

INSTITUTE AND FACULTY OF ACTUARIES

Curriculum 2019

SPECIMEN SOLUTIONS

**Subject SP7 – General Insurance Reserving
and Capital Modelling Principles**

1 Income in annual insurance accounting model

Earned premiums and changes in premium/risk reserves	[½]
Reinsurance recoveries received or accrued when the relevant claim has been recognised/paid	[½]
Changes in reinsurance reserves	[½]
Investment income	[½]

Outgo

Claims paid	[½]
Claims handling expenses and other expenses paid	[½]
Changes in claims outstanding (including IBNR) in the accounting period	[½]
Reinsurance premiums	[½]
Commissions / profit commissions	[½]
Underwriting charges / taxes	[½]

[Maximum 3]

2 Factors influencing the purchase of reinsurance

Class of business	[½]
... likely size, range and volatility of risks	[½]
... desire to smooth profits	[½]
Size of free reserves	[½]
... larger free reserves means less need for reinsurance or higher retentions	[½]
Total premiums written	[½]
Geographical regions in which the risks are located ...	[½]
... e.g. geographical concentration	[½]
... perils associated with specific regions	[½]
Accumulations of risk ...	[½]
... e.g. geographical or other example	[½]
... the need for maintaining a balanced portfolio of risks	[½]
Current market conditions ...	[½]
... availability of reinsurance or coinsurance	[½]
... perceived value for money of additional reinsurance	[½]
... security status of available reinsurers	[½]
... regulatory environment	[½]
Insurers Preferences ...	[½]
... risk appetite and tolerance	[½]
... underwriter influences	[½]
... need for technical assistance	[½]
... financial objectives	[½]
Expectations of reinsurers ...	[½]
... interests of cedant and reinsurer aligned	[½]
Confidence in the line of business	[½]
... especially if new	[½]
Capital requirements	[½]
Relationships with reinsurance brokers	[½]

Expectations of credit rating agencies/regulator [½]

[Maximum 8]

3 Data items used in an internal capital model

(a) **Underwriting risk**

Gross/net of reinsurance unexpired premiums at balance sheet date [½]
 split by class of business or other relevant sub-division [½]
 Gross/net of reinsurance new business premium over model period [½]
 Planned loss ratios by class of business split large/attritional/cat if available [½]
 Expected future reinsurance profile [½]
 Reinsurance costs/disputes etc. [½]
 Historical inflation rates [½]

(b) **Market risk**

Inflation/interest rates/other economic inputs [1]
 Current value of assets [½]
 Current mix of assets by type [½]
 Exchange rates [½]
 Investment income/historic returns [½]
 Investment credit risk [½]

(c) **Counterparty default risk**

Reinsurer's share of ultimate claims [½]
 Reinsurer credit rating [1]
 Reinsurer downgrade assumptions [½]
 Future reinsurance programme [½]
 Debtor information (e.g. broker balances) [1]

(d) **Liquidity risk**

Claims payment profiles [1]
 Premium payment profiles [½]
 Information on other cashflows, e.g. reinsurance recoveries, commissions etc. [½]
 Historic catastrophe losses [½]
 Expenses [½]
 Tax [½]
 Dividends [½]

[Maximum 8]

4 (i) Purpose of sensitivity testing in internal model validation

The purpose of sensitivity testing is to identify the more sensitive assumptions in the capital model, i.e. which assumptions, if changed, would have the greater impact on the results. [½]

Sensitivity testing also helps check that the model responds appropriately to changes in the assumptions. [½]

[Maximum 1]

(ii) Why the test may not match expectations

Simulation error [1]

Calculation basis may mean that a 5% movement shouldn't be expected [1]

Reserve risk calculation may include other elements, e.g. reinsurance or discounting [1]

Reserve risk may be on different basis, for example 1yr vs ultimate or tVaR vs VaR [1]

There may be an error in the model [1]

. . . or the implementation of the test [1]

[Maximum 3]

(iii) Factors influencing expected outcomes

Size of the top three classes relative to other classes [1]

Volatility of top three classes relative to other classes [1]

The risk measure used [1]

Correlations within the reserve risk model [1]

Reinsurance applying to the classes [1]

Way in which reinsurance is modelled if relevant (e.g. recognising a volatility mitigating effect) [1]

Calculation basis differences as in (ii) – note both simulation error and testing error do not impact expected outcomes so no credit given for these [1]

[Maximum 4]

5 (i) Perils from which to seek reinsurance protection

Drought causing crop failure [½]

Hail damage to crops [½]

Flood damage to crops [½]

Insects/plagues destroying crops [½]

Unseasonal frost damage to crops [½]

Natural disaster (e.g. typhoon) causing death of livestock [½]

Livestock disease [½]

Theft of livestock	[½]
Liability Exposures	[½]
<i>Credit for other valid perils</i>	

[Maximum 3]

(ii) **Factors for reinsurers to determine an earned premium profile**

Types of reinsurance written	[1]
. . . since excess of loss treaties and quota shares may earn in different ways.	
	[½]
Proportions of business that will be on a risks attaching/losses occurring basis	
	[½]
. . . as losses occurring business should earn more quickly.	[½]
Dates of inception of the policies	[½]
- if policies in this market tend to incept on 1 January it will be different than if policies were incepting smoothly over the year.	[½]
The main perils that the business is exposed to and their seasonality	[1]
- storms may be seasonal so higher exposure during certain months	[½]
- disease or earthquake are likely to be spread evenly during the year.	[½]
Complications occur for this class by the peak growing and harvest seasons	[1]
- once all crops harvested there is no more risk	[½]
- different seasons for northern / southern hemisphere so proportion of business in each is important.	[½]
Types of risk that are covered	[½]
. . . since livestock risks may have different earning profiles to crop risks.	[½]
Duration of policies as it may be the case that not all policies are annual in this class.	
	[½]
<i>Any other special features of the treaties relevant for the new class of business such as</i>	
the availability of data	[½]
materiality	[½]
no claims bonus	[½]
profit commissions	[½]
<i>other valid examples</i>	

[Maximum 6]

6 (i) (a) **Captive Insurer**

An insurer wholly owned by an industrial or commercial enterprise and set up with the primary purpose of insuring the parent or associated group companies, and retaining premiums and risk within the enterprise. [1]

Some insurers are set up with the primary purpose of selling insurance to the customers of the parent. [½]

These are often known as captives but, as they write third-party business, should not properly be so called. (If the word “captive” is used without qualification it precludes this interpretation.)

[1]

(b) **Free reserves**

Free reserves are the excess of the value of an insurer’s assets over its technical reserves and current liabilities. [1]

Also known as the solvency margin [½]

. . . and sometimes, in the case of a proprietary insurer, referred to as shareholders’ funds or net asset value. [½]

[Maximum 3]

(ii) **Why a company may set up a captive insurer**

To fill gaps in insurance cover that may not be available from the traditional insurance market [½]

To manage the total insurance spend of large companies or groups of companies [½]

To reduce the impact of market cycles on premiums [½]

To enable the enterprise to buy cover directly from the reinsurance market rather than direct insurers [½]

To profit from accepting external risks [½]

To focus effort on risk management [½]

To gain tax and other legislative or regulatory advantage [½]

[Maximum 2]

(iii) **Setting up a partially owned new reinsurer**

(a) **Advantages and disadvantages to the cedant**

It provides an alternative source of risk transfer compared to the traditional reinsurance market [½]

. . . creating opportunities for broader coverage, [½]

. . . more favourable terms and conditions [½]

. . . and increased flexibility. [½]

They may be able to negotiate higher return commission and reduce reinsurance brokerage fees, in return for the high proportion ceded and long-term agreement. [1]

They may also further reduce reinsurance costs by being able to negotiate a tailored and more generous profit sharing deal. [½]

It avoids ceding as much profit to the reinsurer as they retain a 30% interest. [½]

They may be less exposed to the reinsurance underwriting cycle as the new arrangement should avoid price volatility arising from disequilibrium in demand and supply [1]

. . . but this also means that they will not benefit from soft conditions in the traditional reinsurance market. [½]

The cedant may be exposed to increased counterparty risk exposure ceding much of its risk to a single party as opposed to the likely previous position of ceding to a panel of reinsurers [1/2]
... leading to potential issues with the cedant's regulators or leading to higher capital requirements, particularly if the new reinsurer is unrated. [1]

The diversification benefits of its reinsurance may reduce if it keeps its retention levels the same for the business it cedes under the new arrangement as its insurance risk may be more correlated with its market risk through its investment in the new company. [1]

The insurer's purchasing power in the traditional reinsurance market may be reduced due to reductions in the volume of business placed [1/2]
which may make the terms for any residual risk that they may wish to place in the traditional market less favourable. [1/2]

The favourable regulatory regime may result in a better deal for the cedant than they would have achieved previously. [1/2]

The insurer will also be an investor in the new company and will be subject to the benefits and drawbacks of an investor as discussed below. [1/2]

(b) Advantages and disadvantages to the new company

The new company will assume risk from a single cedant exposing it to risk concentrations that would be reduced in a large multi-cedant portfolio, [1]
e.g. pricing errors, poor quality claims handling, weakness in terms & conditions, reinsurance administration problems etc. [1]

The cedant may have had significant influence on the composition of senior management structure perhaps sourcing them from within their own company. [1/2]

Whilst this may ensure the new company has excellent knowledge of the risks it assumes it could also create conflicts of interest which may adversely impact the new company. [1/2]

The new company has a guaranteed source of premium income for the duration of the long-term arrangement [1/2]
though such an arrangement may still allow the proportion of risk ceded and its profit margin to vary between limits or over time depending on the agreed terms. [1/2]

The long-term arrangement should reduce some of the price volatility from the insurance/reinsurance cycle [1/2]
though they may still be exposed to pricing pressure due to the cedant comparing pricing to the traditional market and any impact on the reinsurer from volatility in the retrocession market. [1/2]

The cedant is retaining a large equity interest in the new venture which together with the higher ceded proportion should risk of selective cessions. [1/2]

The company is being established in an environment which appears favourable to these types of arrangements which should ensure it can be set up quickly and efficiently [1/2]
though the low barriers to entry may make it more difficult to raise the required capital on acceptable terms if other start-ups are also competing for this capital. [1/2]

The company may be able to reinsure the risks of other insurers in the future providing it with additional sources of business and diversification. [1]

The favourable regulatory regime may give the reinsurer competitive advantage. [1/2]

May be subject to political risk. [1/2]

(c) Advantages and disadvantages to investors in the new company

This investment is attractive to investors who seek exposure to higher yielding investment risk diversified with insurance risk [1]
and those who want exposure to insurance risk but with a more aggressive investment strategy. [1/2]

Investors are exposed to concentrations of risk that can make returns volatile [1]

Compared to pure investment vehicles this company has an additional source of investment capital through the liquidity arising from premiums proceeding claims. [1/2]

This gearing effect should increase the expected return on capital employed [1]

but they are also exposed to the risk that claims will exceed premiums or the timing of claims payments is not as expected thereby increasing the downside risk. [1/2]

The investment is subject to the usual additional drawbacks of investing in private companies e.g. poor liquidity and marketability, higher dealing costs, value only known on sale or purchase [1]

though they have the opportunity of making additional returns if the company elects to pursue an initial public offering at a later stage. [1/2]

(d) Advantages and disadvantages to the country of the new company

It should attract investment capital and increase economic activity through increased employment, additional demand for goods and services [1]

and increase government revenue through personal / corporate / consumptive taxation, regulatory and corporate fees. [1]

This type of arrangement may fall out of fashion due to changes in business, tax or regulatory rules in the countries of the insurer or investors resulting in large or possibly sudden changes in the demand for these arrangements reversing any benefits to the host country. [1]

The country may develop a reputation of having a lax regulatory environment damaging their international standing and possibly reducing the ease as which they can conduct business with other regulatory regimes. [½]

They may also attract companies with inadequate capital, poor risk management practices or excessive risk tolerances increasing the risk of insolvencies. [½]

[Maximum 12]

(iv) **Investment Strategy Statement**

There is some merit in the concern raised as it is not clear that the investment manager is tasked with meeting contractual obligations. [1]

The cedant (as a major shareholder) and having a related business will want the reinsurer to be mindful of its contractual obligations [1]

This statement is consistent with the typical investment objectives of a general insurance company. [½]

However, the company is not proposing that it change the investment strategy for its own company assets. It can be argued that the investment policy of the new reinsurer remains consistent with this objective as they seek to maximise investment returns whilst still meeting contractual obligations. [1]

Despite the regulatory requirements the contractual obligations remain important due to the cedant being a major shareholder and the success of the venture dependent on the capital remaining protected and generating adequate return and staying within its risk tolerance. [1]

And although the risk tolerance is higher and less restrictive than usual will most likely still exist as a matter of good risk management and corporate governance. [1]

The new reinsurer is required to hold a minimal level of statutory free reserves and is capitalised on a prudent basis [½]
allowing the large free reserves to support an aggressive investment strategy and still remain consistent with the investment objective. [1]

[Maximum 4]

[Total 21]

8 (i) Parameter and Model Uncertainty

Parameter uncertainty refers to the uncertainty arising from the estimation of parameters used in a model. [½]

Given that any model is an artificial of a real life situation, there will always be a certain degree of parameter uncertainty in the models that we use. [½]

Model error arises from the choice of or specification of the model. [½]

By using a simplified model to project the true underlying system, an unknown bias is introduced into the model. [½]

[Maximum 1]

(ii) Sources of Uncertainty in an actuarial reserving model

Parameter uncertainty

When fitting a distribution there will be uncertainty at extreme values. [1]

It is often very difficult to fit a distribution at the tails because of the lack of data at extreme values. [½]

And where there is data it may be too volatile to be usable. [½]

Assumptions will therefore have to be made from what is available which will give rise to uncertainty in the model output. [½]

Certain claim events have insufficient data to model or historic data may be deemed to be inappropriate as it is no longer directly relevant. [1]

Reserving philosophy within a company will change from time to time. [½]

For example, if claims handlers have under-reserved a case in the recent past, they may be inclined to overestimate future claims to compensate. [½]

There may also be changes in reserving philosophy following a change in senior personnel. [½]

Large claims [1]

can be expected to have different frequency and severity distributions to attritional and catastrophe claims. [½]

They are also likely to have different development patterns. [½]

There may also be differences in development pattern based upon the type of large claim / peril. [½]

Uncertainty may also arise in how a large claim is defined, [½]

e.g. they could be defined as claims over a particular threshold, [½]

or large claims may be a subjective management decision. [½]

- On some occasions, there may be an absence of large reported claims which will give rise to additional uncertainty. [½]
There may also be delays in passing the data to the insurer [½]
and these delays may also differ between claims handlers. [½]
- Claims inflation not as expected [1]
Inflation assumptions will often be required and the actual inflationary experience will be a significant determinant in whether the chosen reserves will be too high or too low. [1]
- New distribution channels [1]
Different distribution channels will have different expense profiles. [½]
It may be difficult to predict the expense profile of a new distribution channel. [½]
Set-up costs of a new channel must also be factored in. [½]
- Planned or unplanned changes in mix [1]
Expense uncertainty also arises through a change in the relative proportions of business coming from existing distribution channels. [½]
If the mix of business changes significantly the development pattern is likely to change and in an unpredictable way. [½]

Model uncertainty

- Programming error... [1]
Simulation error/too few simulations... [1]
The output of a stochastic model will be heavily influenced by the number of simulations carried out: [½]
the greater the number of simulations, the greater the accuracy of the output. [½]
- However, large and complex stochastic models can take a considerable amount of time to run. [½]
If the modeller has severe time constraints, there may have to be a sacrifice in the number of simulations or in the complexity built into the model. [½]
Incorrect dependencies... [1]
A number of the variables in the model will be correlated with one another; [½]
for example, interest rates and claims inflation. [½]
Incorrect distributional assumptions in modelling reserve uncertainty... [1]
It is sometimes necessary to calculate a range of possible values for a reserve [½]
in which case distributional assumptions will be required. [½]

[Maximum 9]

(iii) **Process uncertainty**

Process uncertainty [1]
 If a process is assumed to be inherently stochastic, the future outcome will be uncertain because of the randomness of the process and the fact of course that many of these events have yet to occur. [½]
 This uncertainty is present even if model selection is perfect and the parameters are known with certainty. [½]

Data uncertainty [1]
 Poor or inconsistent data will lead to less reliable estimates [1]

[Maximum 2]

(iv) **Methods for quantifying reserve uncertainty**

Political Risk Book

Alternative sets of assumptions... [1]
 estimate reserves using alternative parameters to best estimate parameters (based on judgement) ... [½]
 ... with resulting spread of reserves providing range around best estimate [½]
 note that each individual assumption may be correlated with others (in particular, inflation and discount assumptions are typically correlated.) [½]
 assign probabilities to alternative sets of assumptions and assume a distribution to derive range of possible outcomes (understanding limitations of approach)

[½]
 Expert view from claims department should be sought [½]
 Benchmark CoV... [1]
 benchmark against industry data or alternative class of business... [½]
 adjust for alternative features of benchmark class using judgement [½]
 understand that industry data may exhibit dampened volatility due to increased volume and adjust accordingly [½]
 Scenario testing... [1]
 investigate the top limit of the range of possible outcomes... [½]
 e.g. in a scenario test, we might estimate the required reserves if oil prices crash causing multiple regions to become unstable simultaneously [½]
 In such extreme conditions, many areas of uncertainty may become more correlated than in normal conditions. [½]
 derive scenarios based on an historical event or a hypothetical event using our judgement but typically based on unlikely, but not impossible, events. [½]
 Justification...
 no history with which to perform detailed data based method [1]
 simple to perform in line with likely best estimate method [½]
 relatively straightforward to communicate results [½]

Marine Cargo

Marine Cargo:

- Stochastic ODP model... [1]
- stochastic model of claims development process [½]
- GLM applied to claims triangles where the form is chosen so that the best estimate reserve is equal to that resulting from a deterministic basic chain ladder method [1]
- We can obtain a distribution of possible outcomes from this model that reflects both parameter risk and process risk by using a bootstrapping technique. [1]
- Stochastic Mack model... [1]
- The Mack model reproduces chain ladder estimates, and makes limited assumptions about the distribution of the underlying data, specifying the first two moments only. [½]
- It calculates the mean and variance (including parameter uncertainty) of the distribution of possible outcomes. [½]
- We choose a parametric distribution with this mean and variance, if we require a full distribution of possible outcomes. [½]
- We typically choose a positively skew distribution (for example, a log-normal or gamma distribution). [½]
- A Bayesian approach could also be used for stochastic reserving [1]
- The prior distribution will be chosen based on experience, with the posterior distribution calculated using Bayes' formula [1]

Justification...

- long history of business being written with which to perform analytical or simulation based methods [½]
- The Mack model is distribution-free, in that no distributional assumptions are made, only assumptions about the first two moments.. [½]
- The Mack model can handle negative claim increments, as commonly found within incurred claims data which could be a feature for Cargo [½]
- Whilst not a simple as deterministic, two choices relatively simple to implement in a spreadsheet. [½]

[Maximum 8]

[Total 20]

9 (i) Allocated loss adjustment expenses (ALAE)

ALAE are the expenses incurred in handling and settling claims. They are known in some countries, including the UK, as claims handling expenses. The equivalent term used in the USA (and increasingly elsewhere) is “loss adjustment expenses”. [1]

Allocated loss adjustment expenses are those that can be allocated to a specific claim. [½]

[Maximum 1]

(ii) **Diagnostics to assist in a reserving investigation**

Paid to incurred loss ratios	[1]
Case estimates to incurred ratios	[½]
Average outstanding case estimate	[½]
Ratio of IBNR to case estimate	[½]
Survival ratios	
	[½]
Claim frequency and average cost per claim	[1]
Compare premium development with claims development	[½]
Compare suggested claim development patterns for different classes	[½]
Compare suggested claim development patterns with benchmarks	[½]
Reinsurance to gross ratios	[½]

[Maximum 4]

(iii) **Features of gross to reported incurred claims ratio**

Tail factor requirements

The 2010 paid losses are 92% of incurred at period 84 suggesting any paid losses are not fully developed at this point, [1]
 but it could also mean that incurred claims are excessive due to redundant case estimates on older claims. [½]

Trends across accident years

The paid to incurred ratio for development periods 12–36 shows a decreasing trend from 2010 to 2013 [1]
 which could have arisen due to a slowdown in timing of claim payments e.g. claims contested more rigorously, changes in business mix, change in administrative systems or claim handling resources [1]
 or/ additionally a strengthening in the case estimate basis e.g. changes to case reserving philosophy, management changes in claim department. [½]
 The 2013 calendar year ratios look low compared to 2012 [1]
 this could be due to operational reasons e.g. staff shortages, introduction of a new claims IT system, postal strike [½]
 In accident yr 2011 the ratio falls between reporting months 60 and 72 [½]
 this could be due to a new large loss reported (and reserved for) but not paid [½]

Calendar year effects

The paid to incurred ratios at development period 12 increases between accident years 2014 and 2015 but neither figure look unusual. [1]
 this could be due to random variations or a less pronounced reversal of some of the drivers underlying the 2010–2013 years. [½]
 There is a pronounced increase in 2015 accident year ratio at period 24 and the 2016 accident year ratio at period 12 [1]

which suggest some type of calendar year impact though it does not persist beyond development period 24... [½]
suggesting the impact may be more pronounced for recent accident years or on early reported losses [½]

[Maximum 6]

(iv) **Choice of reserving methods**

If it emerges that paid losses are not fully developed at period 84 any reserving methods using paid claims may require a tail factor [1]
if the cause is redundancy in the case estimates and an incurred method is used this may need to be allowed for by adjusting the data using appropriate development factors. [1]
As reserving method generally assume that the past loss development trends are indicative of future trends... [1]
any changes in development patterns may distort the result if not allowed for

[1]

e.g. if historic trends (or one off claims) are not expected to continue the methods used or underlying data can be adjusted accordingly. [1]

If the distortions are caused by heterogeneity such as changes in mix, change in claim, mix of large and small losses, differences in cover [1]

data can be split into more homogenous groups and projected separately, data permitting. [1]

If the distortions are caused by random error, sparsity of data can be aggregated e.g. with similar classes, business units [1]

or a method which utilises benchmarks, expert judgment, prior expected estimates can be employed [1]

[Maximum 4]

(v) **Unreported claim amounts & ALAE costs calculations**

Assumptions

Stable claims development profile / For each origin year the claim incurred/reported in each development period is a constant proportion of the ultimate cost/number for that origin year [½]

Incurred claims are fully developed after 5 years. [½]

The reported claim count triangle includes nil claims. [½]

All ALAE are legal fees, i.e. no other claims handling expenses [½]

Under the new system ALAE fees are incurred for each claim reported even if they ultimately settle for nil. [½]

No implementation delays so all claims reported after 1 Jan 2016 are subject to the new fee [½]

Claims which are processed through the new system do not incur any additional legal fees e.g. claim settlement under system rejected and legal action taken. [½]

The eligibility criteria remains unchanged until all of these losses have been notified [½]
 Ignore the impact of IBNER changes on claims notified prior to 1 Jan 2016 resulting in some of the future claims movement being subject to the 40% ALAE [½]

Calculations

Firstly calculate the number of claim reported in 2016 and the ALAE for 2016 [2]

<i>Accident Yr</i>	<i>2016 No. Reported</i>	<i>2016 Legal Fees</i>
2012	97	49
2013	169	85
2014	29	15
2015	176	88
2016	800	400

Estimate future number of IBNR and hence future ALAE costs [2]

<i>Accident Yr</i>	<i>No. IBNR</i>	<i>IBNR ALAE</i>
2012	0	0
2013	112	56
2014	138	69
2015	171	86
2016	342	171

Calculate the reported claims triangle excluding ALAE and calculated IBNR claims ex ALAE [3]

<i>Accident Yr</i>	<i>Cumulative Reported Claims £000's (Ex ALAE)</i>				
	<i>Reported Month</i>				
	<i>12</i>	<i>24</i>	<i>36</i>	<i>48</i>	<i>60</i>
2012	1,264	2,992	4,521	5,504	5,765
2013	2,163	3,688	5,275	6,257	
2014	1,972	3,374	4,993		
2015	1,322	2,254			
2016	1,344				
Development factor	1.8313	1.4709	1.2006	1.0473	1.0000
Grossing-up factor	3.3871	1.8496	1.2574	1.0473	1.0000

Calculate IBNR claims ex ALAE [1]

<i>Accident Yr</i>	<i>IBNR (ex ALAE)</i>
2012	0
2013	296
2014	1,285
2015	1,915
2016	3,208

[Maximum 8]

[Total 23]

END OF SOLUTIONS