RESERVING FOR CATASTROPHE REINSURANCE

By D H Craighead M.A.; F.I.A.

Summary

Recent years have seen the impact of a large number of catastrophes, not only on the London catastrophe market but on most general insurance offices.

The paper starts off from the assertions that

a) the development pattern of the loss advices of each catastrophe is unique to that catastrophe and can differ by source of advice, and that

b) the development pattern of the net account is heavily affected by the outwards reinsurance pattern of protections, hence

c) traditional methods of claim development estimates will not provide the correct answers in the reserving process.

The paper then explains a method of reserve estimating by following through a number of steps:

(1) Estimate the ultimate level of claims expected seperately for each catastrophe and by source of business.

(2) Have the office concerned examine each inwards treaty of reinsurance to see the effect of further claim advices expected, taking into account
Limit of cover, against the possibility of both vertical and horizontal exhaustion.
Additional layers of reinsurance accepted.
Reinstatement premiums recoverable.

(3) Arising from that analysis, revise the ultimate level of claims expected for each catastrophe and examine that figure against outward protections in order to estimate the effect on the net account.

A substantial number of examples of estimates of gross catastrophe claims figures are provided in Appendix A (based on figures to 31.12.1991 and calculated in January/February 1992) and there is a Glossary of terms in Appendix C.

RESERVING FOR CATASTROPHE REINSURANCE

by D H Craighead M.A.; F.I.A.

(Appendix C contains a glossary of terms relating to the subject matter for those not familiar with London market terminology).

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. Such a requirement gives rise to problems. 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 zig-zag pattern of development results which is impossible to analyze statistically if examined only on an overall account basis. This article 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 Throughout the article 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 propo-rtional treaty reinsurance outwards of classes or of specific risks, a defined part of each of which is being allocated to the treaty.

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.

2.INWARDS REINSURANCE.

2.1 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 paragraph 2.3 below). Monthly development figures would be preferable - even weekly for very large catastrophes.

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.

2.2.1. 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.
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.

and 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 analyzed 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. 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.

2.2.3. 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.

2.2.4. The treaties of reinsurance normally specify the rates of exchange applying between US dollars (and Canadian dollars) and pounds 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 outward treaties similarly carry stated rates of exchange but abnormally the rates can differ from those on the inwards treaties.

Other currencies are normally converted into £ or dollars when claims are settled. 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.

2.2.5. 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.

2.3 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 (see graphs in Appendix B).

2.3.1 In the United States, 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 of unexpected sources or amounts arising because the damage was more extensive than first appeared. Hence the US CAT account as it is usually called will develop very rapidly indeed and will show reasonably completed figures in a short period of time.

2.3.2 In Britain and on the Continent the advices are rapid but not as quick as in the United States. 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.

2.3.3 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.

2.3.4 Slowest of all will be the marine part of non-marine losses such as Hurricane Hugo. The cause lies mainly in acceptances of so called 'incidental non-marine business' by marine syndicates. Within

such business 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 is a very considerable delay and in practice one finds that there are almost no advices at all for periods up to 2 years; thereafter very rapid development. In some cases the overall claim cost may remain relatively small but in others it is large, particularly in the cases of Hurricane Hugo and 90A.

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 very often 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.

2.5 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.

2.5.1 A method which seems to work is that of modelling with a double set of parameters by use of a double gauss curve (See 'Techniques of reserving' by D H CRAIGHEAD JIA Vol 113 PART III)

The curve is of the form:

where l(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.

B(L) is the parameter determining the length of tail of the long-tail losses.

A then equals A(S) + A(L) and is the total of loss amounts ultimately expected.

In practice a large number of values of l(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.

$$\frac{\Sigma \left\{ l(t) - l'(t) \right\}^2 \times t}{\Sigma t}$$

where l(t) is the calculated value of losses advised as obtained from the curve defined by the parameters so estimated.

2.5.2 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.

2.5.3 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.

2.5.4 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.

2.5.5 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 but more specific guidance can be rendered by producing further information via a graphical picture of likely further development.

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

$$1 - e^{-4} = .9817$$

The graph can then be shown in this 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. Very often, 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.

2.5.6 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.

2.5.7 If the catastrophe has occurred in the latest year of account, it will be very difficult

indeed to obtain a reasonable estimate of the ultimate result. In such a case it will be necessary to work on exposure totals as an upper bound of possibilities. Even for catastrophes which occurred in earlier years, it is well to try to obtain some measure of exposure and perhaps to use an experience rating type of calculation between exposure totals and the estimate obtained from statistical analysis.

The total exposure figure should, in fact, always be obtained where possible as a top limit to the claims development. It may, however, be far too high as it is likely to include cover given to cedants who are not exposed to the catastrophe at all or are exposed only for amounts that are far below the excess point of the cover. On the other hand, the exposure can be exceeded if the catastrophe is spread over a period of time longer than 72 hours and is treated by cedants as two separate claims e.g. Hugo.

2.6 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.

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) and that figure adjusted upwards to give the total figure expected.

2.7 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.

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 five years.

Appendix A shows a table produced with figures ratioed up or down to maintain anonymity. Some of the figures are those obtained after re-assessment following discussions with the underwriter. Actually the larger of the two figures shown on each line is better accepted as the jumping-off point. There are also copies of the graphs obtained for Hurricane Hugo. The LMX account graph may be indicating in the small but steady upwards trend the presence of the LMX spiral.

2.8 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.

This procedure can be used to give weight to the different sources of information of claims and the varying rapidity with which they develop.

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.

3. ADJUSTING FOR EXHAUSTION OF INWARDS REINSURANCE TREATIES.

3.1 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. A 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.

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.

For example, suppose for Hurricane Hugo (see schedule in Appendix A)

Incurred Loss	251769	Ultimate Loss Ratio 1.1367	286194
Deduct losses from cedants where top limited has been reached, say	65426		65426
	186343		220768

Adjusted ratio 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 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.

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.

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

3.4 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
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.

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 be advised later that the claims from another catastrophe, which occurred earlier within the duration of the same treaty, have breached the excess point. Although practice varies and non-narine 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, practice varies in this regard. In marine treaties it is often the date of settlement which determines which catastrophe has preference. This

factor introduces an element of choice into the equation on the part of the cedant.

3.5 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 3.1 above, 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.

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 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 5.1 below.

3.8 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.

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

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. Cat. 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. 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 able to compare against excess points and limits and 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:

4.4.1 Parts of the outwards treaty which the office has not been able to place.

4.4.2 Self retention (also called 'co-insurance or 'co-reinsurance'), particularly within the non-marine treaties. They are less frequent in the marine treaties.

4.4.3 The effect of any horizontal exhaustion.

4.4.4 The effect of any vertical exhaustion.

4.4.5 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.

4.4.6 Actual and potential reinsurance failure.

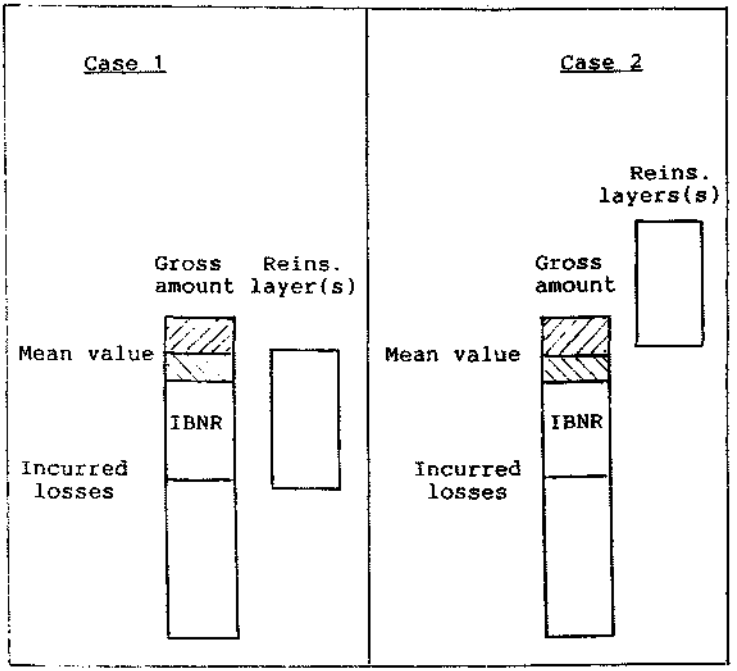
4.5 The greatest difficulty in the most recent years of account is likely where catastrophes may be very little developed and it becomes extremely difficult to estimate ultimate amounts with any degree of assurance that can safely be used in the reserving process. In most cases the accounts will be on 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 will be the best guide to the ultimate losses expected.

5. STATISTICAL VARIABILITY

5.1 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.

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.

There are cases, best explained by the illustrations shown below, where the mean value net of reinsurance outwards is not equal to the mean of the gross amounts less the relevant reinsurance recovery.



where  denotes an increase from the expected mean value.

while  denotes a decrease.

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.

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.

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 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. It may be preferable 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 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.

Once a reasonable estimate of reserves net of reinsurance protections outwards has been obtained then there should be no difficulty in dealing with any class retrocessions or whole account subrogations 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 and 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 Once a forecast has been made of the ultimate development 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.

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
Outstanding claim amounts advised as at each quarter end

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
Higher level risks which might later give rise to claims from that catastrophe

At very least, a suitably printed out computer list will be of considerable assistance to clerical analysis.

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.

9.1 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 Rickton and David Tomlinson, together with more general comments from the London market group of actuaries.

I should also like to thank those offices who allowed their development figures to be used as a basis for the estimation of expected results.

APPENDIX A

The figures below relate to a large number of catastrophes, as derived from actual quarterly development figures up to 31.12.1991 reported in the market by several offices with projections made by several actuaries, the estimates being made early in 1992. So as not to be capable of being directly related to source, the figures for each catastrophe and each office have been multiplied by a constant.

Care should be taken in applying the ratios of development, from incurred to ultimate, as shown by these figures, to other offices as each office is unique in the portfolio of reinsurance acceptances it writes.

The wide variations shown in the estimated run-off factors are far more a result of differences in the portfolios of reinsurance treaties written than in differences of opinions between the several actuaries involved.

Catastrophe claims as at 31.12.1991

Net of risk-related reinsurances outwards
Gross of reinsurance protections

Common US$ 000

Catastrophe	Date of Loss	Account	Incurred Losses	Est. final amount		Run-off Factor %
				First Estimate	Adjusted	
North-West Airlines	16.8.87	Aviation	10381	10610		2.2
Hurricane 87J	15.10.87	International	8540	8683	8804	3.1
		LMX	37566	37731	38256	1.8
		Marine	23890	28219	28612	19.8
		Total	69996	74633		
		Whole A/C	69996	75672	75672	8.1
Bourbon Platform Shell Oil	3.11.87	Marine	4020	5064	6026	49.9
South African Airways	27.11.87	Aviation	6068	6913		13.9
Mexican Storms	18.1.88	Marine	2190	2307		5.3
Enchova Platform	24.4.88	Marine	19578	25026		27.8
Norco Refinery Shell Oil	5.5.88	Marine	2552	3040	3606	41.3

Catastrophe claims as at 31.12.1991

Net of risk-related reinsurances outwards
Gross of reinsurance protections — Common US$ 000

Catastrophe	Date of Loss	Account	Incurred Losses	Est. final amount		Run-off Factor %
				First Estimate	Adjusted	
Barcelona Seawise Larak	14.5.88	Marine	3902	4376		12.1
Piper Alpha (A)	6.7.88	LMX	2451	3065	3071	25.3
		Marine	53829	55605	55716	3.5
		Total	56280	58670		
		Whole A/C	56280	58787	58787	4.5
(B)		Whole A/C	25951	26781		3.2
Air France New Delhi	23.7.88	Aviation	7389	9675		30.9
Hurricane Gilbert	9.9.88	International	5963	6008	6008	0.8
		LMX	14236	16608	16608	16.7
		Marine	1725	2202	2202	27.7
		Total	21924	24818		
		Whole A/C	21924	23317	24818	13.2
Rowan Gorilla	15.12.88	Marine	4586	5228		14.0
Pan Am Lockerbie	21.12.88	Aviation	4125	5281	5697	38.1
British Midland Kegworth	8.1.89	Aviation	4580	5331		16.4

Catastrophe claims as at 31.12.1991

Net of risk-related reinsurances outwards
Gross of reinsurance protections

Common US$ 000

Catastrophe	Date of Loss	Account	Incurred Losses	Est. final amount		Run-off Factor %
				First Estimate	Adjusted	
Ind.Air/ Azores	8.2.89	Aviation	2025	2112		4.3
Flying Tiger	18.2.89	Aviation	12207	14524		19.0
Atlantic Richfield Arco B Louisiana (A)	19.3.89	Marine	31854	43934		37.9
(B)			9296	13860		49.1
Exxon Valdez (A)	24.3.89	Marine	52243	67656		29.5
(B)			15654	21994		40.5
Chevron Refinery Richmond CA	10.4.89	Marine	2618	3499		33.7
United Airlines Sioux City	19.7.89	Aviation	23736	29207		23.0
Korean Airlines Tripoli	26.7.89	Aviation	20442	28318		38.5

Catastrophe claims as at 31.12.1991

Net of risk-related reinsurances outwards
Gross of reinsurance protections Common US$ 000

Catastrophe	Date of Loss	Account	Incurred Losses	Est. final amount		Run-off Factor %
				First Estimate	Adjusted	
Hurricane Hugo (A)	17.9.89	International	9663	10638	10638	10.1
		LMX	117862	123939	123939	5.2
		Marine	119105	143537	146478	23.0
		US Cat.	5139	5139	5139	0
		Total	251769	283253		
		Whole A/C	251769	286194	286194	13.7
(B) (Does not accept marine Business)			251769	269015		6.8
(C)		LMX incl.LMX	17451	23873		36.8
		X/L incl.X/L	479	932		94.6
		Lond. W. A/C	7098	13124		84.9
		For. W. A/C	457	569		24.5
		Lond.N-M X/L	3830	3914		2.2
		For.N-M X/L	651	670		2.9
		Lond.N-M W.A/	4899	5119		4.5
		For.N-M.W.A/C	1437	1492		3.8
		Top and Drop	527	807		53.1
		Misc.	136	234		72.1
		Total	36965	50734		
		Whole A/C	36964	49112	50734	37.2
(D)		Mar.mainly LM	87000	10800		24.1
		N-M Direct	32310	32400	(**)	0.3
		N-M retroc.	1683	1700	(**)	1.0
U.T.A. DC10 Nigeria	19.9.89	Aviation	1810	2106		16.4

(**) The outstanding notifications had already been raised to total expected for cedants who had advised claims to the layer. Hence the estimated further increase covers mainly layers not yet breached.

Catastrophe claims as at 31.12.1991

Net of risk-related reinsurances outwards
Gross of reinsurance protections

Common US$ 000

Catastrophe	Date of Loss	Account	Incurred Losses	Est. final amount		Run-off Factor %
				First Estimate	Adjusted	
US Air off runway into river	20.9.89	Aviation	10665	12845	15583	46.1
California Earthquake	17.10.89	LMX	3452	4343		25.8
Tan Sahsa Honduras Air	21.10.89	Aviation	1827	2612		43.0
Phillips Petroleum Pasadena (A)	23.10.89	LMX	5198	6199	6822	31.2
		Marine	39153	52524	57801	47.6
		Total	44351	58723	64623	
		Whole A/C	44351	64623	64623	45.7
(B)		Whole A/C	12536	24972		99.2
US Winter Freeze CAT 24	19.12.89	LMX	2575	3508		36.2
89AE Australia Earthquake	28.12.89	International	6231	7267	8148	30.8
		LMX	6218	9092	10195	64.0
		Total	12449	16359	18343	
		Whole A/C	12449	18343	18343	47.3

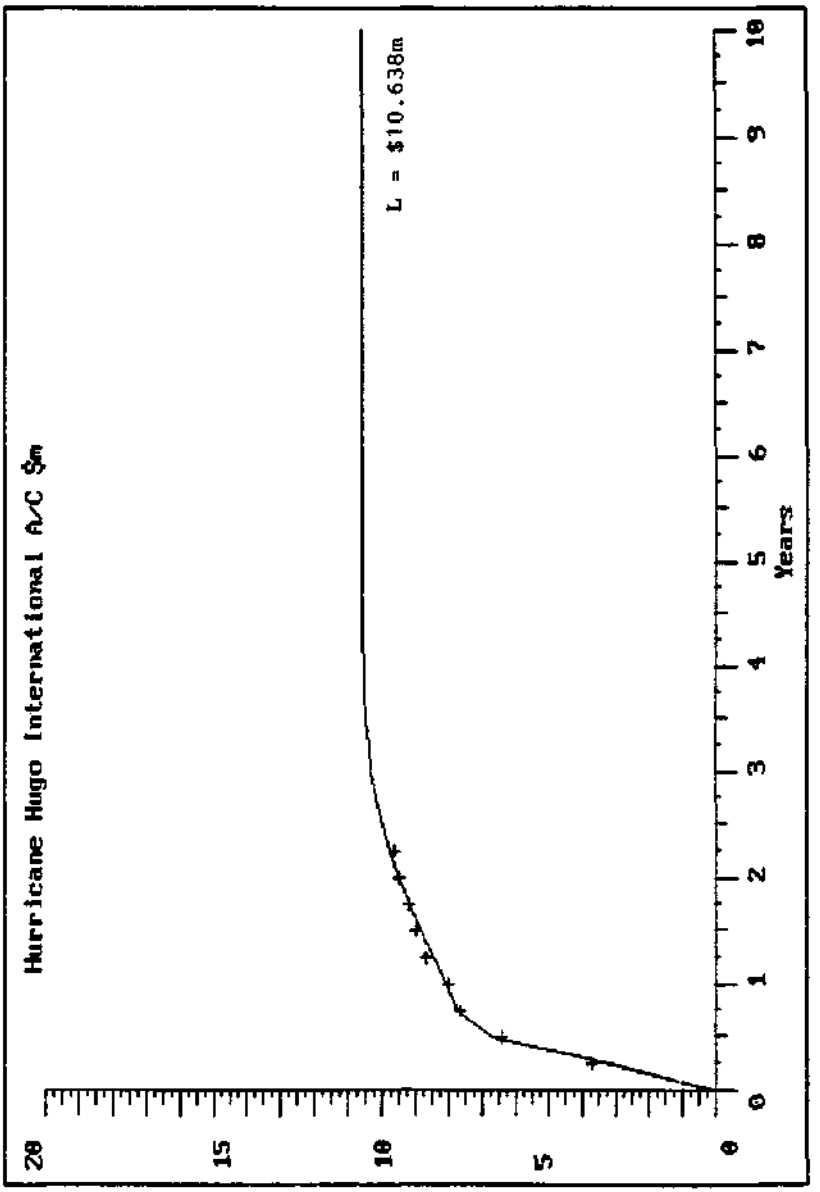
Catastrophe claims as at 31.12.1991

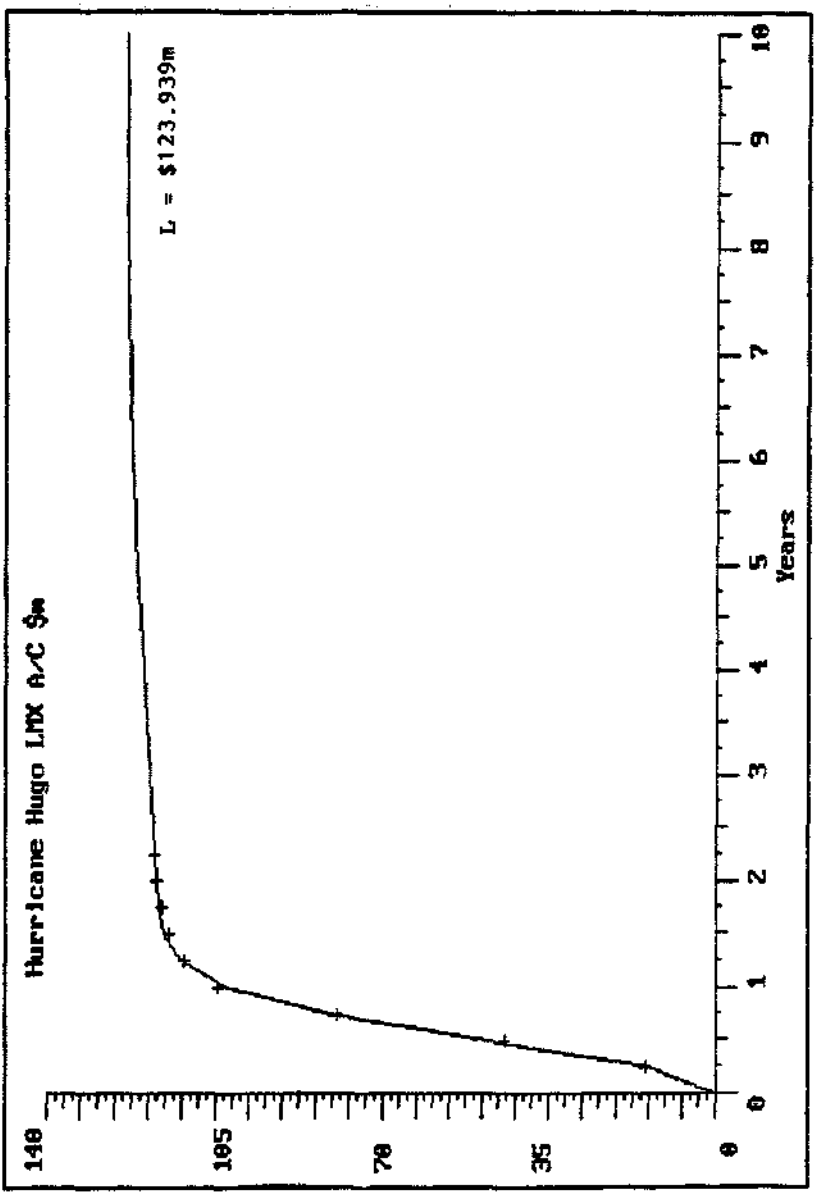
Net of risk-related reinsurances outwards
Gross of reinsurance protections

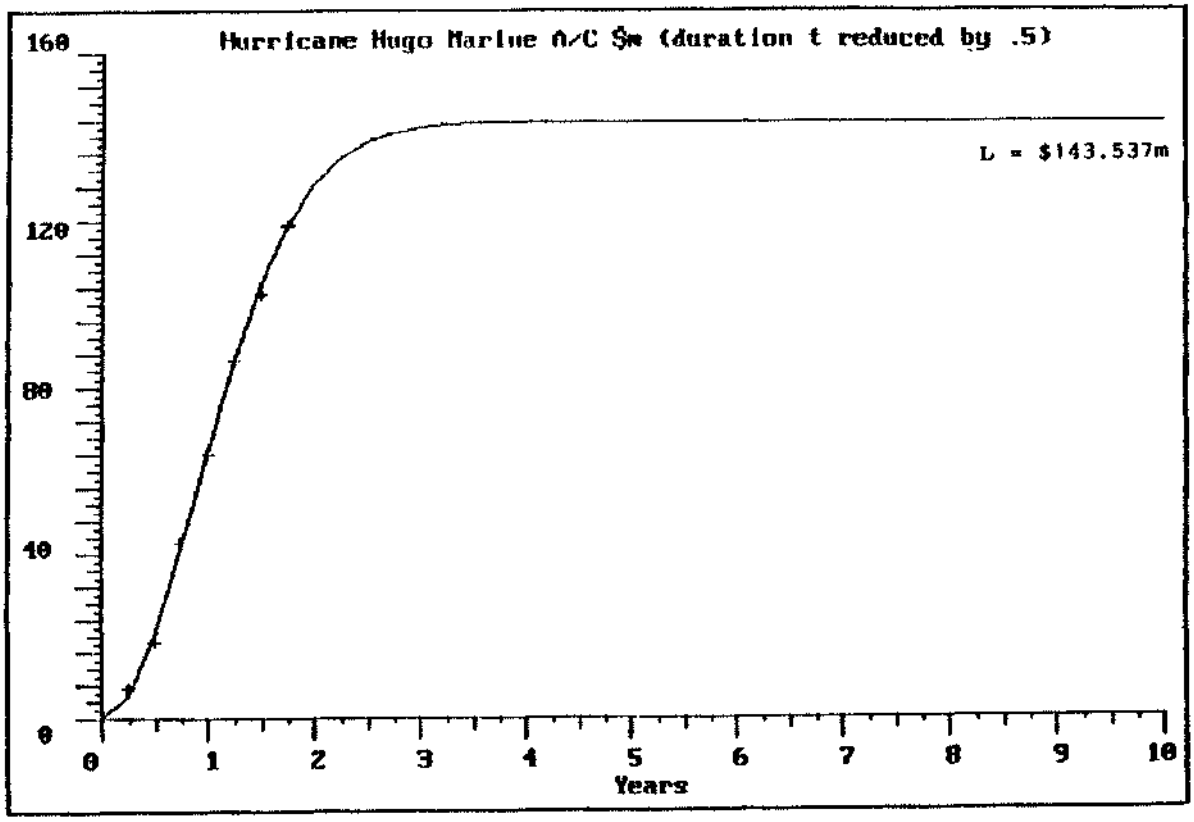
Common US$ 000

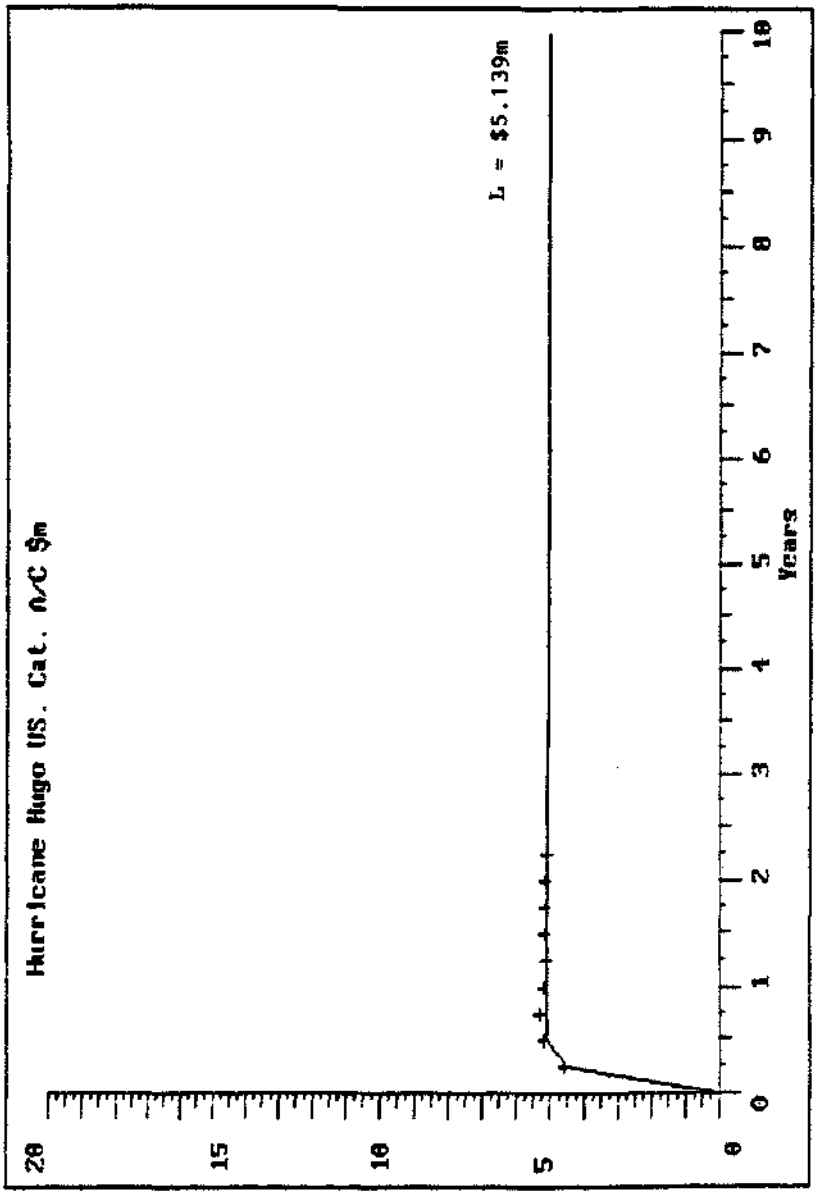
Catastrophe	Date of Loss	Account	Incurred Losses	Est. final amount		Run-off Factor %
				First Estimate	Adjusted	
90A	25.1.90	International	23450	23493	27557	17.5
Windstorm		LMX	94689	95168	111632	17.9
Daria		Marine	54518	79334	93059	70.7
(A)		Total	172657	197995		
		Whole A/C	172657	232248	232248	34.5
(B)		Whole A/C	172657	225404		30.6
(C)		LMX incl.LMX	9949	30006	30491	206.5
		X/L incl.X/L	256	684	695	171.5
		Lond. W. A/C	1304	3788	3849	195.2
		For. W. A/C	306	489	497	62.4
		Lond.N-M X/L	3365	4516	4589	36.4
		For.N-M X/L	479	778	791	65.1
		Lond.N-M W.A/	3616	6158	6258	73.1
		For.N-M.W.A/C	1047	1642	1669	59.4
		Misc.	255	538	547	114.5
		Total	20577	48599	49386	
		Total Direct	20577	49385	49385	140.0
(D)		N-M Direct	18540	18810	(**)	1.5
		N-M retroc.	10880	11050	(**)	1.6

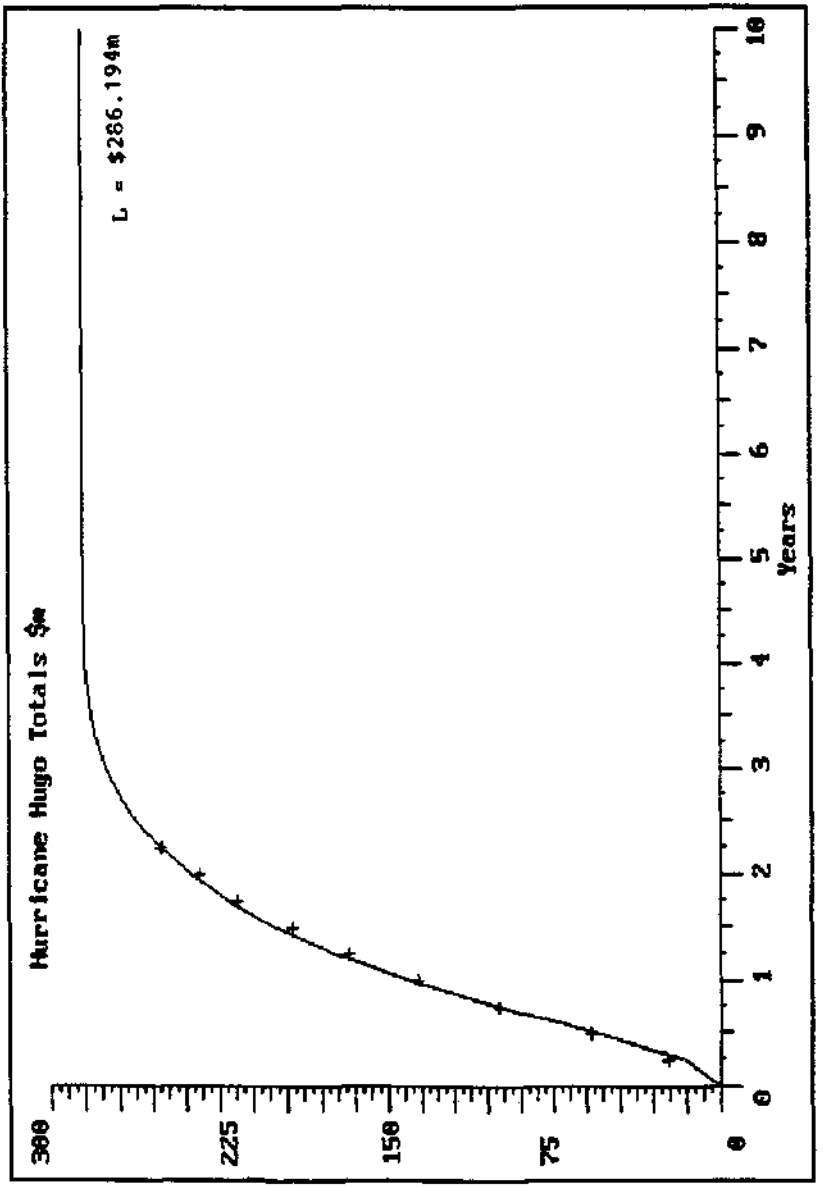
(**) The outstanding notifications had already been raised to total expected for cedants who had advised claims to the layer. Hence the estimated further increase covers mainly layers not yet breached.


Hurricane Hugo International A/C $m
L = $10.638m
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
Years


Hurricane Hugo LMX A/C $m
L = $123.939m
140
105
70
35
0
0
1
2
3
4
5
6
7
8
9
10
Years


Hurricane Hugo Marine A/C $m (duration t reduced by .5)
L = $143.537m
160
120
80
40
0
0
1
2
3
4
5
6
7
8
9
10
Years


Hurricane Hugo US. Cat. A/C $m
L = $5.139m
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
Years


Hurricane Hugo Totals $m
L = $266.194m
300
225
150
75
0
0
1
2
3
4
5
6
7
8
9
10
Years

Glossary of Terms

While the following definitions and explanations are provided for terms used in this article 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 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 x $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 eg.

Non-Marine	$ 50,000 x $50,000
	$100,000 x$100,000
	$300,000 x$200,000
Marine	Somewhat similar
Whole Account	$500,000 x$500,000
	$1m x $1m
	$3m x $2m
	$5m x $5m

(See 2.2.4 of the article 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, 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 1 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 x $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 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) US Cat A/C	Catastrophe business advised directly by insurers in the United States.
(b) World-wide Cat A/C	Catastrophe business advised directly by insurers in countries other than the United States.

(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 with 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 established, but not both within the year of account concerned. For example, a top and drop of $250,000 x $250,000 can be used either parallel to the existing treaty of that magnitude or alternatively, if the top limit of all other treaties is, say $5m, as a treaty for $.25m x $5m.
(g) Franchise Cover	Cover with a loss exceeding a specified amount but then repaying the total loss from

	ground up, to an agreed limit.
(h) 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 of even two years later. The inception date is by no means always 1st January. It may be any other date in the year.