Model risk and industrialisation

4^{th} Seminar on Enterprise Risk Management

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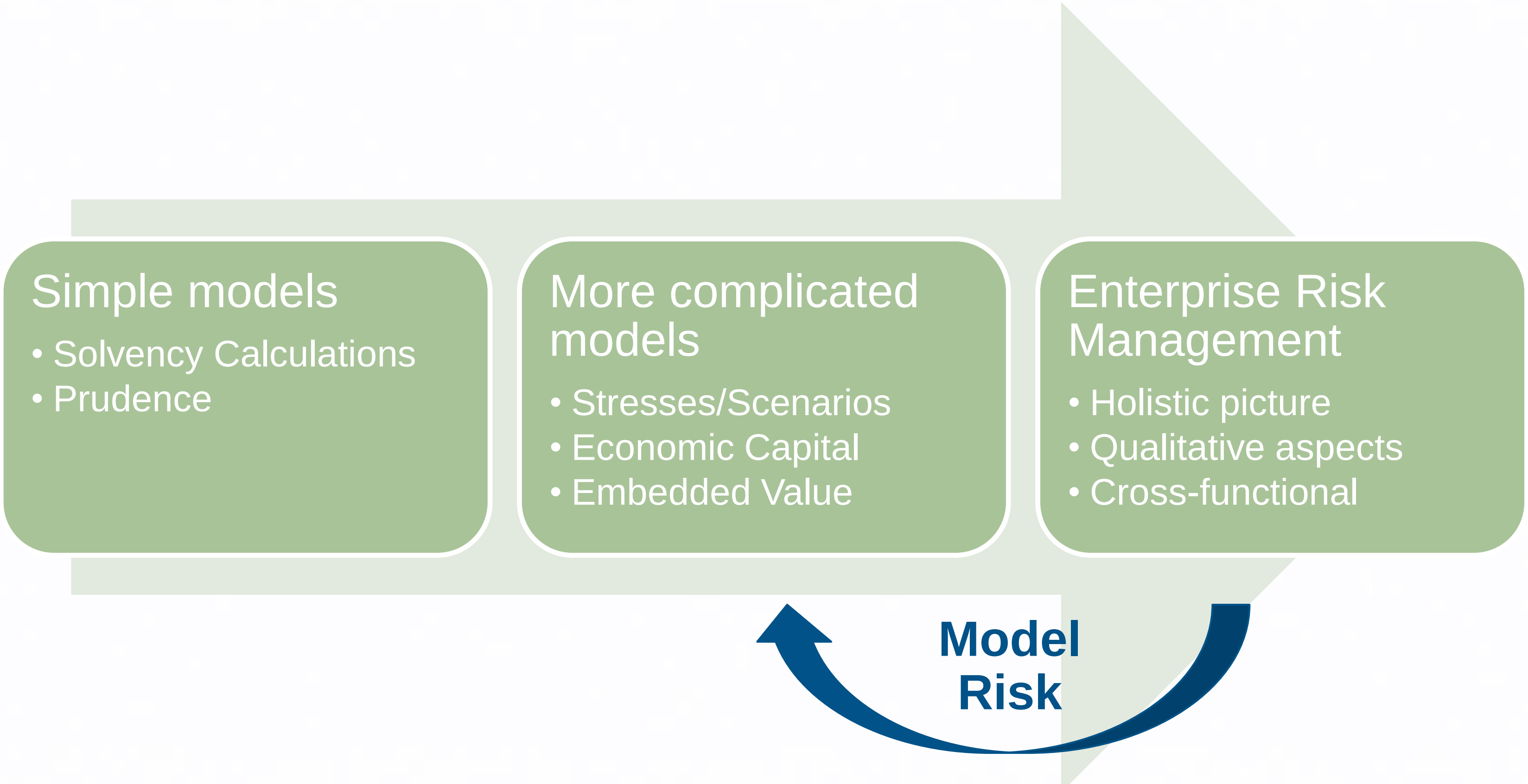
Introduction

- Introduction to model risk
- Model maintenance
- Industrialisation case study

Model Risk

Setting the stage within an ERM framework



Model Risk – Incorrect or inappropriate uses

"Then the model fell apart. Cracks started appearing early on, when financial markets began behaving in ways that users of Li's formula hadn't expected. The cracks became full-fledged canyons in 2008—when ruptures in the financial system's foundation swallowed up trillions of dollars and put the survival of the global banking system in serious peril."

wired.com/2009/02/wp-quant/

RECIPE FOR DISASTER: THE FORMULA THAT KILLED WALL STREET

In the mid-'80s, Wall Street turned to the quants—brainy financial engineers—to invent new ways to boost profits. Their methods for minting money worked brilliantly... until one of them devastated the global economy. *Photo: Jim*

Model Risk

- The use of models invariably presents model risk, which is the potential for **adverse consequences** from **decisions** based on **incorrect or misused** model outputs and reports.
- Model risk can lead to financial loss, poor business and strategic **decision making**, or damage to a bank's **reputation**.
- Model risk occurs primarily for two reasons:
  - The model may have **fundamental errors** and may produce inaccurate outputs when viewed against the **design objective** and intended business uses. […]
  - The model may be used **incorrectly or inappropriately**.

Model Risk – Indian Context

The past

- High product turnover & diverse product mixes
- Rapid regulatory change
- Start-up phase – compromises to be made, expense overruns, up-skilling

The future

- Risk-based capital
- Embedded Value Disclosures & IPOs: Speed of production
- IFRS
- Consistency across all models
- Best-estimate not prudent

Model maintenance

Model maintenance

An example of International Best Practice (1/2)

- Best practice model maintenance is split into two key phases :
  - Development of a new feature including documentation and review. This includes 4 key phases as outlined below in the table
  - Integration of the new feature(s) into a new production version of the model

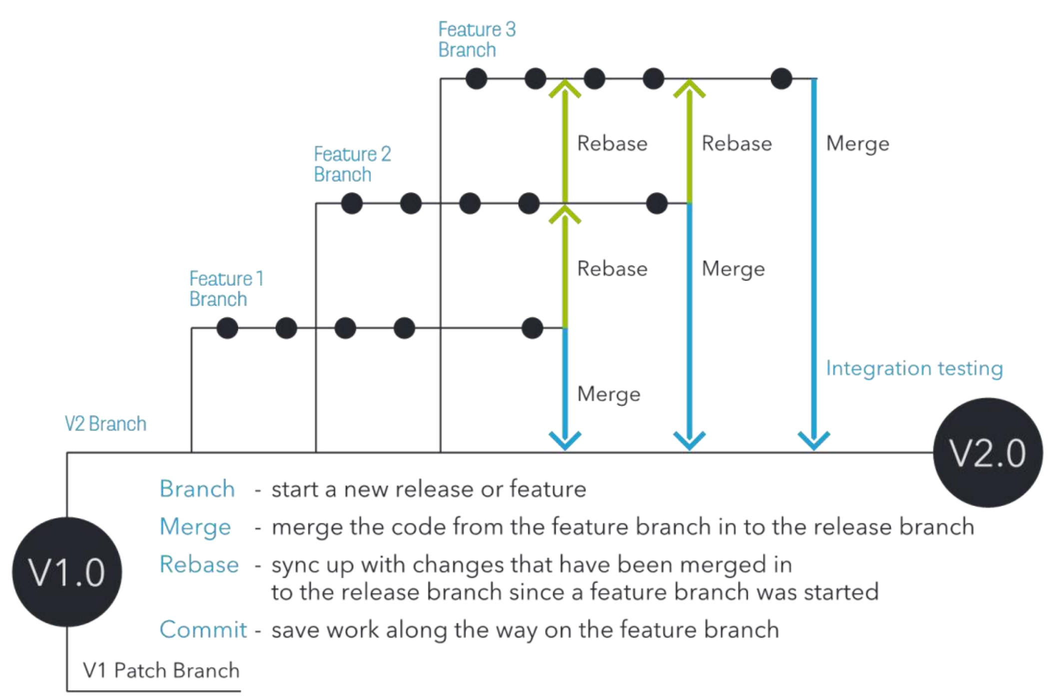
Stage	Name	Description
Requirements	Write requirements	Create the requirements document
Requirements	Review requirements	Review the requirements
Requirements	Sign-off	Confirm sign-off of requirements through governance process
Design	Write specs	Write the implementation specifications. Include all dependencies on changes to data, assumptions and runs
Design	Review specs	Peer review of the implementation specifications
Implement	Write code	Make the necessary changes to the code and adjust specs if necessary
Implement	Review code	Review the coding changes
Test	Write test plan	Create the test plan for the feature
Test	Execute feature testing	Test the feature
Test	Sign-off testing	Confirm review and sign-off of the feature testing

- An important step is to ensure a review and sign-off at each step within the process
- This process ensures that the code is sufficiently tested before being available for inclusion in production version

Model maintenance

An example of International Best Practice (2/2)

- It is not uncommon for several features to be developed simultaneously. The diagram below outlines a best practice approach.
- Once a feature is signed-off, it is merged into the Production version.
  - Changes to the production version can only be made by the designated “Model Owner”
  - A “light” integration testing is performed at this stage
- Simultaneously the merged version is reflected in the other Feature Branches
  - The reflection in feature branches helps reduce time between final feature development and new version release
- The final integration testing before a new release should be full re-run of the previous production results



Model maintenance

Our recommendations

- The approach laid out is a very governance heavy approach to model maintenance. Although we believe this is industry best practice, we understand that it is not always practical to have such a detailed framework.

- Our view is that minimum governance requirements are :
  - Inclusion of 4 steps in the feature development phase
  - Independent sign-off / review of each feature development
  - Designation of "model owner" who is solely responsible for changes to production version
  - Full integration testing prior to version release

Case study : Industrialisation of actuarial processes

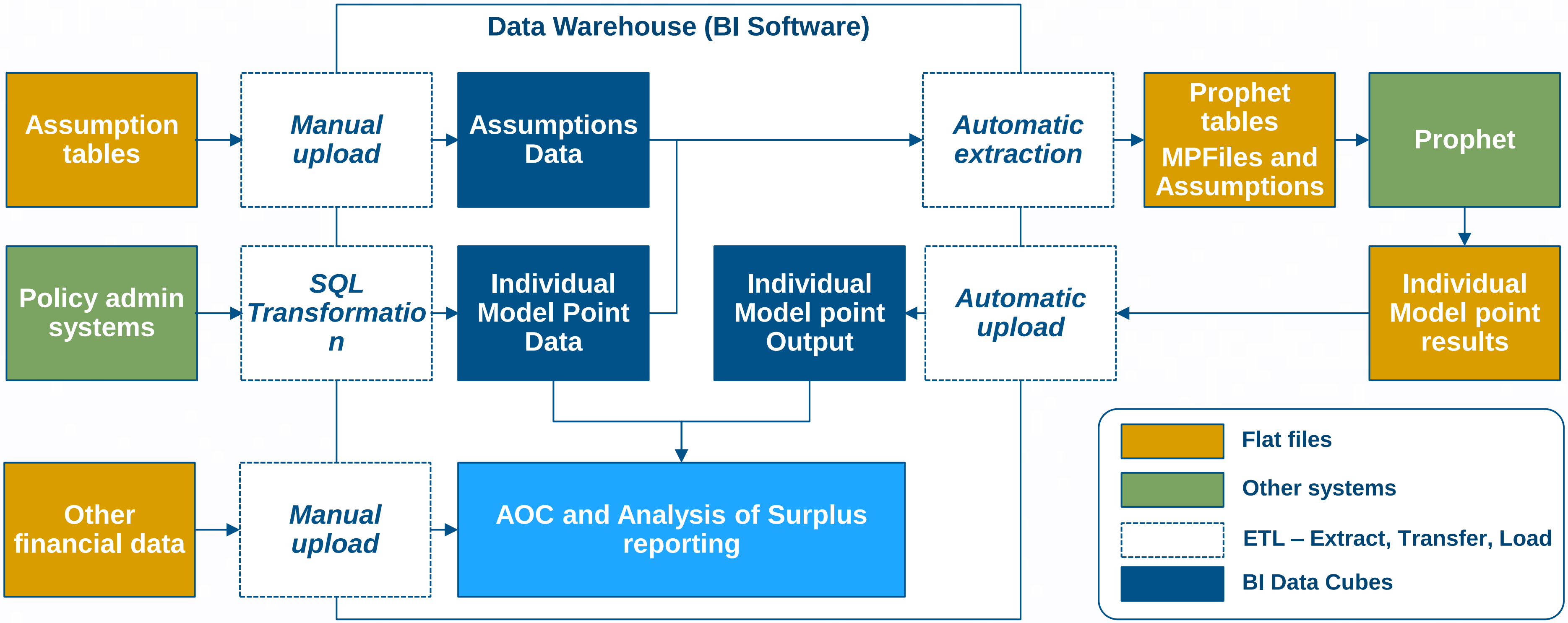
Industrialisation project & case study

The context and our objectives

Context	• Company was required to produce annual EV reports with typical analysis of change • In addition, company needed to provide management with a detailed source of earning reporting on a monthly basis
Issues	• Company had problems being able to produce accurate results in a timely manner • Viability of the incoming data was a major concern • Had difficulties in explaining in detail the results
Objectives	• Automatic production of MPFs and validation of datasets coming from source systems • Centralisation and control of assumptions • Improved AOC and sources of surplus analysis

Industrialisation project & case study

The datawarehouse is a central component of the industrialisation process



- Matching of individual model point data with individualised model point data enables detailed and accurate AOC and Analysis of surplus reporting

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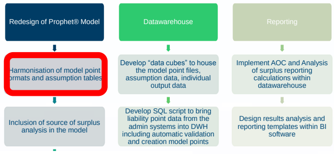
High level project plan

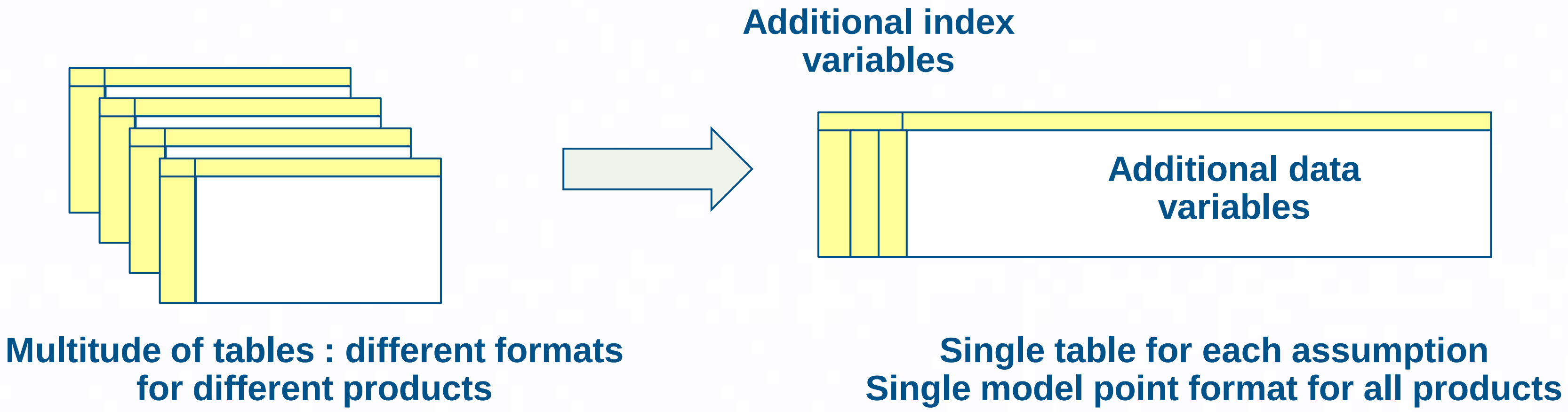
Redesign of Prophet® Model	Datawarehouse	Reporting
Harmonisation of model point formats and assumption tables	Develop "data cubes" to house the model point files, assumption data, individual output data	Implement AOC reporting calculations within datawarehouse
Individual model point output reporting templates	Develop SQL script to bring liability point data from the admin systems into DWH including automatic validation and creation model points	Design results analysis and reporting templates within BI software

Industrialisation project & case study

Model point and assumption table harmonisation is recommended to faciliate industrialisation



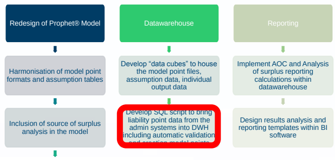
- Model point and assumption table harmonisation



- Key advantages
  - Simplifies creation of data cubes in datawarehouse
  - Enables easy cross product analysis on both individual model points data and assumptions data
  - Due to industrialisation process, size of input tables into Prophet is less of a concern

Industrialisation project & case study

Validation of model point data



- The SQL scripts were designed to both transform the data and check the validity of the data at the moment the upload is performed

Type of checks

Absolute checks on the validity of individual cells

- Ensure that the value used is consistent with the expectation, e.g.
  - All products: current age > 0, age<120
  - All products: maturity date > valuation date
  - Regular premium products: status = 0 (premium paying), 1 (PUP)

Coherence checks across an individual model points

- Pick up data inconsistencies which are not blatantly incorrect (for example premium <0), but are highly unlikely to occur, e.g.
  - All products: sum assured > premium paid
  - Term life: premium / sum assured > 0.00001 (the lowest possible mortality)

Coherence checks with the previous years data on an individual model point basis

- The coherence tests with the previous years data is a very powerful method for capturing errors in the data transformation routines. The data, and the type of check would be split into two types:
  - Data that should not change (e.g. sex, policy term, etc)
  - Data that is likely to change (e.g. current age = current age from previous period + 1)

Treatment of error

Report
Report the issue into an error log

Change
Modify the value to a pre-defined default value

Exclude
Exclude the record

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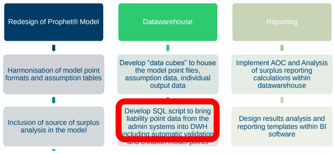
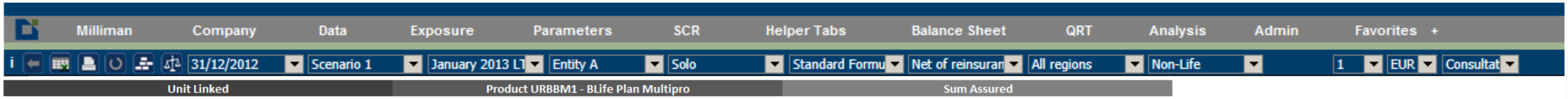
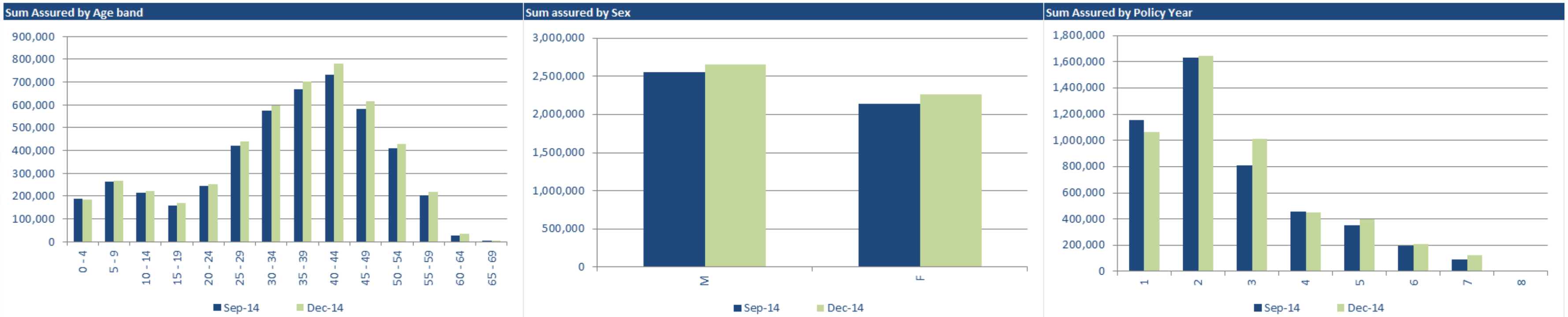
Validation of model point data



- Business intelligence software enables easy drill into model point data





Sum Assured by Age band

Age Band	31/09/2014	31/12/2014
0 - 4	189,315	186,377
5 - 9	263,365	268,691
10 - 14	214,955	221,290
15 - 19	160,047	169,384
20 - 24	245,281	250,841
25 - 29	419,408	438,047
30 - 34	574,063	598,126
35 - 39	666,921	703,583
40 - 44	732,819	779,665
45 - 49	582,959	616,193
50 - 54	411,315	429,843
55 - 59	201,520	219,222
60 - 64	28,375	32,667
65 - 69	384	385
Total	4,690,727	4,914,312

Sum assured by Sex

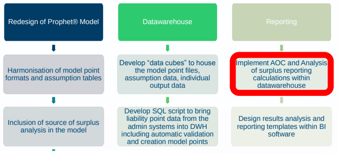
Sex	31/09/2014	31/12/2014
M	2,550,157	2,655,873
F	2,140,570	2,258,439
Total	4,690,727	4,914,312

Sum Assured by Policy Year

Policy Year	31/09/2014	31/12/2014
1	1,153,496	1,066,153
2	1,635,118	1,645,716
3	809,502	1,008,961
4	456,641	452,583
5	350,685	398,209
6	192,218	210,999
7	93,067	126,546
8	0	5,144
Total	4,690,727	4,914,312

Industrialisation project & case study

Typical AOC reporting template

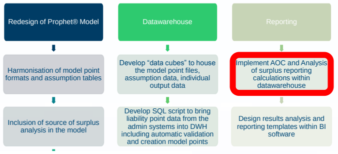


- A typical Analysis of Change template contains the following :

	ANAV	VIF	EV	
Opening EV (n-1)				Initial EV after adjustments
Opening adjustment				
New Business Value				Value of new business sold during the year
Unwind		x (1+RDR)		Unwind the discount rate
Transfer to ANAV	+Profit(n)	-Profit (n)	0	Transfer of first year profit to ANAV from VIF
Operating Experience Variances	ExpProfit(n) -			Impact on Profit(n) and VIF(n) of actual experience versus expected experience
Investment Experience Variances	ActProfit(n)			
Operating Assumption Changes				Impact on VIF(n) of change in future assumptions (no impact on ANAV)
Economic Assumption Changes				
Dividend Paid / Capital Injected				
Closing EV (n)				Final EV

Industrialisation project & case study

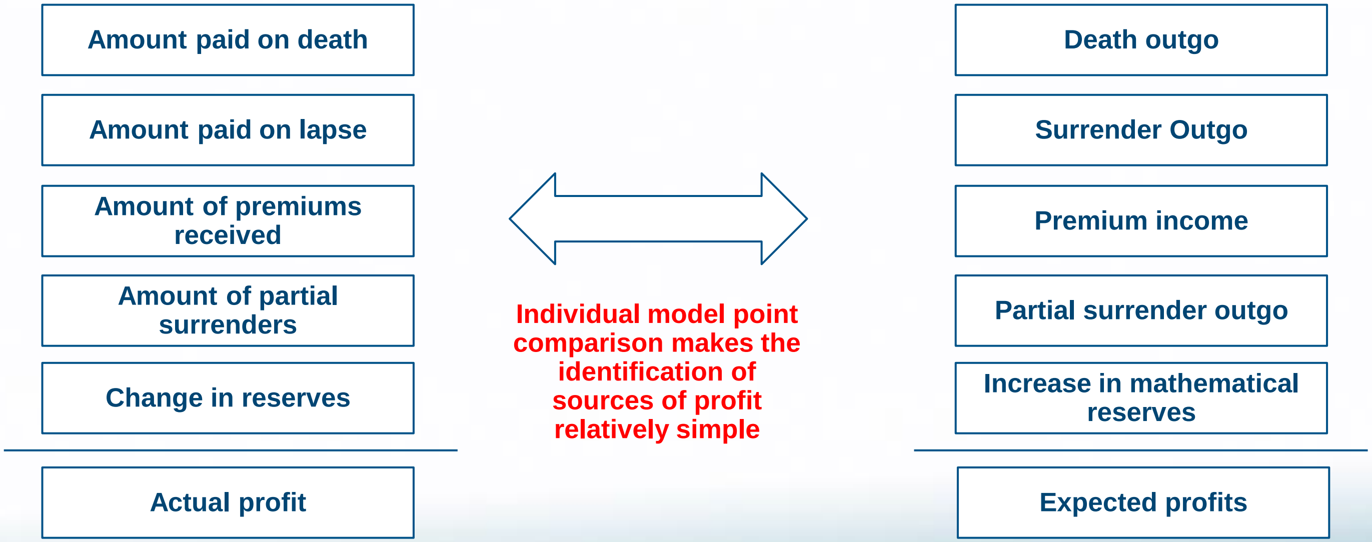
Industrialised solution to experience variances – Unit Linked example



- A typical process for experience variances involves running the model many times, updating the “actual” assumptions one by one.
- Under the industrialised solution, only two runs are needed (start of period and end of period) as the results can be analysed on an individual basis. However, additional data is required at the individual model point data level. In particular, for those policies that exited over the period, we need to get additional data from the administration systems

Actuals : from the admin systems

Expected : from BOP actuarial run



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The outcome – Unit Linked example

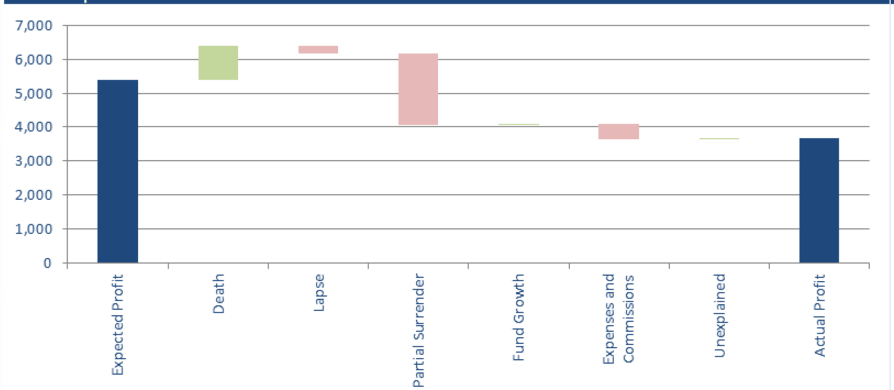
- The results are very good – unexplained is very small
- Global results can hide some underlying trends

Milliman | Company | Data | Exposure | Parameters | SCR | Helper Tabs | Balance Sheet | QRT | Analysis | Admin | Favorites +

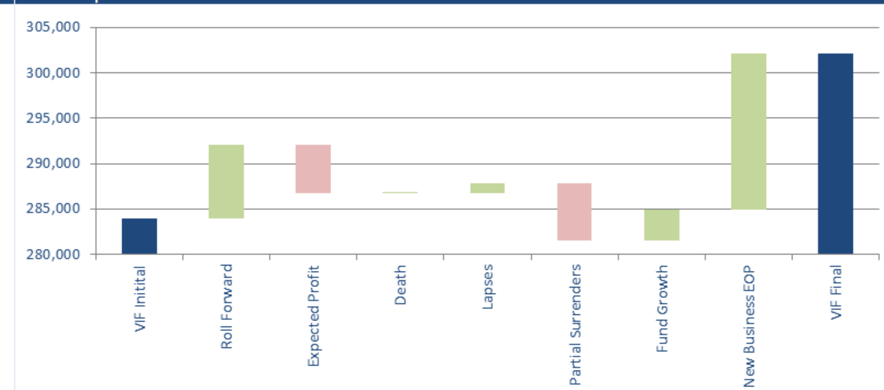
31/12/2012 | Scenario 1 | January 2013 LT | Entity A | Solo | Standard Formu | Net of reinsuran | All regions | Non-Life | 1 | EUR | Consultat

Unit Linked | AOC | Buildup

AOC Buildup - Profit



AOC Buildup - VIF



AOC Buildup - Profit

AOC BuildUp	Profit
Expected Profit	5,394
Death	1,007
Lapse	-240
Partial Surrender	-2,095
Fund Growth	41
Expenses and Commi	-452
Unexplained	11
Actual Profit	3,666

AOC Buildup - VIF

AOC BuildUp	VIF
VIF Initital	284,007
Roll Forward	8,106
Expected Profit	-5,394
Death	71
Lapses	1,023
Partial Surrenders	-6,232
Fund Growth	3,353
New Business EOP	17,213
VIF Final	302,147

Industrialisation project & case study

The outcome – Mortality Surplus

- Lower deaths focused in the high ages.

Milliman | Company | Data | Exposure | Parameters | SCR | Helper Tabs | Balance Sheet | QRT | Analysis | Admin | Favorites +

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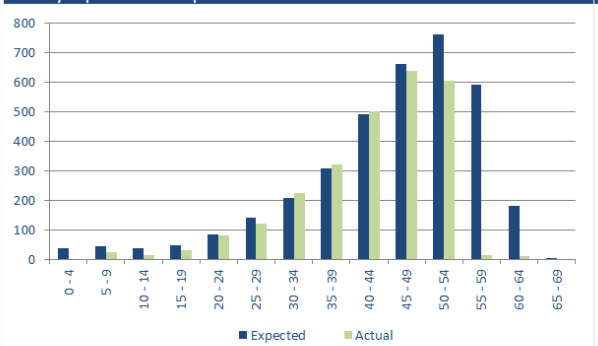
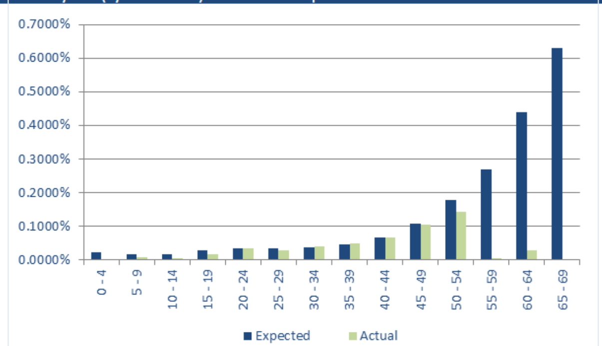
Unit Linked | AOC | Mortality Surplus

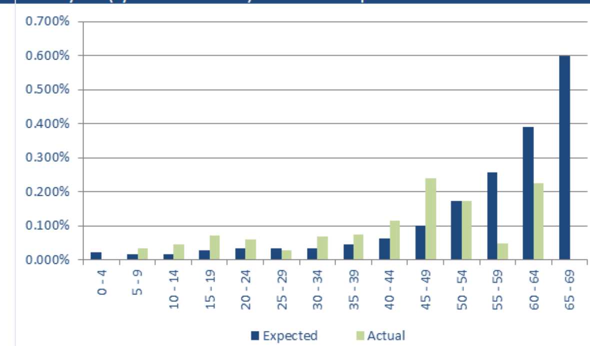
Mortality Surplus - Actual vs Expected



Mortality Rate (by Death Strain) - Actual versus Expected



Mortality Rate (by Number of Policies) - Actual versus Expected



Sum Assured by Age band

Age Band	Expected	Actual
0 - 4	36	0
5 - 9	43	25
10 - 14	36	14
15 - 19	48	30
20 - 24	83	80
25 - 29	139	120
30 - 34	207	225
35 - 39	307	320
40 - 44	491	500
45 - 49	662	638
50 - 54	761	603
55 - 59	590	12
60 - 64	179	12
65 - 69	3	0
Total	3,586	2,579

Sum assured by Sex

Age Band	Expected	Actual
0 - 4	0.022%	0.000%
5 - 9	0.016%	0.009%
10 - 14	0.017%	0.006%
15 - 19	0.030%	0.019%
20 - 24	0.036%	0.035%
25 - 29	0.034%	0.030%
30 - 34	0.037%	0.040%
35 - 39	0.047%	0.049%
40 - 44	0.067%	0.068%
45 - 49	0.109%	0.105%
50 - 54	0.180%	0.143%
55 - 59	0.269%	0.006%
60 - 64	0.439%	0.029%
65 - 69	0.632%	0.000%

Sum Assured by Policy Year

Age Band	Expected	Actual
0 - 4	0.022%	0.000%
5 - 9	0.016%	0.034%
10 - 14	0.016%	0.046%
15 - 19	0.029%	0.072%
20 - 24	0.035%	0.060%
25 - 29	0.034%	0.028%
30 - 34	0.035%	0.068%
35 - 39	0.045%	0.075%
40 - 44	0.063%	0.114%
45 - 49	0.101%	0.240%
50 - 54	0.172%	0.172%
55 - 59	0.257%	0.050%
60 - 64	0.392%	0.225%
65 - 69	0.600%	0.000%

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The outcome – Surrender Surplus

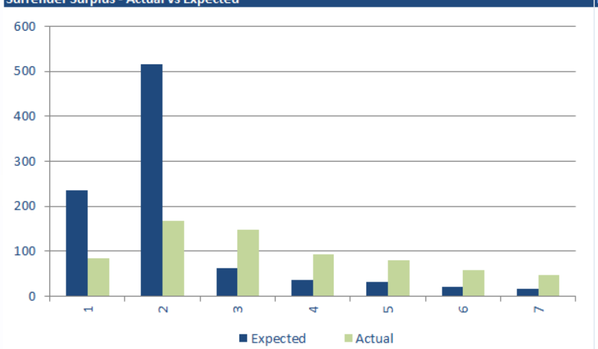
- Total surplus is relatively close but distribution very different from expected

Milliman | Company | Data | Exposure | Parameters | SCR | Helper Tabs | Balance Sheet | QRT | Analysis | Admin | Favorites +

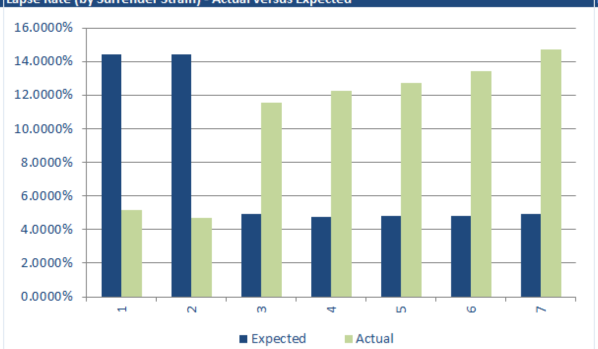
31/12/2012 | Scenario 1 | January 2013 LT | Entity A | Solo | Standard Formu | Net of reinsuran | All regions | Non-Life | 1 | EUR | Consultat

Unit Linked | AOC | Surrender Surplus

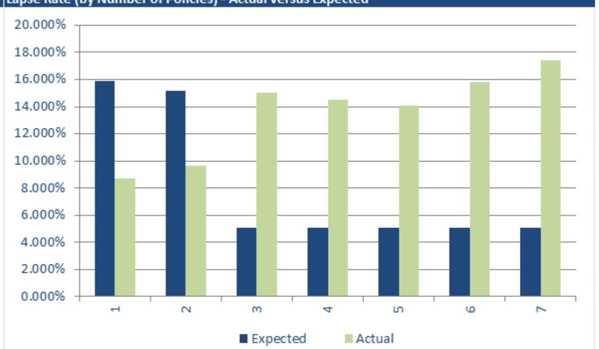
Surrender Surplus - Actual vs Expected



Lapse Rate (by Surrender Strain) - Actual versus Expected



Lapse Rate (by Number of Policies) - Actual versus Expected



Sum Assured by Age band

Age Band	Expected	Actual
1	235	84
2	515	167
3	62	147
4	35	92
5	30	80
6	21	58
7	16	47
Total	914	675

Sum assured by Sex

Age Band	Expected	Actual
1	14.455%	5.148%
2	14.454%	4.695%
3	4.913%	11.565%
4	4.732%	12.263%
5	4.835%	12.752%
6	4.842%	13.438%
7	4.925%	14.738%

Sum Assured by Policy Year

Age Band	Expected	Actual
1	15.915%	8.739%
2	15.143%	9.681%
3	5.095%	15.005%
4	5.093%	14.531%
5	5.094%	14.106%
6	5.094%	15.839%
7	5.094%	17.439%

Industrialisation project & case study

Operational results

AOC production timescales significantly reduced (3 weeks to 4 days)

Accuracy significantly improved (unexplained around 1%)

Early detection of underlying trends – lapse experience was tightly followed post-implementation

Much greater confidence in results from management – in particular, confidence that no hidden data errors are coming through

Industrialisation project & case study

Key takeaways

Modification of Actuarial Models

- Harmonisation of input formats - model points & assumption tables is a key phase to simplify Data Warehouse design and make future proof
- Inclusion of additional output variables deemed necessary

Design of Data Warehouse

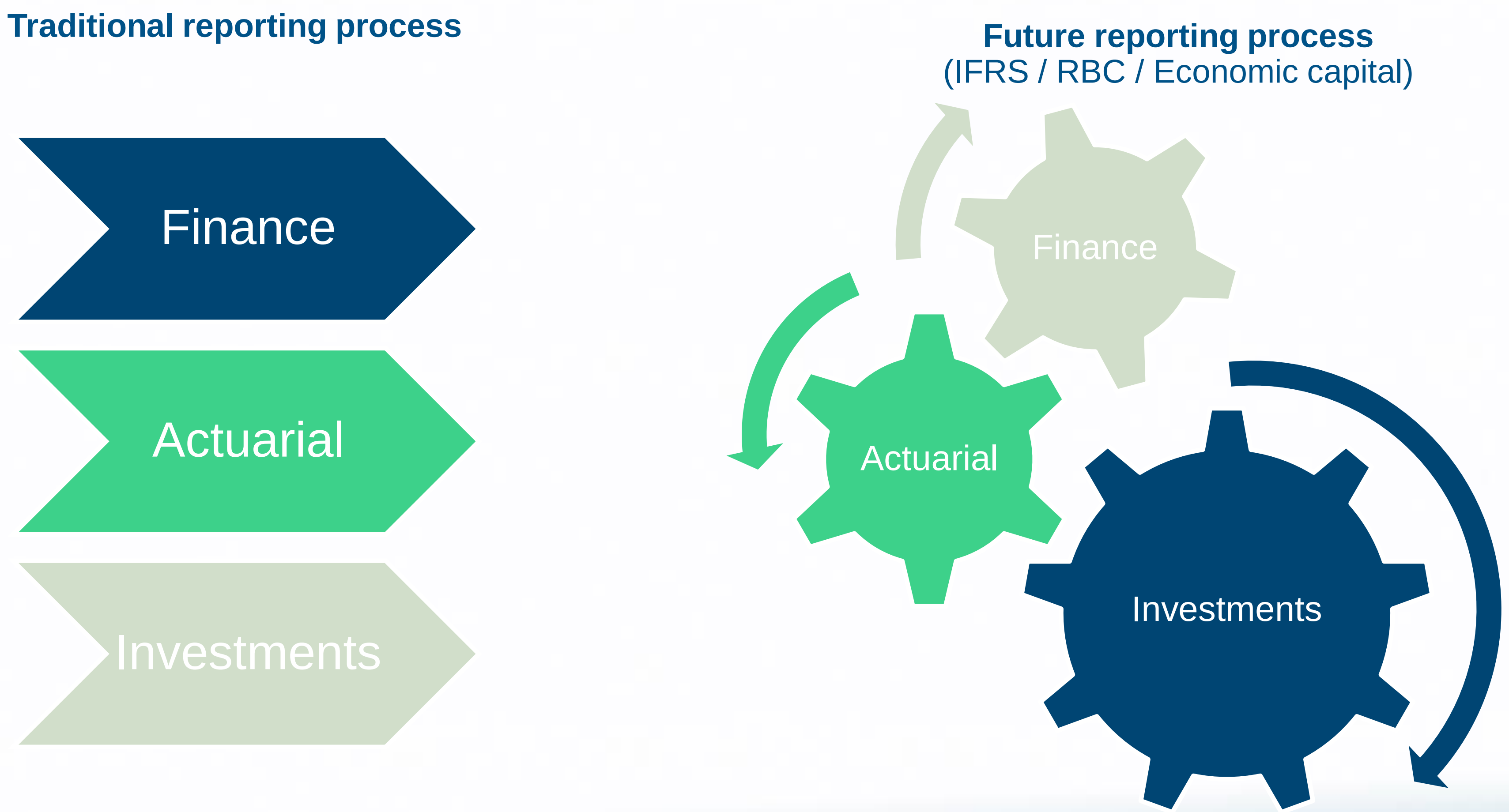
- Don't overreach – initial reaction is to try to put everything in the datawarehouse; resisting this temptation ensures IT elements are delivered
- Focus on key reporting elements and work backwards – AOC was the key reporting output ; solution focused on AOC with other elements being "nice to have"
- Adaptive design important to ensure future updates can be made easily
- Do not underestimate the volume of the SQL phase – data conversion and validation is always more difficult than you think

Reporting

- Get the first two phases right - once the data is in the system, a myriad of reports can be produced

Conclusion

Industrialisation will be a growing trend…



…and reduction of model risk will become a key focus