

# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION BOOKLET – ONLINE VERSION

May 2016

### CA2: Model Documentation, Analysis and Reporting

#### Paper 2

**This document must be destroyed after the examination has been completed**

**Please note that the content of this booklet is confidential and students are not to discuss or reveal the contents under any circumstances.**

#### **Examination instructions**

1. You must download the exam assignment at the start of the exam time stated. All times given are UK times. Please note that it will not be available to you at any other time. The exam period commences at 14.00hrs and ends at 17.15hrs. The exam paper is three hours plus 15 minutes reading time. **It is your responsibility to ensure that all of your files are submitted within this time limit. Failure to do so will result in your assignment not being marked.** To submit your assignment please upload your documents as instructed or e-mail your files to [online\\_exams@actuaries.org.uk](mailto:online_exams@actuaries.org.uk). Only your first submission will be accepted and marked.
2. You may refer to any written or electronic reference material provided as part of the CA2 exam. You have been supplied with all data electronically at the start of the exam time. It is recommended that you use the first 15 minutes as reading and planning time.
3. The work you submit **MUST** be saved in Microsoft 2007 format, i.e. using docx (Word) or xlsx (Excel) file extensions. Do not embed documents in your spreadsheet.
4. You must build your model from scratch and not use an imported e-template.
5. You are required to work through the exam assignment without assistance from another person. The assessment regulations of the Institute and Faculty of Actuaries apply as set out in the Examination Regulations except that you may refer to reference material. By submitting your files you are confirming that all material is entirely your own work and you wish this to be taken into account for this assessment.
6. Save your work regularly. You do not have to print out your work but you may choose to do so from time to time if you prefer to check a printed copy. Saving your work is your responsibility so failure to do so will not be a significant mitigating circumstance.
7. You must not discuss or disclose the material. To do otherwise may lead to a disciplinary case.
8. You are reminded that by undertaking this exam you are bound by the Institute and Faculty of Actuaries' Examination Rules and Regulations.
9. At the end of the allotted time or when you have completed your exam, you need to submit your work.  
Your filenames must include your ARN, the name of the document and the paper sat. (e.g. 90XXXXXX – Summary-Paper 1) and each file should also contain your ARN as a header or footer on at least one page. If you experience difficulties in submitting your work, you must inform the Online Exams Team immediately at [online\\_exams@actuaries.org.uk](mailto:online_exams@actuaries.org.uk) or T. +44 (0)1865 268 255.

**Professional behaviour is mandatory and no material relating to the exam may be disclosed or discussed with others, nor used in a further attempt at the exam.**

**Failure to comply with this will be deemed to be a breach of examination regulations and may result in disciplinary action.**

*This page has been left blank.*

## Exam requirements

1. Read the background document, which describes the scenario that has been modelled and documented for this project and the work which remains outstanding.
2. Read the audit trail which has been written by your colleague, another actuarial student, for the calculations that they performed. This will assist you in following and understanding the calculations performed in the Excel model provided.

**You are not required to add to or amend the audit trail.**

3. Build on the model provided to produce the following additional calculations. You should ensure that the additional spreadsheet work which you perform contains appropriate self-checks.
  - (i) Calculate the revised profit assuming the rumour about the rugby players is true. [3]
  - (ii) Calculate both as a percentage per day and per annum, the revised Internal Rate of Return assuming the rumour about the rugby players is true. [3]

**You should assume that your colleague's calculations have been checked and are correct.**

**[Sub-total 6]**

4. Construct, for each of the following, a suitable chart to illustrate:
    - The reduction in the number of red, green and black bags of wool during transportation from the farmer to the factory
    - The reduction in the number of red, green and black felt sheets during transportation from the factory to the market, for both the base scenario and the scenario assuming the rumour is true
    - A comparison of the profit earned and the Internal Rate of Return between the original and new scenarios.
- [9]**

5. Prepare a summary document of around six or seven pages, capturing the main features and results of the work done by you and your colleague. You can assume that the summary is being prepared for your boss, a senior actuary, who will present the work to the Board of FeltCo.

Your summary should include the following:

- purpose of the project, data, method and assumptions used by you and your colleague
- all the results produced in the model that the client has asked for, including charts
- commentary on the results, key conclusions and suggested next steps

The summary should cover the full scope of the project, including the modelling already done by your colleague in the spreadsheet provided.

**You are not required to add to or amend the audit trail.**

**Marks available for the summary:**

<b>Methodology (including purpose, data, method and assumptions)</b>	<b>[20]</b>
<b>Results, including charts</b>	<b>[10]</b>
<b>Commentary on results and conclusions</b>	<b>[20]</b>
<b>Next steps</b>	<b>[25]</b>
<b>Drafting</b>	<b>[10]</b>

**[Sub-total 85]**

**[Total 100]**

## Background

The company FeltCo is a wholesaler of felt sheets in the country of Actuarial. It purchases wool from one of the sheep farmers in the North Actuarial and ships it to a factory in Central Actuarial. At the factory, the wool is processed into felt sheets which are transported to South Actuarial to be sold in the local craft market. FeltCo have contacted your company for some advice and have provided the following information.

In Actuarial, the sheep, and hence the wool, can be one of three different colours – red, green or black. The farmer that FeltCo deals exclusively with owns 300 sheep, of which 100 produce red coloured wool, 100 produce green coloured wool and 100 produce black coloured wool.

Each sheep has produced one bag of wool. Once the bags of wool are paid for and collected from the farmer, they are shipped to the factory to be processed into felt sheets. Each bag of wool produces ten felt sheets on average, the sheets being the same colour as the wool.

However, during transportation, which takes fifteen days to get to the felt producing factory, the wool attracts the infamous Wool Eating Moth. The moths will eat six bags of wool from the entire shipment per day. It is assumed that the moths will eat the same amount of black wool as green wool, but twice as much red wool as green wool.

At the factory, the wool is first cleaned and all moths are removed. It takes seven days in total for the wool to be cleaned and processed into felt sheets at a cost to FeltCo of \$100 per day.

The felt sheets are then shipped to South Actuarial where the markets can be found. The journey from the factory to the market takes twenty days.

For this part of the journey, there is no risk from the moths, but there is a different threat to the felt sheets. Members of the Actuarial Rugby Club dress entirely in black and so are attracted by the black felt sheets that are being transported. Each night, one of their players manages to climb aboard the train and steals 2% of the sheets on the train. Operating in the dark means that it is not possible to distinguish between different coloured sheets and so felt sheets of any colour are equally likely to be stolen.

At market, the red and green felt sheets are the most popular as the national costume of Actuarial consists of a red shirt and green trousers, both of which are made from felt. This means that historically at market, red and green felt sheets have sold for \$30 each and the less popular black felt sheets have sold for \$15 each. Demand for felt sheets is always strong and all the felt is expected to be sold within two days of being on sale at the market.

The costs that FeltCo incur in transporting the bags of wool and felt sheets are as follows:

- Between North and Central Actuarial, there is a fixed cost of \$150 per day, plus a one-off variable cost of \$3.00 per bag of wool payable at the start of this stage of the journey.
- Between Central and South Actuarial, there is a fixed cost of \$250 per day, plus a one-off variable cost of \$0.60 per felt sheet payable at the start of this stage of the journey.

The Board of FeltCo is about to take delivery of the bags of wool from the farmer and they have approached your boss, a senior actuary, to help them determine an appropriate price to pay the farmer for each bag of wool.

A colleague of yours has already started work on the model and performed a projection of the daily reduction, during transportation, in the number of bags of wool due to the Wool-Eating Moth and also the felt sheets due to theft. The model calculates the total expenses incurred by FeltCo throughout the transportation process and the total income expected to be received at the market.

The model determines how much could be paid to the farmer for each bag of wool for FeltCo to target a net present value profit of \$2,500 based on the information provided above. For this calculation, the model uses an Internal Rate of Return target of 10% per annum. Inflation in Actuarialia has been extremely low for the past few years.

The model also calculates the Internal Rate of Return that FeltCo will earn from the overall transaction.

Your boss has just taken a call from one of the Board members at FeltCo who has heard a rumour that the rugby players have bought torches. As a result, they are more likely to steal a black felt sheet than a red or green one. Your boss has suggested that you assume that the theft decrement is doubled for the black felt sheets, and halved for the red and green felt sheets.

The impact of this would be that there would be fewer black felt sheets for sale at the market. FeltCo believes that with a lower supply of black felt, they can be sold for 150% of the original price. FeltCo do not wish to change the sale price of the red and green felt sheets, nor the price paid for the bags of wool to the farmer.

Your colleague who produced the model is no longer able to work on this project and has handed over to you the spreadsheet which contains what he has produced so far.

Assuming that the rumour is true, your boss has asked you to calculate how the rumour would impact the profit earned by FeltCo and the revised Internal Rate of Return. He would like you to use your colleague's model to perform these calculations.

He would like your additional modelling to include appropriate checks where necessary.

Your boss needs you to prepare a summary document covering both the original scenario and the new scenario allowing for the rumour.

He is out of the office visiting a client and cannot be contacted for the next three hours. He would like the additional calculations finished and written up ready for his return, when he will review them and present your findings to the Board of FeltCo.

Your colleague has produced an audit trail of his model. A copy of the audit trail is contained in this booklet and an electronic copy of the model is provided.

**You are not expected to include the additional modelling request in the audit trail, but your results should be included in the summary.**

# Audit trail

The following audit trail should be read alongside the provided model.

## Purpose of the model

The purpose of this model is to determine the following:

- the number of bags of wool reaching the Central Actuarian factory, based on the deterioration during transportation arising from the Wool Eating Moth
- the number of felt sheets reaching the South Actuarian markets, based on the deterioration during transportation arising from the theft by rugby players
- all cashflows (ie income received and expenses incurred) during the period starting from when the wool is bought from the farmer to when the felt sheets are sold at market
- the Net Present Value of all cashflows (including the purchase of the bags of wool) and the prices to be paid for each coloured bag of wool allowing for the required profit criteria
- The Internal Rate of Return (IRR) of the whole transaction

## “Parameters” worksheet

*This worksheet includes all the data and information provided in the question.*

The farmer has 300 sheep and that overall, the sheep will produce 100 bags of red wool, 100 bags of green wool, and 100 bags of black wool. These parameters can be found in cells B6 to B8.

The calculations have been split into four distinct stages:

- time (in days) from farmer to factory (1 to 15 inclusive)
- time (in days) at the factory (16 to 22 inclusive)
- time (in days) from factory to market (23 to 42 inclusive)
- time (in days) at the market (43 to 44 inclusive)

The cells A10 to C15 in this worksheet hold this information.

Cells A32 to D39 set out the five different types of expenses – the one off and daily expenses incurred during the transportation of the bags of wool, the one off and daily expenses incurred during the transportation of the felt sheets, and the factory’s processing cost.

Cells B45 to B47 set out the price, per sheet, to be charged at the market for each of the different coloured felt sheets.

The range A17 to E30 includes all the decrements. The bags of wool will be reduced due to being eaten by Wool Eating Moths, where we are told that they can eat 6 bags in a 24 hour period. We are also told that twice as many bags of red wool will be eaten than green or black, so the moths are assumed to eat 3 bags of red wool per day, and 1.5 bags of green or black wool per day. These rates are in cells D20 to D22.

Cell D24 is the parameter for the number of felt sheets produced from one bag of wool.

For the second part of the transportation, felt sheets are stolen each night at the total rate of 2%. It is assumed that there is an equal chance that the rugby players will pick any coloured felt sheet so the rate per coloured sheet is also 2%. These rates are in cells E27 to E29.

The table in cells A49 to C53 contains the profit target of \$2,500 and the assumed IRR of 10% per annum. As the projections are on a daily basis, the 10% per annum is converted into a daily rate using the calculation  $1.10^{1/365} - 1$ .

## **“Scenario 1” worksheet**

*This worksheet carries out all the calculations for the original scenario – the projections of the bags of wool and the felt sheets, the revenue earned and the expenses incurred, and the determination of the prices that should be paid to the farmer for each bag of wool to meet the profit criterion.*

### **Assumptions**

- Each of the 300 sheep produces exactly one bag of wool.
- The price paid for each coloured bag of wool is in the same ratio as the price paid for each coloured felt sheet, so the red and green bags of wool are the same price and the black bag of wool is half this price.
- All expenses are settled at the end of the day in which they are incurred.
- The one-off transportation expenses are paid at the start of the relevant part of the journey.
- The revenue received at the market is uniform across the two days and is deposited in a bank at the end of each day.
- No interest is earned on the revenue deposited in the bank.
- Inflation of the price of felt sheets can be ignored, as we are told that historically there has been very little inflation in Actuarial.
- Apart from the moths and the rugby players, no other decrements apply.

The timescale from buying the bags of wool from the farmer to sale at the markets is 44 days in total, so the projections and calculations in rows 4 to 49 have been carried out on a daily basis. The number of days elapsed since buying the bags of wool are shown in column A.

Columns B to E indicate the different stages of the projections. Using the start and end date parameters from the “Parameters” worksheet, column B indicates when the wool is being transported to the factory, column C indicates when the wool is being processed at the factory, column D indicates when the felt sheets are being transported to the market and column E indicates when the felt sheets are at the market.



Columns G, H and I project the number of bags of wool during the transportation to the factory. An IF statement will determine if the days elapsed correspond to this transportation stage and if it does, then the bags of wool from the previous day is reduced by 3 bags of red wool or 1.5 bags of green or black wool respectively. The formulae in G5, H5 and I5 are different to the rows below so these cells have been highlighted in yellow.

**Check:** we would expect the total number of bags of wool reaching the factory to be 300 less  $15 \text{ days} \times 6 \text{ bags per day} = 210$ , which is what the model calculates.

Columns L, M and N project the number of felt sheets during the transportation from the factory to the market.

First, the IF statement determines when the days elapsed mean it is the last day at the factory. On this day, the number of felt sheets processed (10) from each bag of wool is calculated. The second IF statement will determine if the days elapsed correspond to the transportation stage from the factory and if it does, then the number of felt sheets from the previous day is multiplied by (1 less the theft decrement of the rugby players).

**Check:** we would expect the total number of felt sheets reaching the market to be  $2,100 \times 0.98^{20} = 1,401.98$  compared with the actual projection of 1,401.98.

Columns Q to X determine the daily cashflows, both expenses paid and revenue earned. Expenses are shown as negative values, revenue as positive values.

Columns Q and R calculate the expenses incurred for the transportation from the farmer to the factory. In particular, column Q calculates the initial one-off expense as the number of bags of wool bought from the farmer multiplied by the \$3 per bag of wool expense. Column R states the \$150 daily cost incurred for 15 days (days 1 to 15 inclusive).

Column T states the \$100 daily cost incurred at the factory for the seven days (days 16 to 22 inclusive).

Columns U and V calculate the expenses incurred for the transportation from the factory to the market. In particular, column U calculates the initial one-off expense as the number of felt sheets produced at the factory multiplied by the \$0.60 per felt sheet expense. Column V states the \$250 daily cost incurred for twenty days (days 23 to 42 inclusive).

Cell W1 contains the price to be paid to the farmer for a bag of red or green coloured wool. The total amount paid to the farmer is determined in cell W5 and allows for the price of the bag of black coloured wool to be half the price in cell W1.

Column X calculates the revenue received at market. The total revenue for all the felt sheets that reach the market is calculated, and then divided by 2 as it is assumed that the felt sheets are uniformly sold over the two days.

Column Z calculates the present value factor to be applied to the cashflows to determine the present value at time  $t = 0$  using the 10% per annum IRR (after it has been converted into a daily rate).

Column AA multiplies the net total of the expenses, purchase price and revenue for each day and multiplies by the present value factor for that day. This converts the amounts into a present value at time  $t = 0$ . The sum of the present value of the cashflows is calculated in cell AA51.

To determine the price to be paid to the farmer for each bag of wool, goal seek is used. The figure in AA51 needs to be equal to the profit criterion, in this case \$2,500. To achieve this, the figure in cell W1 needs to be adjusted. Cell D62 is the difference between the target and actual profit and needs to be set to zero. A check cell to show if the goal seek needs to be re-run is included in cell E62.

Cells D56, D57 and D58 set out the prices for the red, green and black coloured bags of wool, respectively based on the goal seek value in cell W1.

The question also requires the IRR of the project and this is the discount rate determined when the profit is zero. The daily IRR can be found in cell D68 and is determined by goal seek, as described below. Note that the prices for the bags of wool determined above are not changed for this calculation.

Using the daily IRR as the interest rate, the present value factors are calculated in column AC. These factors are applied to the net cashflows for each day and these calculations are in column AD. The sum of the present value of the cashflows at time  $t = 0$  is calculated in cell AD51.

Another goal seek is used to determine the IRR. Cell D65 refers to cell AD51 (the total profit), cell D66 is the “target” profit (set to zero in this case) and cell D67 is the difference between these two cells. The goal seek sets cell D67 to zero by changing the IRR in cell D68. A check cell to show if the goal seek needs to be re-run is included in cell E67.

Cell D69 converts the daily IRR into an annual IRR using the formula  $(1 + \text{IRR})^{365} - 1$ .

With a lower target profit, the IRR is expected to be higher than the 10% p.a. discount rate and this is the case.

As another check on the IRR, if the target profit in cell D66 is set to \$2,500, re-running the goal seek produces an IRR of 10% per annum, as expected.

**END OF PAPER**