OLIVER WYMAN

Consulting Actuaries

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GETTING THE MOST OUT OF AXIS™

ADAPTING TO AN EVER-CHANGING LANDSCAPE

Editor's words: Welcome to the Fall 2018 edition of our AXIS newsletter. This issue outlines the latest developments in AXIS for US variable annuity statutory reform and also discusses methodologies and key considerations for model compression. You will find helpful tips and tricks for navigating the system and highlights of new features in recent AXIS releases. We hope you enjoy the newsletter.

IN THIS ISSUE

MARSH & McLENNAN COMPANIES

EXECUTIVE CORNER

US VARIABLE ANNUITY STATUTORY AND CAPITAL FRAMEWORK REFORM: WHAT YOU NEED TO KNOW

INTRODUCTION

Major regulatory reforms are impacting US life insurers. In our Spring 2018 Executive Corner, we covered the impact of US tax reform on insurers and related AXIS modeling considerations. In this edition, we will cover another major industry change: NAIC variable annuity ("VA") statutory and capital reform.

Over the past three years, the Variable Annuities Issues (E) Working Group ("VAIWG") has worked to establish a new framework for determining US statutory reserves and required capital with the intention to reduce non-economic volatility in reserves and decrease utilization of captives. Two quantitative impact studies ("QIS") were performed leading to 27 recommended changes addressing the VAIWG's goals. The VAIWG met in March and May of this year to review each recommendation. In a joint session with the VAIWG, the Financial Condition (E) Committee met on July 31, 2018, and unanimously voted to adopt the new VA framework.[1]

This article provides a summary of key modeling changes driven by the new framework, an overview of how AXIS is currently equipped to handle them, and a look forward to how Moody's Analytics plans to further enhance AXIS's capabilities.

"While there is much work to be done to implement and validate the changes in production, several insurers have already publicly reported anticipated impacts on their statutory reserves and capital"

1 New York, as part of the VAIWG, voted against adoption of the framework

SUMMARY OF VA STATUTORY REFORM CHANGES

Exhibit 1 summarizes many key changes associated with the adopted framework.

Exhibit 1: VA statutory reform – Key changes[2]

Change	 Scenario generation	 Asset modeling and greatest present value of accumulated deficiency ("GPVAD") calculation	 Standard scenario
Description	• Designates VM-20 scenario generator as prescribed interest rate and separate account return generator, including the parametrization specified in VM-20 • Allows the use of proprietary ESG if and only if it does not materially reduce the total asset requirement	• Removes working reserve (aligns with VM-20) • Discounts deficiencies at the net earned rate on additional assets; allows starting assets to be iteratively solved for such that the average GPVAD in the tail scenarios is zero • Follows VM-20 guidance on general account assets (NAIC prescribed gross spreads and default costs, with company investment expense assumptions); disallows CTE amount to be lower than what would be calculated from a reinvestment portfolio of 50/50 AA/A bonds	• Calculates the Total Standard Projection Amount as a scenario GPVAD using the same mechanics as the CTE 70 "adjusted" run (e.g., starting assets, inforce hedge runoff, reinvestment) • Uses prescribed policyholder behavior assumptions, which were aligned with industry experience • Standard Scenario becomes an "add-on", calculated as the difference between the Total Standard Projection Amount and the CTE 70 adjusted, net of a buffer • Two options are available to calculate the Total Standard Projection Amount: (1) use 40 prescribed market paths and calculate the average GPVAD for the two scenarios closest to the CTE 70 adjusted or (2) use the same set of stochastic scenarios as the CTE 70 adjusted run, but with prescribed policyholder behavior

These VA reform changes will require significant updates to stochastic and Standard Scenario statutory models. While there is much work to be done to implement and validate the changes in production, several insurers have already publicly reported anticipated impacts on their statutory reserves and capital.

2 There are additional proposed changes not covered in this article (e.g., C-3 capital calculation, treatment of hedges, disclosure requirements). The full list of changes can be accessed on the VAIWG's website.

AXIS CHANGES

AXIS functionality has been considerably improved over the past five years to make it a powerful asset-liability modeling software; these improvements include significant new VA functionality. The updates have positioned AXIS well to handle many of the new VA statutory calculations.

Exhibit 2: VA statutory reform – Implementation in AXIS

Change	 Scenario generation	 Asset modeling and GPVAD calculation	 Standard Scenario
AXIS functionality	• AXIS already supports the VM-20 economic scenario generator in its User Defined Market Models, thus requiring minimal coding updates • Insurers using proprietary scenarios can either import external scenarios or code the scenario generator in AXIS	• AXIS contains a switch to set the working reserve to zero • There are multiple methodologies for iterating initial assets to solve for zero GPVAD and setting discount rates; however, additional enhancements may be required to handle company-specific methodologies for deriving discount rates • Asset modeling functionality in AXIS is extremely robust; specific enhancements have been previously released to meet all VM-20 asset modeling requirements	• The Standard Scenario calculation will be moved directly into the Embedded Block to align with the CTE "adjusted" methodology • A new Assumption Set can be coded to hold the prescribed policyholder behavior assumptions; while the prescribed lapse and annuitization assumptions are more complex than the current framework, AXIS Formula Tables should readily support the prescribed assumptions for most products[3] • AXIS allows multiple Embedded Blocks in a run and prescribed assumptions and company assumptions can be separately assigned to distinct Embedded Blocks. The final Standard Scenario "add-on" may be calculated in the Block Summary Report

Moody's Analytics has scheduled monthly meetings with industry clients to ensure all new modeling requirements will be addressed in AXIS.

CONCLUSION

VA statutory reform requires significant modeling updates, careful validation and subsequent review of impacts by management. There is currently a flurry of activity as insurers work to understand how their statutory financials will be impacted by the adopted framework. AXIS users will benefit from improvements made to the software over the past several years and, thus, will be able to accelerate analyses addressing key stakeholder questions.

3 Moody's Analytics has indicated they are willing to consider additional system enhancements to simplify implementations if the Formula Table coding becomes too complex

IN THE SPOTLIGHT

LIABILITY INFORCE DATA COMPRESSION IN AXIS

A SMART WAY TO ACCELERATE MODEL RUNS

INTRODUCTION

In the Fall 2017 edition of this newsletter, we presented liability inforce data compression as a solution to shorten model runtime by reducing the number of model points. In this article, we will dive deeper into advanced compression approaches, specifically clustering algorithms, and outline how compression can be implemented effectively in AXIS.

Section 1 provides an overview of cluster analysis and describes two common clustering algorithms: K-means and hierarchical agglomerative clustering. Section 2 outlines how to implement a hierarchical agglomerative clustering algorithm in AXIS. Section 3 illustrates runtime savings achieved in an AXIS model under different levels of inforce data compression.

Definitions of certain technical terms are provided on page 7; these terms are bolded the first time they are used below.

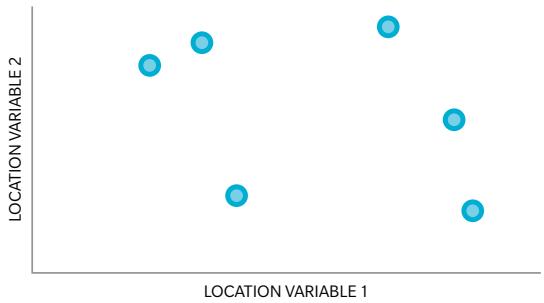
"Once a satisfactory compression model is established, significant efficiency can be achieved without material loss of fidelity in results"

SECTION 1: CLUSTER ANALYSIS

Compression is a type of **cluster analysis** that groups data points based on a set of characteristics. Clusters can be defined as a group of data points with short **distances** among members or as dense areas in the data space. While clustering algorithms differ in the methodology used to combine data points, all share common properties:

- Clustering is accomplished by setting specific characteristics of data points as **location variables**

Exhibit 1: Plot of data points based on two location variables



- The chosen clustering algorithm then iteratively groups data points to optimize a defined objective function

TIPS & TRICKS

Understanding asset market value calculations

When performing integrated asset-liability modeling in AXIS, the purchase and sale prices of assets are determined by their market values. AXIS can calculate an asset's market value from first principles using a discounted present value of future cashflows approach. These market value calculations are often opaque at the Fund level due to the volume of assets being modeled (e.g., reinvestment assets purchased periodically). AXIS has robust functionality to help users analyze market value calculations at an individual asset level.

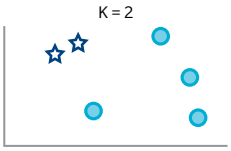
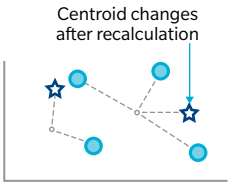
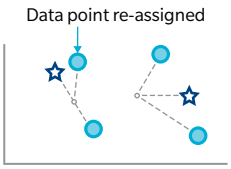
Asset and Reinvestment Cells include a processing option "MV Details"; the resulting "Market Value Details" report illustrates the cashflows and discount rates used in calculating a given market value. In an Asset Cell, the user can review the market value calculation at the valuation date or any future date, while in a Reinvestment Cell the user can select the valuation date or any future date an instance of the reinvestment asset is purchased.

The "Market Value Details" report includes all required output to reproduce asset market values: regular income, income from calls/puts/prepayments, maturity, outflows and the relevant discount rates.

CLUSTERING ALGORITHMS

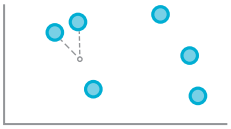
Two common clustering algorithms are K-means and hierarchical agglomerative clustering.

Exhibit 2: K-means clustering algorithm

Step 1	Randomly select k data points as centroids, where k represents the desired number of clusters	
Step 2	Assign every data point to its nearest centroid	
Step 3	Redetermine the centroid of each cluster based on available data points in the cluster	
Step 4	Repeat steps 2 and 3 until clusters reach their target state, which is when additional iterations have no impact on the cluster selection	

A K-means clustering algorithm is simple to define and illustrate. It partitions the data into a well-distributed set of clusters when k is relatively small. However, this technique can be sensitive to outliers and initial assignment of the k data points.

Exhibit 3: Agglomerative hierarchical clustering algorithm

Step 1	Treat every data point as an individual cluster. Calculate the distance between each cluster	
Step 2	Merge the closest pair of clusters	
Step 3	Repeat step 2 until the target clustering level is reached	
Step 4	The result is a set of clusters meeting the target clustering level	

DEFINITIONS

Centroid: The arithmetic mean position of a given set of data points

Children: Member policies of a cluster that are not the parent

Cluster analysis: Data analysis technique that groups data points into clusters

Compression: Type of cluster analysis technique that compresses large sets of data points into more compact sets

Compression ratio: Number of data points (e.g., model points) after compression relative to the original number of data points

Distance: The Euclidian distance between two data points in terms of their location variables

Distortion: Alteration of the original characteristics of the data. In AXIS, it is the difference in measure variable between the full seriatim and clustered data points (referred to as "data models" in AXIS). As a clustering algorithm executes, distortion is inherently introduced into the data model

Grouping factor: A factor used to scale the measure of the parent to be equal to the sum of the measures of the children when running a compressed data model

Location variables: Location variables reflect policy characteristics or risk drivers of the underlying policies in the clustering algorithm. In AXIS, there can be a combination of **static location variables**, from the Policy Information Table, or **dynamic location variables**, from one or more Seriatim Summary reports

Measure: A metric an actuary attempts to control, or preserve, between the full seriatim and compressed data models (e.g., total reserves)

Parent: The representative policy of the cluster. Location variables of this policy are used to represent the cluster as a whole

Weight: Importance assigned to each location variable used to determine the measure metric

KEY CONSIDERATIONS

Careful consideration is required when choosing the location variables. The performance of an AXIS model utilizing compressed data depends on how well the location variables represent the underlying policies. For example, for a valuation model, one should choose location variables that drive reserve levels. If policies are not well represented by the location variables, **distortion** will occur even with minimal compression.

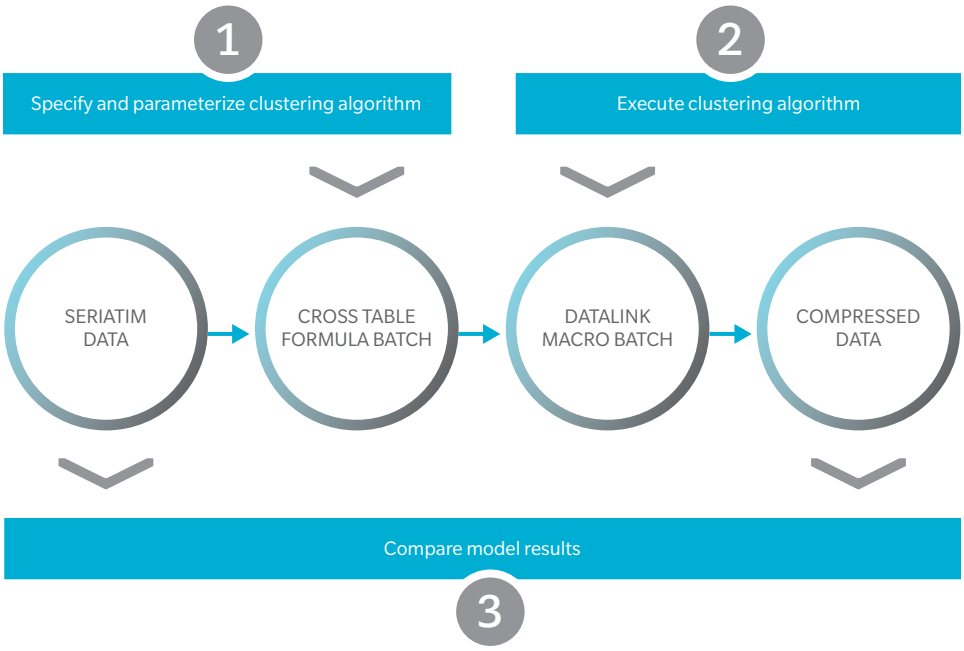
Furthermore, once a compression process continues beyond **compression ratios** supported by the data and attempts to cluster policies that differ more significantly, distortion will increase. This is called over-clustering. As an example, consider the loss of accuracy when attempting to group all policies into a single model point.

Thus, the compression process should involve a tuning phase specific to the intended application. This phase involves selecting location variables and their respective **weights** based on trial runs and may require several iterations to achieve adequate calibration. However, once a satisfactory compression model is established, significant efficiency can be achieved without material loss of fidelity in results.

SECTION 2: PERFORMING COMPRESSION IN AXIS

Exhibit 4 outlines key steps involved in compressing inforce data in AXIS.

Exhibit 4: Compressing inforce data in AXIS



STEP 1: SPECIFY AND PARAMETERIZE CLUSTERING ALGORITHM

The compression approach is specified in a "Cross Table Formula Batch". In this Batch, the Policy Information Table containing the full seriatim data is selected, and model parameters are defined with DataLink formulas.

The Policy Information Table must include location variable fields and Optional Fields "Do Not Export" and "**Grouping Factor**". A second DataLink table needs to be selected and could either be a copy of the first Policy Information Table or a table containing **dynamic location variables**.

Location variables, weights, and the measure are defined in the "Cross Table Formula Batch" along with the following parameters:

- **Similarity measure:** used to specify how to calculate the distance between clusters. AXIS currently supports "Euclidean distance" only

  ```
  Formula: =SetSimilarityMeasure (EUCLIDEAN_DISTANCE)
  ```

- **Cluster linkage rule:** used to specify how clusters should be combined when they are grouped. AXIS currently supports an "Importance" linkage rule only, which pairs clusters that have the shortest measure-scaled distance

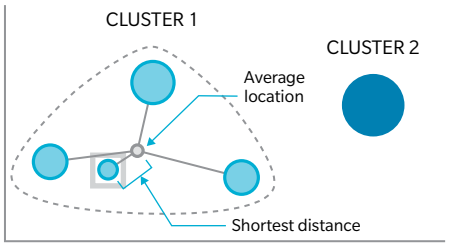
  ```
  Formula: =SetClusterLinkageRule (IMPORTANCE)
  ```

- **Output linkage rule:** used to specify how the parent of each cluster is selected in the output step. AXIS currently supports four output linkage methods. The differences between each are shown in Exhibit 5

Exhibit 5: Output linkage rules in AXIS

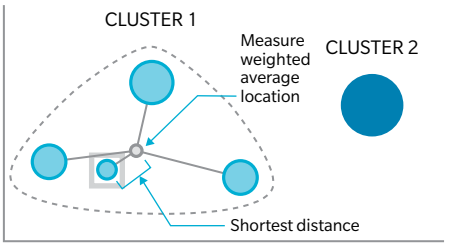
CLOSEST TO AVERAGE LOCATION

```
Formula:
=SetOutputLinkageRule (CLOSEST_TO_AVGLOCATION)
```



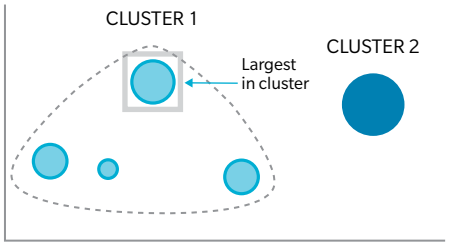
CLOSEST TO MEASURE WEIGHTED AVERAGE LOCATION

```
Formula:
=SetOutputLinkageRule (CLOSEST_TO_
MEASUREWEIGHTED_AVGLOCATION)
```



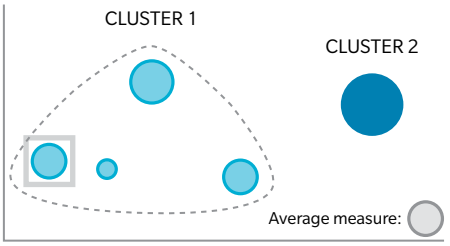
LARGEST MEASURE IN CLUSTER

```
Formula:
=SetOutputLinkageRule (LARGEST_IN_CLUSTER)
```



CLOSEST TO AVERAGE MEASURE

```
Formula:
=SetOutputLinkageRule (CLOSEST_TO_AVGMEASURE)
```



- **Compression Output Table:** DataLink Table containing policy IDs and grouping factors of the compressed data
- **Compression Report Table:** DataLink Table containing the compression results for each cluster including the measure and distance outputs for the parent and **children**

AXIS provides functionality to test different compression ratios using a single compression Batch. This can be implemented by repeating the DataLink formula specified below for each desired compression ratio. The Compression Output Table and Compression Report Table objects must be created for each compression ratio before the model run.

```
Formula:
=SetCompressRatioAndOutputTable (40, "Compression
Output Table 40", "Compression Report Table 40")
=SetCompressRatioAndOutputTable (30, "Compression
Output Table 30", "Compression Report Table 30")
```

COMPRESSION BY SEGMENT

Segmenting policies (e.g., by major product line, GAAP cohort, gender, etc.) and separately compressing each segment (e.g., different compression ratios, location variables, etc.) will generally lead to the best fit of results.

To do so, add and populate the "Compression Segment" Optional Field in the Policy Information Table and use "If" statements in the "Cross Table Formula Batch" to vary the compression logic by segment. In the following example, certain segments are not compressed while others are assigned a compression ratio of 40 percent:

```
Formula:
IF A.[COMSEG] = "NOCOMPRESSION" THEN
=SetCompressRatioAndOutputTable (100, "Compression
Output Table 100", "Compression Report Table 100")
ELSE
=SetCompressRatioAndOutputTable (40, "Compression
Output Table 40", "Compression Report Table 40")
ENDIF
```

STEP 2: EXECUTE CLUSTERING ALGORITHM

To execute the clustering algorithm, add "Perform Compression" and "Export seriatim data" action steps in a DataLink Macro.

After running the DataLink Macro, the resulting set of compressed data, i.e., Data Model, will be available for use in AXIS and can be selected via Tools > Inforce Seriatim > Set Active Model.

STEP 3: COMPARE MODEL RESULTS

The compressed model should be evaluated by comparing model outputs between compressed and seriatim model runs. Experimentation may be necessary to determine optimal parameters: location variables, weights, measure, output linkage rule, segments, and compression ratios.

SECTION 3: ILLUSTRATIVE MODEL RESULTS

Compression was performed on an illustrative variable annuity product in AXIS using a range of compression ratios and compressing on key risk drivers. The following charts show resulting statutory reserves under a range of compression ratios along with the reduced model runtime.

Exhibit 6: Statutory reserves under a range of compression ratios

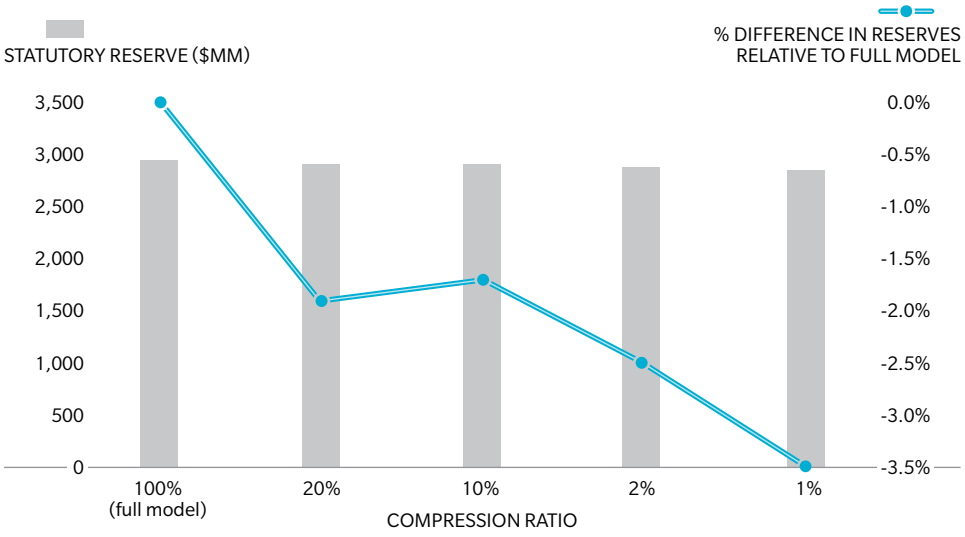
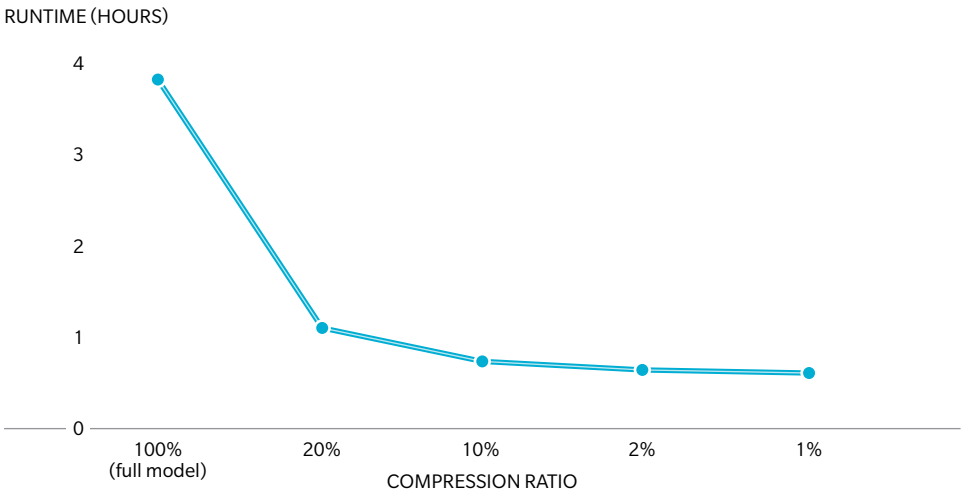


Exhibit 7: Model runtime under a range of compression ratios



TIPS & TRICKS

Using compressed model points for inner loop projections

Certain reserving standards (e.g., AG43, VM-20, SOP 03-1) require stochastic calculations. Performing stochastic reserve calculations in an actuarial forecast (often referred to as "stochastic on deterministic") significantly increases the computational strain to generate financial results. To overcome this challenge, AXIS introduced functionality to perform reserve revaluations (i.e., "inner loop projections") using compressed model points while maintaining the granularity of the main forecast (i.e., "outer loop projection") with uncompressed seriatim data:

1. In Fund > Assumptions > Embedded Block, create a new Table under the section "Emb Block Data Model Table [Composite]"
2. In row 1 of the new Composite Table, select the desired Embedded Block Assumptions Table
3. In row 2 of the new Composite Table, create a new Table under the section "Embedded Block Data Model [Formula]" and use the "SetActiveSeriatim ModelThisBlock" function to select the desired Data Model. The compressed model points corresponding to that Data Model will then be used for all inner loop projections without affecting the outer loop projection

The setup above improves model runtime proportionally to the compression ratio of the inner loop Data Model. For example, compressing at a 20:1 ratio can improve a forecast run taking 40 hours on 2,000 cores to 2 hours on the same farm. This improvement enables additional analyses previously unattainable due to high computing time and cost.

The example above illustrates the significant benefit a company may realize by implementing an intelligent clustering algorithm. Valuation (i.e., calculation) runtime is reduced proportionally to the reduction in model points, while calculated reserves deviate by a reasonable margin. Note that overall runtime does not reduce proportionally due to model overhead, including DataLink and certain model aggregation and output processes.

CONCLUSION

The inforce data compression functionality available in AXIS provides insurers advanced data clustering techniques and a practical solution to reducing model runtime. For computationally intensive tasks such as stochastic modeling and forecasting, the efficiency achieved by developing a robust compression process could outweigh the loss in model fidelity and upfront development costs.

WHAT'S NEW IN AXIS

OPTION TO FLOOR TOTAL SOP 03-1 LIABILITY

Description

- In the Annuity module, a new option ("Floor negative total SOP 03-1 liability at zero") has been added to the "Negative SOP 03-1 liab. treatment" switch in the Subfund screen:
  - This option floors the total SOP 03-1 liability at zero
  - The US GAAP Details report has two new rows to display the adjustment to SOP 03-1 reserves as a result of flooring:
    1. Gross SOP 03-1 floor adjustment
    2. Net SOP 03-1 floor adjustment

Details

- Version 20183601

Learn more

- https://www.ggy.com/client/BugEnhance/UpdateDetail/25390/

"XLOOKUP" FUNCTION TO ALLOW A RETURN FIELD NAME AS TEXT PARAMETER

Description

- In DataLink, two functions were expanded:
  1. "XLOOKUP"
  2. "XLOOKUPBYNAME"
- The return field parameter can now be specified by field name instead of by field index
- There is no impact to existing formula text that returns a field index

Details

- Version 20183101

Learn more

- https://www.ggy.com/client/BugEnhance/UpdateDetail/25142/

REVALUATION FREQUENCY OPTION "EVERY YEAR FOR M YEARS THEN AT LEAST ONCE EVERY N YEARS"

Description

- In the Annuity, Disability, Par Products, Regular Life and Universal Life modules, the revaluation frequency option ("M yrs., then every N yrs.") available under Feature Code 621 has been designated as a feature to be removed
- It is advised to use the "Reserve revaluation frequency" setting in the Dataset Parameters instead:
  - To enable this option, the Cell "Revaluation frequency" switch must be set to "Based on Reserve Revaluation Frequency setting in Dataset Parameters"

Details

- Version 20182601

Learn more

- https://www.ggy.com/client/BugEnhance/UpdateDetail/24974/

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