Progress with the Manual has, regrettably, been slower than hoped. To produce a fully satisfactory work has proved a larger task than at first envisaged. But momentum has been regained, and publication in mid-1988 is now confidently expected. As shown on the enclosed Contents List, the Manual is structured in two main parts, or ‘logical volumes’.

These are as follows:

**Logical Volume 1 — Simple Reserving Methods**

§§ A–D contain introductory material on the insurance background, data and forecasting methods, company and external influences, and dimensions of choice in claims reserving.

§§ E–J describe the main methods at this level—basically, evaluation of run-off triangles. Included are projection of both paid and incurred claims, the adjustment of case reserves and loss ratio methods. Further sections deal with average cost per claim methods, IBNR estimation and adjusting for inflation.

§§ K–N round off the first volume. Miscellaneous topics such as claims expense are treated, and another section looks at the actuarial approach to claims reserving. Two sections of case studies then follow, plus a final note to tie up the algebra for Volume 1.

To date, §§ A–H are complete, and will be on display in the typeset version at Torquay. The remaining sections, except the case studies, are due for completion later in 1987.

**Logical Volume 2 — Mathematical & Statistical Modelling**

The work of volume 1 is naive, statistically speaking. It demonstrates the methods by means of arithmetical example, and is deliberately intended for use by those without higher degrees in mathematics or actuarial qualification. The level of the work, however, is not trivial. Pains are taken to show the variability of the estimates which can be produced in claims reserving, and the need to exercise judgment. But there is no formal treatment of the variance and other statistical parameters.

Volume 2 is intended to remedy this deficiency. It will introduce ideas of explicit modelling, curve fitting, time series, Bayesian estimation, and so on. The contents are at present still under discussion, and §§ P–T on the enclosed listing should be regarded as very far from the final form. Recent discussions, however, have identified certain methods which it is essential for the Manual to include. These are as follows:

- a) Craighead’s curve fitting method, plus Benjamin & Eagles’ developments.
- b) Reid’s method and its variations.
- c) Recent formal work on least squares & run-off triangles by Kramer et al.
- d) Methods developed by the Swedish actuary Bjorn Ajn.

Zehnwirth’s Bayesian technique using the Kalman filter may also be included. Suggestions for other methods and topics which ought to be in the Manual, especially Volume 2, will be sought at Torquay. This part of the Manual is still in a formative stage, and the views of GISG members will be particularly welcomed as an influence.

Gary Chamberlin / Oct 1987
CLAIMS RESERVING MANUAL

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   2. Data Groupings: Principle of Homogeneity
   3. The Claims Development Table
   4. Data Quantities
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THE INSURANCE BACKGROUND

Preamble
Before embarking on the methods and techniques for claims reserving, which make up the greater part of the Manual, it is important to establish the background to the work. Why is claims reserving such a vital topic in General Insurance, and what purposes does it serve in the industry? What are the characteristics of the main classes of business to which the reserving relates? And what is the place of the claims reserve within the technical reserves as a whole? The present section provides answers for these questions, but in summary form only. The Manual is not, and cannot be, a study of the whole of general insurance. The crucial point to establish is that the methods do not operate in a vacuum. In themselves, they are but abstractions. The reserver should take as starting point the concrete world of business which the methods are intended to serve, and keep such a view in mind. Claims reserving methods are of little value unless they become good practice as well as good theory.

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DATA & FORECASTING

Preamble
This section introduces some of the main building blocks for claims reserving. To begin with, there is the important idea of making a projection of past experience forward on to the future. Since the future never takes the trouble to conform properly with the past, any projection whatsoever will be subject to error. One needs, therefore, to understand the principles which can lessen the likely degree of error, and so bring credibility to the work.

Apart from those principles which make for stability, there is the matter of the data itself and the actual means for forecasting. These are not intrinsically difficult matters, but there is a fair amount of detail to be mastered. On the data side, a number of different quantities can be used in the projections, or as supporting evidence — not only claim amounts, but such items also as claim numbers, premium income and loss ratios. They can often be displayed in different ways in the search for pattern and regularity, and the concept of the development table is particularly important here. Then there is the question of data validation, and of how the classification of the risk groupings is to be made.

On the forecasting side, there are some surprisingly simple means available. It is straightforward, almost intuitively obvious, to look for the average or trend which is present in a sequence of figures. The really vital question to ask is to whether the available evidence supports the continuation of such average or trend into future periods. Although far more elaborate types of projection can be devised, it is these simple foundations on which they rest, and which should therefore first be thoroughly understood.

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Preamble

If we lived in a world where nature and human artifice were well behaved and gave no cause for upset or surprise, then claims reserving would be a simple matter scarcely requiring the services of the expert. One would need to assess the values of at most three quantities for each class of business: a) the exposure to risk, b) the frequency of claim, and c) the average loss per claim. Past and present trends for these factors could be assumed to hold equally in the future, and the known patterns could be projected forward with confidence.

In such a world, however, insurance itself would scarcely be necessary at all. The world we do inhabit has a sufficient degree of natural cussedness and human fallibility that the long-term prospects for insurance remain bright. The cussedness and fallibility affects the claims reserving process as it does everything else. The projections are seldom straightforward to make. For protection, the reserver needs to arm himself with a knowledge of the influences which are most likely to disturb the picture. Only in this way can he hope to produce figures in which theory is properly tempered by reality. The present section outlines the main influences, both internal and external to the company, which usually need to be taken into account.

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DIMENSIONS OF CHOICE

Preamble

Emarking on the claims reserving exercise, there are a number of underlying choices which have to be made. Often, they will be constrained by the availability of data, but on other occasions there will be considerable freedom. Again, the choices may not all be made consciously - they may be implicitly made through an office’s established procedures for claims reserving. In this case, a periodic review of their propriety should still be made.

To make the choices clear, they are here brought out as a series of 'either/or' dimensions. But often the right answer will not be 'either/ or' but 'both'. The reserver is likely to build up a fuller and more reliable picture if he approaches the problem in a number of different ways.

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D7. Paid Claims v. Incurred Claims Development
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Section E
THE PROJECTION OF PAID CLAIMS

Preamble
As a starting point for the simpler statistical methods, the projection of paid claim amounts is ideal. The idea underlying the method is a simple one, but it is quite fundamental. Thus, we can watch the claims for a given accident or report year developing to the ultimate value, and see the pattern that is established over the intervening years. The pattern can be expressed in terms of the proportion of the final amount which is paid out as the years progress. If subsequent accident years can be shown or assumed to follow a similar pattern, then we have a simple and direct means for arriving at the claims estimate.

When projecting claims in this way, there are two main techniques which can be followed. These are respectively the Grossing Up and Link Ratio methods, and on each a number of variations can be played. In fact, the two methods are opposite sides of the same coin, and will normally give very similar results. The skill comes in the choice of variation, and in the assessment as to how far the data conforms to the basic assumption of a stable claim payment pattern. The methods are easy to follow in principle, and are illustrated in the text by means of an extended numerical example.

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E3. Grossing Up — Variations 3 & 4
E4. Comparison of Results
E5. The Link Ratio Method — Introduction
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E8. Original Weightings — the Chain Ladder Method
E9. Link Ratios with Trending
E10. Comparison of Link Ratio Results
E11. Link Ratios v. Grossing Up
E12. Paid Claim Projections & the Claim Settlement Pattern
In spite of producing a variety of estimates, the method as used so far is still open to objection. In fact, the work has been based on information from old accident years. There has been no attempt to use the data from later years, as appear in the paid claims triangle, apart that is from accident year 1 itself. But claims payment patterns may be changing, and the reserver should be abreast of the current situation. Hence it is time to drop the earlier accident years, and concentrate on what may be discovered from the paid claims triangle itself.

To recap, the triangle is:

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1001</td>
<td>1855</td>
<td>2423</td>
<td>2988</td>
<td>3335</td>
<td>3483</td>
</tr>
<tr>
<td>2</td>
<td>1113</td>
<td>2103</td>
<td>2774</td>
<td>3422</td>
<td>3844</td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>3</td>
<td></td>
<td>3233</td>
<td>3977</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1490</td>
<td>2873</td>
<td>3880</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1725</td>
<td>3261</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1889</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To make use of the information, one convenient way is to work back through the triangle, starting from the top right hand corner. This will be done in Variations 3 & 4.

**Variation 3 — Averaging**

For Year 1 the ultimate value of the claims is estimated at 3705, and analysis of its payment pattern gives the vector:

<table>
<thead>
<tr>
<th>d</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>ult</th>
</tr>
</thead>
<tbody>
<tr>
<td>pC%</td>
<td>27.0</td>
<td>50.1</td>
<td>65.4</td>
<td>80.6</td>
<td>90.0</td>
<td>94.0</td>
<td>100</td>
</tr>
</tbody>
</table>

This can be applied to the latest development value for Year 2, i.e.: 3844, attained at $d=4$. The appropriate grossing factor is 90.0%, giving a final estimated loss for Year 2 of:

$$3844 / .900 = 4271$$

Using this value, the whole payment pattern can be derived for Year 2 as well:

<table>
<thead>
<tr>
<th>d</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>ult</th>
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</thead>
<tbody>
<tr>
<td>pC</td>
<td>1113</td>
<td>2103</td>
<td>2774</td>
<td>3422</td>
<td>3844</td>
<td>4271</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>26.1</td>
<td>49.2</td>
<td>64.9</td>
<td>80.1</td>
<td>90.0</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
THE PROJECTION OF PAID CLAIMS

(Note: it is not necessary to write down the PC% value for \( d=5 \), although if needed it would be taken as 94.0% directly from the Year 1 vector).

Coming to Year 3, we now have 2 different payment patterns to choose from. The vital value is that for \( d=3 \), and the available figures are 80.6% from Year 1, and 80.1% from Year 2. The obvious step is to take an average, which gives 80.4% as the grossing factor. (80.35% could be used, but 3-figure accuracy will be quite sufficient in the example). Hence the estimated final loss for Year 3 is:

\[
3977 / .804 = 4947
\]

This leads immediately to the payment pattern for Year 3, this time taken only to \( d=3 \):

<table>
<thead>
<tr>
<th>( d )</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>ult</th>
</tr>
</thead>
<tbody>
<tr>
<td>( PC% )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1265</td>
<td>2433</td>
<td>3233</td>
<td>3977</td>
<td>4947</td>
<td></td>
</tr>
<tr>
<td>25.6</td>
<td>49.2</td>
<td>65.4</td>
<td>80.4</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

We now have 3 values for the \( PC\% \) at \( d=2 \): 65.4, 64.9, 65.4%. The average is 65.2%, which can be applied to the latest claims figure for Year 4, ie 3880. The process continues automatically until the whole triangle has been covered, and all claims projected to their ultimate values. It is most convenient to set the procedure out in a single display, as follows:

<table>
<thead>
<tr>
<th>( d )</th>
<th>0</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
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<td>2423</td>
<td>2988</td>
<td>3335</td>
<td>3483</td>
<td>3705</td>
<td></td>
</tr>
<tr>
<td>27.0</td>
<td>50.1</td>
<td>65.4</td>
<td>80.6</td>
<td>90.0</td>
<td>94.0%</td>
<td></td>
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</tr>
<tr>
<td>1113</td>
<td>2103</td>
<td>2774</td>
<td>3422</td>
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<td>4271</td>
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</tr>
<tr>
<td>26.1</td>
<td>49.2</td>
<td>64.9</td>
<td>80.1</td>
<td>90.0%</td>
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<tr>
<td>1265</td>
<td>2433</td>
<td>3233</td>
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<td>4947</td>
<td></td>
</tr>
<tr>
<td>25.6</td>
<td>49.2</td>
<td>65.4</td>
<td>80.4%</td>
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<tr>
<td>1490</td>
<td>2873</td>
<td>3880</td>
<td></td>
<td></td>
<td></td>
<td>5951</td>
<td></td>
</tr>
<tr>
<td>25.0</td>
<td>48.3</td>
<td>65.2%</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1725</td>
<td>3261</td>
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<td></td>
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<td>6628</td>
<td></td>
</tr>
<tr>
<td>26.0</td>
<td>49.2%</td>
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</tr>
<tr>
<td>1889</td>
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<td></td>
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<td></td>
<td></td>
<td>7293</td>
<td></td>
</tr>
<tr>
<td>25.9%</td>
<td></td>
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</tr>
</tbody>
</table>

Overall Values:  
\[
\sum L - ult = 32,795 \\
\sum PC* = 20,334 \\
Reserve = 12,461 \\
\sum
\]

32,795
If this display looks somewhat elaborate, it may help to recall that the backbone of it is just the given triangle of paid claims values. The percentage values, and the final column to the right are the ones which have to be calculated.

As for the method of working through the display, this should be clear from the preceding development. Remember that we begin from the top right hand corner, and work down the leading diagonal. Each % estimate on the diagonal is found as the average of the % values above it in its own column. Then it is applied as a grossing up factor to the current paid claims figure which is immediately beside it. This gives the estimate of the ultimate loss for the accident year, which is written in the final column of the display. With this figure, the other % values in the row can then be calculated, working Arabic fashion from right to left. That done, we move to the next lower position on the leading diagonal, and repeat the process, until the work is finished on the lowest rank of the diagram.

**Variation 4 — Worst-Case Estimate**

As with Variations 1 & 2 above, a conservative or worst case estimate can be made using the data in the triangle. All that is necessary, when working down the columns of %'s, is to choose the lowest value found rather than taking the average. E.g: in the above display in column \( d=2 \), use 64.9% instead of 65.2% as the choice. This new value will then appear in the 3880 cell, and be used for grossing up the Year 4 claims. The new procedure will of course affect the whole progress of the calculations, and the display must be redrawn. It appears as follows:

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>1</td>
<td>1001</td>
<td>1855</td>
<td>2423</td>
<td>2988</td>
<td>3335</td>
<td>3483</td>
<td>3705</td>
</tr>
<tr>
<td></td>
<td>27.0</td>
<td>50.1</td>
<td>65.4</td>
<td>80.6</td>
<td>90.0</td>
<td>94.0%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1113</td>
<td>2103</td>
<td>2774</td>
<td>3422</td>
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<td>4271</td>
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<td></td>
<td>26.1</td>
<td>49.2</td>
<td>64.9</td>
<td>80.1</td>
<td>90.0%</td>
<td></td>
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<tr>
<td>3</td>
<td>1265</td>
<td>2433</td>
<td>3233</td>
<td>3977</td>
<td></td>
<td></td>
<td>4965</td>
</tr>
<tr>
<td>a</td>
<td>25.5</td>
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<td>65.1</td>
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\[33,285\]
The value obtained for the reserve is appreciably higher than that with simple averaging, by some 3.9%. A full comparison of the grossing up results appears in the next section.
Preamble

At a given reserving date, more is usually known than the bare fact of the actual claim payments. For each class of business, there will be a number of claims still outstanding, and to these individual estimates will be attached by the Claims Department. Hence the reserver will have a further source of information towards producing his final figure for the liability. The question that arises will be as to the adequacy of these case estimates — if they are compounded with the paid amounts on settled claims, how close will the figure be to the ultimate loss on the business?

The quantity obtained by adding the case reserves to the paid claims is commonly called the 'incurred claims'. It turns out that the set of methods derived for projecting paid claims to the ultimate can be applied in just the same way to the incurred claims. Comparison of the results with the paid claim projections can be instructive. But this time, there are more possible disturbing influences at work — as well as the settlement pattern, the reporting pattern of the claims has to be considered. And as well as the adequacy of the case reserves, their consistency over time is of prime importance. One useful development of the projection techniques enables the reserver to assess this consistency. The example of the previous section is extended here to continue the illustration by numerical means.

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F1. Nature of Case Estimates
F2. The Incurred Claims Function
F3. Incurred Claims — Grossing Up
F4. Incurred Claims — Link Ratio Method

F5. Grossing Up of Case Reserves
F6. Adequacy & Consistency of Case Reserves
F7. Adjustment of Incurred Claims Projection
**Preamble**

Introduction of the loss ratio into claims reserving methods at first sight seems paradoxical. If one were to know the loss ratio for a class of business with confidence, then the reserving procedure would become almost trivial. But of course the loss ratio is subject to uncertainty, just like other quantities used in claims reserving. Here again the past is no sure guide to the future. But though the reserver cannot have full knowledge of the future for the loss ratio, some familiarity with its past history and the current expectations of underwriters and ratemakers will be of great service to him.

This familiarity, in fact, should help to provide him with a kind of standard, or benchmark, against which the results of other projections can be assessed. It should help to stabilise results where data are volatile, and provide a first guide to reserves where data are scanty or even non-existent. The loss ratio, and the techniques associated with it, thus form an important part of the reserver’s toolkit. The only additional data element required for this work is the premium income (earned or written) for the class of business in question. Being a valid measure of the risk exposure, it gives *scale* to the loss data, and hence enables the loss ratio benchmarking to begin.

**Contents**

G1. Concept of the Loss Ratio  
G2. Naive Loss Ratio Method  
G3. Bornhuetter-Ferguson Method — Introduction  
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G5. Bornhuetter-Ferguson on Paid Claims  
G6. Comparison of Results  
G7. Taking Stock of the Methods  
G9. Paid Loss Ratio & Its Projection  
G10. Stepwise Projection of Paid Loss Ratio  
G11. Incurred Loss Ratio & Its Projection  
G12. Comparison of Results