoverable on inwards business. It is, therefore, crucial that the estimates for reinstatements due in on inwards treaties and those payable out on protections be estimated on a basis and on assumptions consistent one with the other.

—Net claim figures from each of these causes will be converted at current rates of exchange.
—Actual and potential reinsurance failure.

4.5 The greatest difficulty in the most recent years of account is likely where catastrophes may be very little developed and it becomes extremely difficult to estimate ultimate amounts with any degree of assurance that can safely be used in the reserving process. In most cases the accounts will be on a funded basis and in any case no profit should be taken from the account during the first or second year of development. If, however, the ultimate loss ratio looks as if it will be over 100% then perhaps judgement based on discussion with the underwriters, supplemented by carrying out an exposure analysis, will be the best guide to the ultimate losses expected.

5. Statistical Variability

5.1 In the case of non-proportional treaty cover, simply to assume that the average net claim amount is equal to the average gross claim amount less the reinsurance recoveries is dangerous under certain circumstances.

5.2 From a stochastic viewpoint, the estimated ultimate claim amount arising from a catastrophe is the mean of a distribution which is very likely to be skewed upwards.

5.3 There are cases, best explained by Figure 1, where the mean value net of reinsurance outwards is not equal to the mean of the gross amounts less the relevant reinsurance recovery. It is in Case 1 where the danger exists. It will be seen that the mean expected value leaves only the original excess amount as the net liability (unless there is a small self-retention, the effect of which is likely to be relatively minor), while an increase leads to a substantial extra net liability arising from vertical exhaustion.

5.4 From the illustration it is possible to draw the conclusion that, if the expected mean value is well covered by the reinsurance layers in place, there is little need to consider the possibility of an upwards variation, but if the mean expected ultimate is at or above the top level of cover, then it is wise to add an extra amount to the gross figure for safety before deducting the reinsurance recovery amount.

5.5 Considering the IBNR part of the gross amount, if the recent values of incurred claims are flat or nearly flat, then as little as 5% need to be added on. If the figures are still rising rapidly, add perhaps 25% or even 50% to the IBNR content. If the catastrophe has occurred very recently, then it is perhaps better to work on exposure figures as an indication of where the ultimate gross amount may end up. Even then, it may be useful to start from a statistical approach in determining the expected ultimate value, so as to produce a range of values set to a predetermined percentage confidence expectation. However, it should be borne in mind that the problem may not be purely statistical—when a whole chain of

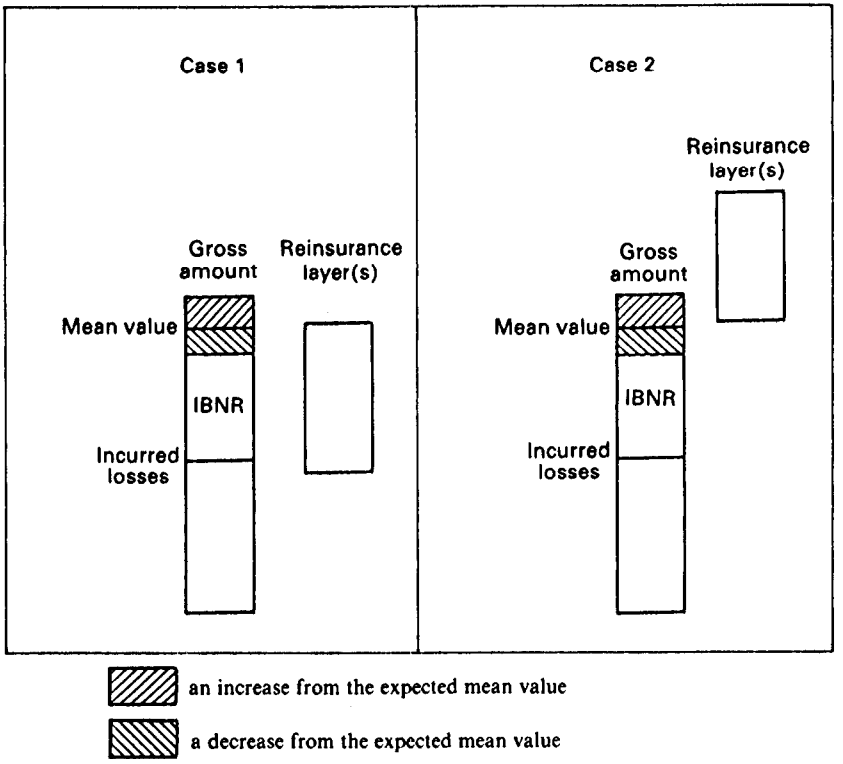


Figure 1. Variations in the gross claim amount from the mean expected value.

reporting is involved, one failure or other cause of delay or error along the line, may have substantial effects on the figures of incurred losses reported to date.

6. Other Claims

6.1 In most offices, there will be a steady flow of claims arising from non-catastrophe sources. Once the figures relating to a specified list of catastrophes (probably varying office by office according to the intensity of their effect) have been subtracted from the triangle of development figures produced, it will be possible to carry out estimates of reserves required on the residue, both on a gross and on a net account, in the ways that have become traditional. The development statistics of the residual account will not be easy to obtain unless the computer system has been designed so as to be able to deduct first the losses, both paid and outstanding, arising from specified catastrophes.

7. Higher Level Reinsurance Outwards

7.1 Where there are catastrophe losses, the difficulties in regard to obtaining estimates of net absolute reserves stem chiefly from the detailed effect of limits on treaties, both inwards and outwards. The method of dealing with these problems is set out above.

7.2 Once a reasonable estimate of reserves net of reinsurance protections outwards has been obtained, then there should be no difficulty in dealing with any proportional class retrocessions or whole account subrogations, or stop loss protections, which might exist, as protected by the outwards reinsurance treaties. Further complications could arise, however, if any such treaty is protected only by part of the reinsurance protection programme.

8. Computer Program Requirements

8.1 To make full use of the system of reserving herein described, requires the use of computer systems which are complex to the extent that parts of them may correctly be described as 'expert systems'. A few such systems have been developed and are now available on the market as software packages.

8.2 Claims relating to specific catastrophes will already have been recorded by the claims department while maintaining records for purposes of reinsurance recoveries. Thus it will be possible to obtain claim development figures for each catastrophe. Difficulty may still stem, however, from efforts to obtain development triangles of claims which exclude specified catastrophes. Also, there is likely to be a weakness in regard to amounts which should be part of a known catastrophe, but have not yet been identified as such. Rectification can be assisted by examining all claim records of a specific date of claim (within a range of dates) and by location of claim. A clerical system may also not identify catastrophe claims by source of advices. All such relevant data should be carried on the main claims record file.

8.3.1 Once a forecast has been made of the ultimate development effect of a particular catastrophe, the computer system should be able to assist by relating the further claim amounts expected, both to each particular risk giving rise to that claim and to further risks that might give rise to it. It should also be possible for the computer, given further claim expectations from specific catastrophes, to calculate both reinstatement premiums and burning costs additional premiums and to indicate possible vertical and horizontal exhaustion.

8.3.2 To this end, the computer system for each risk should include:

Cedant identification,
Treaty identification,
Percentage participation,
Classification of treaty (specific, class general, whole account, etc.),
Sources covered,
Any limitation as to sources of business or of geographical location of losses,

Date of commencement of treaty and duration,
Rate of conversion, dollars to pounds,
Excess point and limit,
Rate on line,
Codes as to what aggregation permitted,
Reinstatements; number permitted,
Rates and terms of reinstatement premium,
Formula and details of any burning cost premium adjustments,
Individual settlements to date, and
Outstanding claim amounts advised as at each quarter end.

8.3.3 A system specially developed for the purpose should provide all the information required in regard to:

Risks which have given rise to the catastrophe,
Additional risks at different layers from the same cedant, and
Higher-level risks which might later give rise to claims from that catastrophe.

8.3.4 At very least, a suitably printed out computer list will be of considerable assistance to clerical analysis. The less assistance that can be obtained from computer records the more clerical work that will have to be carried out, the time and degree of effort required escalating rapidly if computer assistance is not available, even to a complete search of all records. The computer system must provide a list of risks written by exposure and claim advices for tracking claim development.

8.4 Once the totality of gross claim amounts arising from a specific catastrophe has been set, the computer system should be able to calculate recoveries automatically, test for vertical exhaustion and hence net claim amounts. With all the catastrophes concerned that impact that underwriting year, it should also be able to test for horizontal exhaustion.

9. Acknowledgements

While I must take all responsibility for the views expressed in this paper, I should like to acknowledge the valuable criticism and suggestions supplied by a number of colleagues, in particular by Fred Duncan, David Hindley, Peter Johnson, Tony Jones, Haidee Pickton and David Tomlinson, together with more general comments from the London Market group of actuaries.

APPENDIX A

This paper has been written as a result of forecasting estimates based on statistical procedures carried out over recent years starting from the progression of incurred losses to date: for a few catastrophes as at 3 year-ends to date; for very many more as at 2 year-ends. Many of the figures were provided sub-divided by channel of reporting as well as for each catastrophe as a whole. It has, therefore, been possible to see to what extent later developments have followed the earlier patterns forecast or have deviated from them.

While some forecasts have so far proved to be sufficient and roughly correct, there are three areas in which earlier forecasts are now proving to be insufficient:

(1) Aircraft crashes, where the liability content was not sufficiently provided for and is proving to be much larger than previously expected or where the reporting is much slower than anticipated. It now looks as if the period to full estimation of the claims will be at least 6 years, requiring the parameter $B(L)$ as set out in Section 2.2, to be pre-set at 3·0 or more if a first determination under the curve-fitting process used indicates a lower figure.

(2) Incoming reinsurance designated as 'LMX sources', where, even if the full LMX spiral is not operating, the business is, in fact, of a retrocessional nature, and hence considerable delays in advices must be expected.

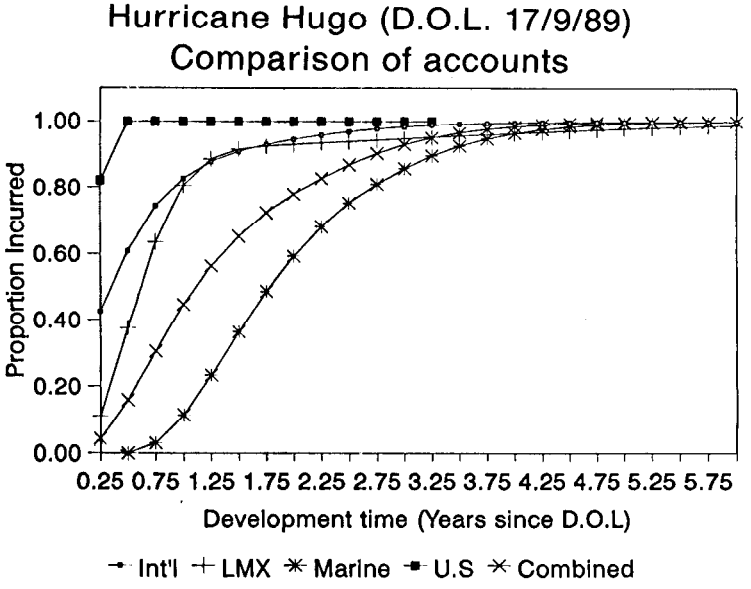
(3) Marine sources in respect of non-marine catastrophes such as Hurricane Hugo. Where such a portfolio of acceptances applies, the results have been disastrous and the development figures shown on a graph form almost a straight line upwards. The development patterns for both Hurricane Gilbert and Hurricane Hugo show a strong impact from this factor, as well as do those for Hurricanes 87J and 90A. Hurricane Andrew is unlikely to contain the same feature, as market practice had changed by the time of its impact.

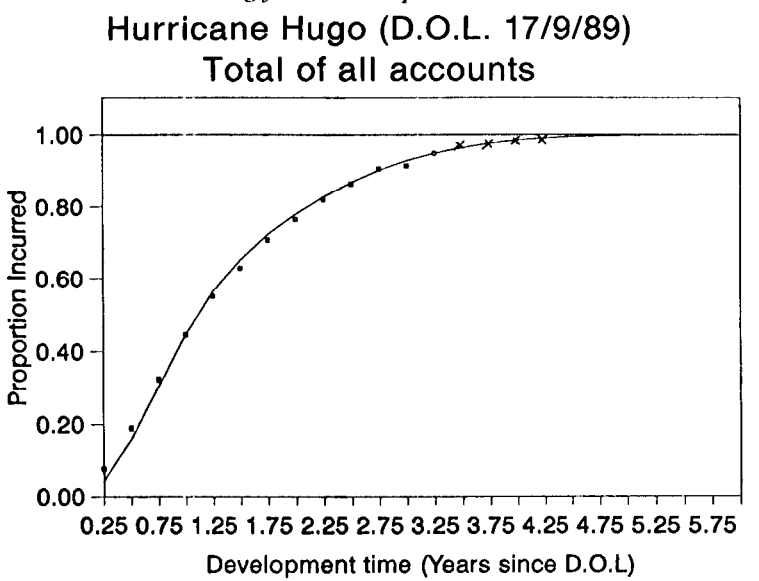
APPENDIX B

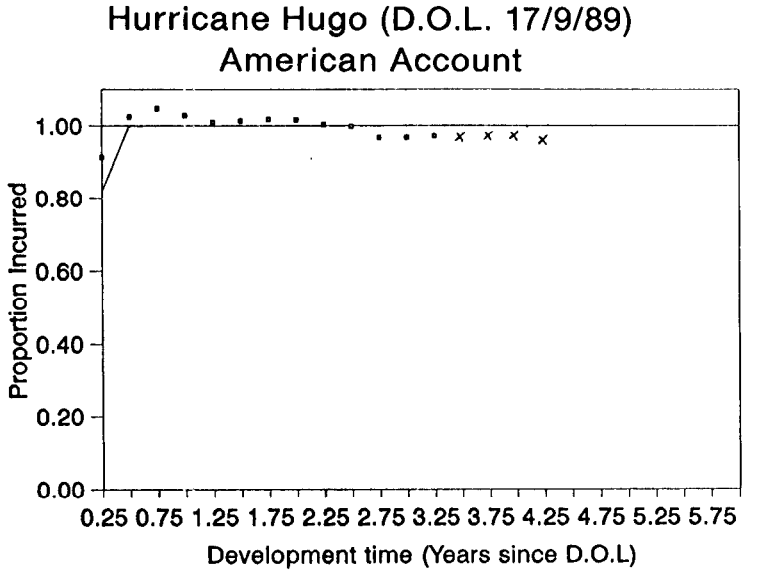
The figures in this Appendix indicate the nature of the development patterns of incurred losses for the catastrophe Hurricane Hugo, broken down by channel of reporting.

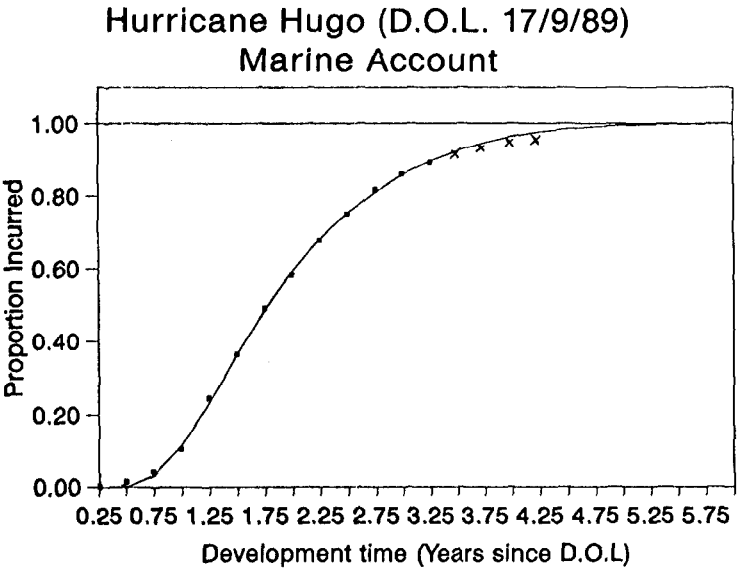
Each has been standardised by ratioing down to an expected ultimate loss amount of 100, as obtained by means of statistical forecasting. The time periods stem from the date of loss.

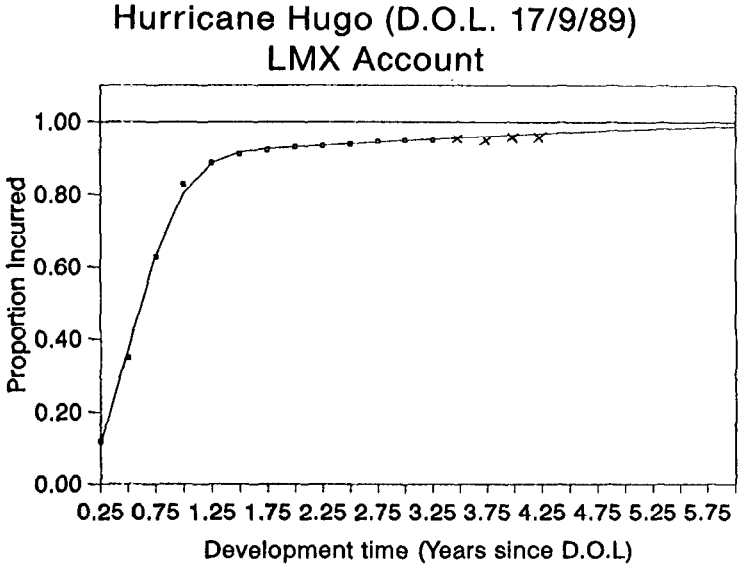
The estimates were made early in 1993 on the basis of incurred losses to 31 December 1992. Since that date the quarterly figures of incurred losses during 1993 have become available, and these are shown on the figures as crosses, except on the first figure.

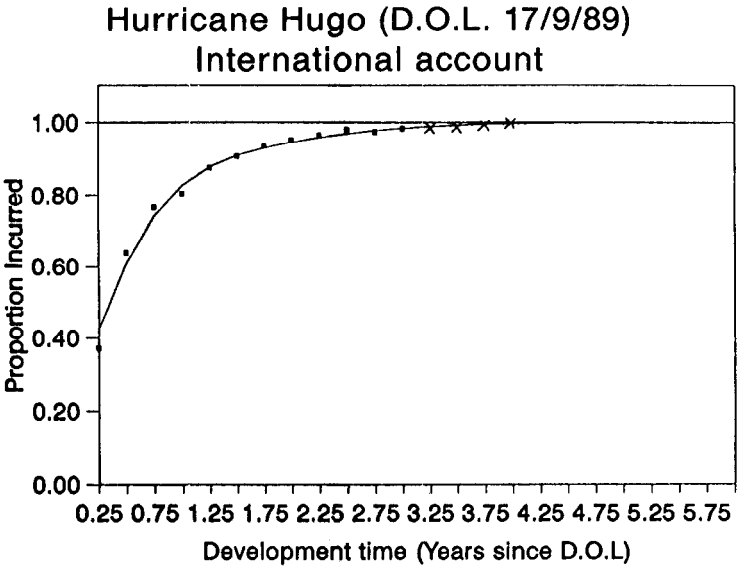



Hurricane Hugo (D.O.L. 17/9/89)
Total of all accounts
Proportion Incurred
1.00
0.80
0.60
0.40
0.20
0.00
0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75 5.25 5.75
Development time (Years since D.O.L)


Hurricane Hugo (D.O.L. 17/9/89)
American Account
Proportion Incurred
1.00
0.80
0.60
0.40
0.20
0.00
0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75 5.25 5.75
Development time (Years since D.O.L)


Hurricane Hugo (D.O.L. 17/9/89)
Marine Account
Proportion Incurred
1.00
0.80
0.60
0.40
0.20
0.00
0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75 5.25 5.75
Development time (Years since D.O.L)


Hurricane Hugo (D.O.L. 17/9/89)
LMX Account
Proportion Incurred
1.00
0.80
0.60
0.40
0.20
0.00
0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75 5.25 5.75
Development time (Years since D.O.L)


Hurricane Hugo (D.O.L. 17/9/89)
International account
Proportion Incurred
1.00
0.80
0.60
0.40
0.20
0.00
0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75 5.25 5.75
Development time (Years since D.O.L)

APPENDIX C

GLOSSARY OF TERMS

While the following definitions and explanations are provided for terms used in this paper, it should be realised that precise usage varies between offices. Several terms may be used by different offices to mean the same thing, while different offices may use a specific term to mean different things. Hence there can be no standard definitions. Different sections of the same office may even use terms differently---for example, the marine and non-marine sections.

Aggregate excess of loss reinsurance

Provides cover on an excess of loss basis for losses in excess of an agreed reinsurance limit, sometimes small, but only when the total of all such losses in the year of account concerned exceeds a specified amount, up to an agreed limit.

Burning cost adjustments

A non-proportional treaty is usually (but by no means always) written with a minimum and deposit premium payable in 4 instalments. The amount is set somewhat below that demanded by the estimated premium income of the portfolio of business covered. At the end of the year an adjustment premium is paid based on the actual premium income of the business ceded. Sometimes there are further adjustments at yearly intervals, based on the loss ratio of the underlying business, according to a format such as 100/70 times the total losses, as the premium payable, with a lower and an upper limit.

Cedant

The insurance or reinsurance office reinsured under the treaty of reinsurance.

Excess of loss reinsurance

A non-proportional treaty is written in a form described as, for example, \$50,000 × \$100,000 where any one large loss is reinsured as to a claim exceeding \$100,000 up to a total of \$150,000. If there are, for example, 3 reinstatements on which reinstatement premiums are payable, then 4 different large losses are covered in that year of account.

In practice, an office covering catastrophe business will have several outwards reinsurance treaties (referred to as 'layers') to cover its operations, e.g.

Non-marine	\$ 50,000 × \$50,000
	\$100,000 × \$100,000
	\$300,000 × \$200,000
Marine	Somewhat similar

Whole account	$500,000	× $500,000
	$1m	× $1m
	$3m	× $2m
	$5m	× $5m

(See § 2.2.2.4, in regard to the effect of different currencies.)

Exhaustion of treaties

(*a*) *Vertical*

When the total loss from any one catastrophe exceeds the limit of the highest layer of protection written, e.g. in the above case, this exceeds $10m.

(*b*) *Horizontal*

When the number of catastrophes in any one year of account impacting a specific layer exceeds the number of reinstatements plus one and no more cover exists.

Ground up losses

Loss amounts calculated in terms of the original total loss. For example, a loss of $23,000 to a layer of reinsurance cover $50,000 × $100,000 will indicate a ground up amount of $123,000.

IBNR

Incurred but not reported.

Losses which have occurred during the period of insurance concerned, but have not yet been reported, or where the reporting has not yet travelled fully down the line of insurer/brokers/reinsurer to the office concerned. In reinsurance the term has wider coverage than in the case of a direct insurer, and can include IBNER (incurred but not enough reserved) and even, exceptionally, further burning cost adjustments if they are regarded as claims rather than premiums.

Incurred losses

The cumulative value of losses settled to date and entered into the books of account (whether actually paid or not) plus the latest values of outstanding claim notifications.

LMX treaties

London Market excess of loss.

The reinsurance of business from other reinsurers operating in the London Market.

The terms of the treaty may exclude the reinsurance of business already in the LMX category (though in practice a little always seems to seep through), but more usually the term is taken as meaning treaties which include the reinsurance of business already categorised as LMX and hence can give rise to a spiral effect.

In the case of foreign business it is usually called X/L on X/L.

Sources

(*a*) *U.S. CAT A/C*

Catastrophe business advised directly by insurers in the United States of America.

(*b*) *World-wide CAT A/C*

Catastrophe business advised directly by insurers in countries other than the United States of America.

(*c*) *Marine*

Reinsurance under treaties accepted from cedants who are marine insurers/reinsurers or the marine specifics or generals of any cedants.

(*d*) *Aviation*

Reinsurance under treaties accepted from cedants who are aviation insurers/reinsurers or the aviation specifics or generals of any cedants.

(*e*) *Other groupings exist*

Reinstatement

When a catastrophe loss has been advised to a layer, the office reinsured may elect to pay a reinstatement premium to cover further losses to that layer in the same year of account. It is nominally optional to the reinsured, but, in practice, is always paid. The amount is proportional to the amount of cover in the layer burnt through by the cedant office. It used to be proportional to the time period remaining, but that factor has now generally been dropped from the wording of the treaty.

Reinstatement premium protections

Insurance covering reinstatement premiums payable in the year of account. It may cover one or all reinstatement premiums on a specified treaty, or all reinstatement premiums payable in a specified year of account, as defined by the terms of the placing treaty.

Retrocession

Any type of reinsurance treaty that is a reinsurance, whether proportional or non-proportional, of one or more reinsurance treaties.

Risks

In a reinsurance office the term 'insurance policy' is replaced by the term 'risk' which may be anything from a simple facultative cover to a large proportional treaty or a complex non-proportional treaty.

Risk-related

Used in reinsurance outwards when it is possible to relate the reinsured amount to a stated proportion of all losses from one risk or a number of risks, as

against the losses from part of each of a number of risks that arise from one happening and go to make up a catastrophe loss.

Self-retention

Many excess of loss non-marine treaties written in recent years required that the reinsured retain at least a stated proportion of the risk, usually 10% or 5%. Also known as co-insurance or co-reinsurance.

Treaties of reinsurance—excess of loss

A large number of classifications exist, with variations in nomenclature between different years. The total number is restricted only by the overall requirements of offices for reinsurance and the ability of reinsurance brokers to think of new plans. The following are the main terms in use:

(*a*) *Specifics*

Can be the reinsurance of a specific treaty, particularly a large proportional treaty, but more usually used in the marine market to cover one line of business, e.g. the hull account.

(*b*) *Generals*

Covers several classes of business or, in the case of an office, writing only one overall class such as marine, the whole account of that office.

(*c*) *Whole account*

Used mostly by a reinsuring office handling most classes of business, e.g. marine, non-marine and aviation, for treaties of reinsurance covering the whole account.

(*d*) *Second loss, parallel treaties, back-up treaties*

All used to explain additional reinsurance taken out after the first treaty has been written to a specific excess point and limit. It provides effectively more reinstatements. It is usually written immediately after the first treaty written to the same layer, but exceptionally may be taken out later in the year.

(*e*) *Blanket cover*

Covering all risks to the office, or within a main class of business, as against cover of the types explained in (*a*) to (*d*) above, which sometimes carry exclusions, e.g. losses from a certain country or a certain geographical area.

(*f*) *Top and drop*

The cedant can decide whether to use the treaty for a loss coming in over and above the top limit of the generals or whole account, or whether to use it parallel to a lower layer on which reinstatements have been exhausted.

For example, a top and drop of \$250,000 × \$250,000 can be used either parallel to the existing treaty of that magnitude to avoid horizontal exhaustion, or, alternatively, if the top limit of all other treaties is, say \$5m, as a treaty for \$0·25m × \$5m.

(*g*) *Cascade*

Similar to a top and drop, but, depending on the wording of the treaty, may be used as additional cover at any point between the top and the bottom of the overall cover.

(*h*) *Franchise cover*

Cover with a loss exceeding a specified amount, but then repaying the total loss from ground up, to an agreed limit.

(*i*) *Stop loss*

Covering all losses within the year of account, from one class of business or from all classes taken together, cumulatively above an excess point up to a specified limit.

Whole account subrogations

A reinsurance on a proportional basis of an agreed percentage of the account of a section of the business or of the whole account, usually after taking into account the effect of excess of loss protections.

Year of account

For a reinsurance office, usually taken as the calendar year in which the reinsurance incepts, whether the term be one year (as usual) or less than or greater than one year.

For Lloyd's syndicates it is the year in which the cover is 'signed', which means the year in which the reinsurance is 'closed' by specific advices from the broker. It is usually the year of the date of inception, but exceptionally can be one year or even two years later. (It is now scheduled to be changed to an inception date basis.)

The inception date is by no means always 1 January. It may be any other date in the year.