FINANCIAL MODELING

RMS® CCRA® Training Program

Certified Catastrophe Risk Analyst

 February 5, 2020

AGENDA

- **Unit 1: Financial Model Definitions and Basic Concepts**
- Unit 2: Primary Insurance Structures
- Unit 3: Reinsurance Structures
- Unit 4: Expected and Distributed Modes
- Unit 5: Aggregate Data
- Unit 6: Exceedance Probability (EP) Curves
- Unit 7: Year Loss Tables (YLTs) and EPs

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This is the agenda for the Financial Modeling course. In addition there are three exercises to complete.

UNIT 1 – LEARNING OBJECTIVES

- Financial Model Definitions and Basic Concepts
  - Discuss the framework for catastrophe modeling
  - Explain what the financial model does and why it is important in catastrophe modeling
  - Diagram the RiskLink® aggregation levels

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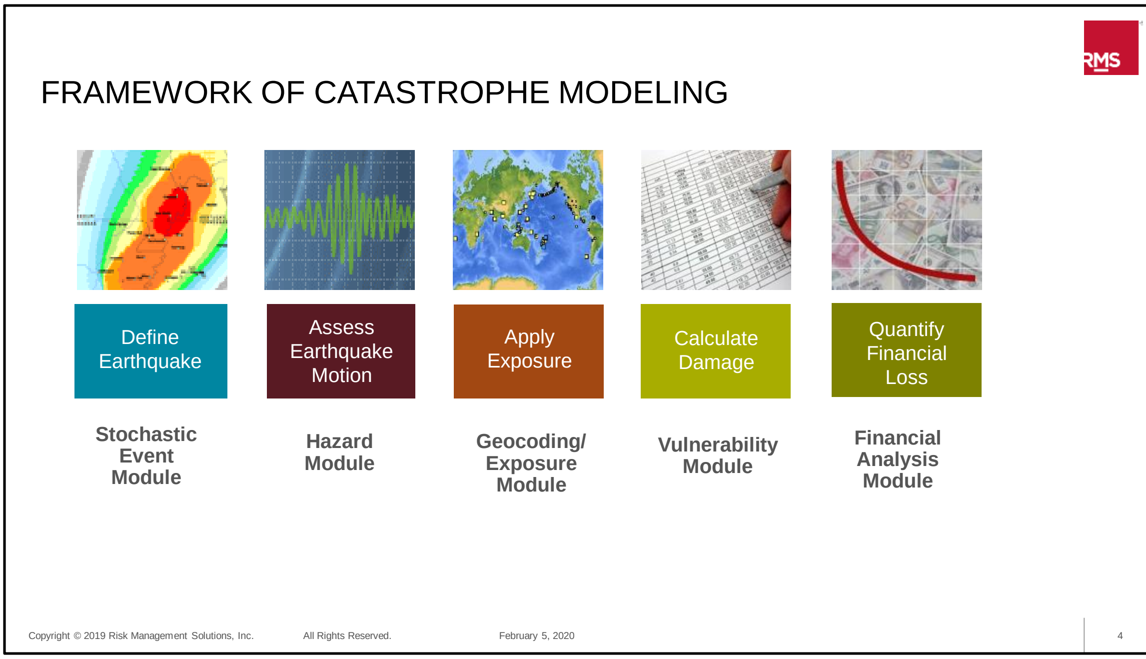
At the end of this unit you should have a concrete understanding of each of the three learning objectives listed on this slide.



Each model built by RMS, whether for natural or man-made catastrophes, follows the same basic pattern. First, we recreate the characteristics of the physical phenomenon being modeled. This process includes generating a stochastic event set that accurately depicts the likely range of events. This step is depicted in the first box of the diagram on the slide, using earthquake events as an example.

Second, we use these event characteristics to generate the loss-inducing hazard from the event at a location. Using the earthquake example on this slide, the second box would represent the calculation of likely damage-causing earthquake ground motion as measured by spectral acceleration (Sa) or shaking intensity (MMI).

Next, we apply the exposure and estimate the amount of physical damage due to the modeled ground motion at the location, which calculates a mean damage ratio (MDR) and coefficient of variation (CV).

Finally, we apply the calculated MDR and CV to the financial structure of the loss transfer mechanisms that are in place for that location. We can now evaluate the financial implications to locations, groups of locations, polices, accounts, and portfolios to all participants in the loss transfer mechanisms.

WHY DO WE NEED A FINANCIAL MODEL?

- To quantify losses not only at the individual location level, but also at the portfolio level
- To divide the total property loss among the different players (insured, primary insurer, reinsurer)
- To model the losses using probability distributions

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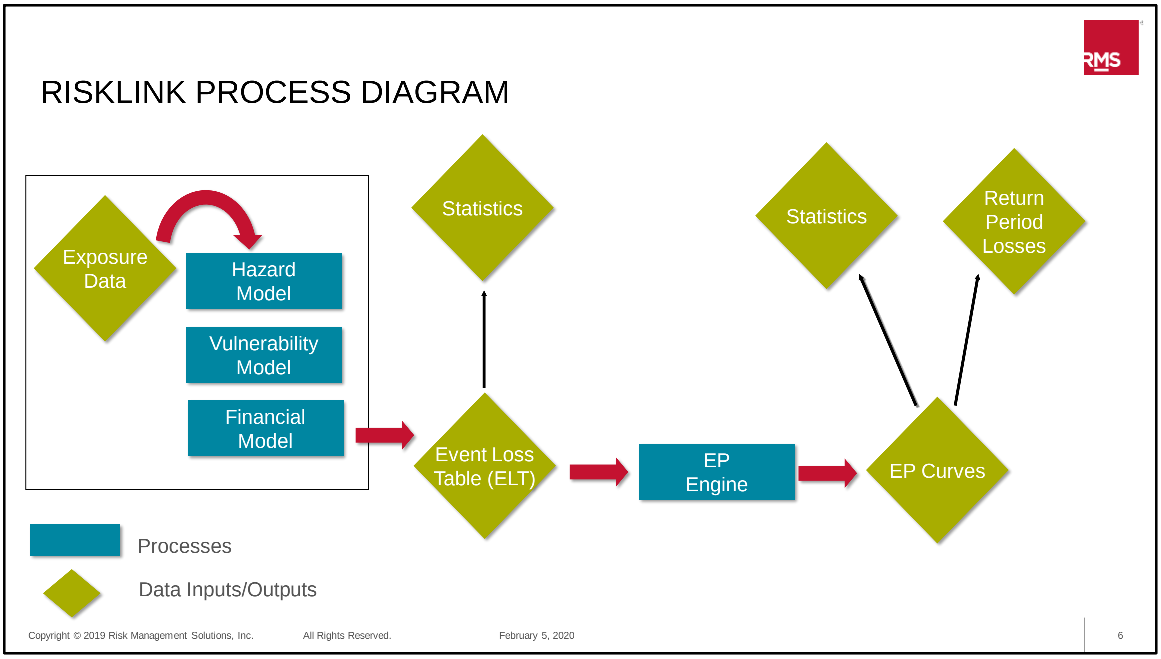
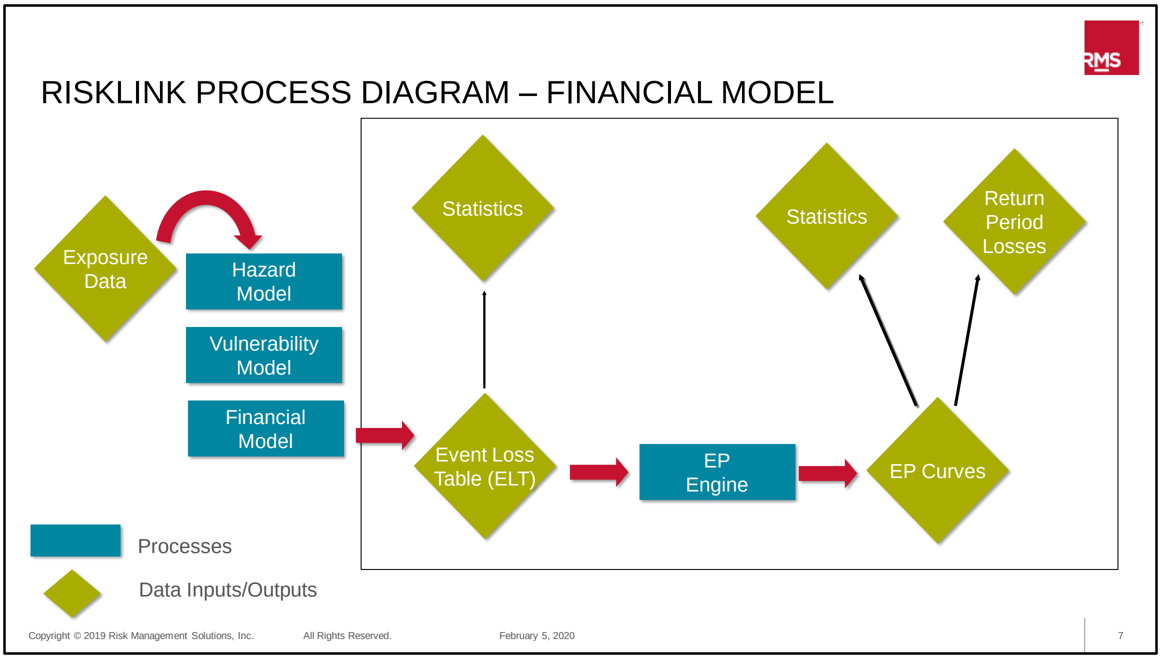
The financial model allows the physical damage from the location to be distributed to each of the participants in the loss transfer mechanism in place, including the insured, the insurer, other insurers, and reinsurers that are participating. It also allows for the evaluation of the financial losses to locations, groups of locations, polices, accounts, and portfolios for all participants in the loss transfer mechanisms. In order to account for the uncertainty around the modeled losses, the financial model also applies probability distributions around the mean loss.



This diagram illustrates the process RiskLink and RiskBrowser® use when an Exceedance Probability (EP) analysis is run and highlights the financial model calculations. Note that the yellow diamonds are data inputs/outputs and the blue rectangles are RiskLink/RiskBrowser processes.

The process starts with the exposure data and ends with the EP curves and related statistics. First, exposure data is entered (or imported) into the model for analysis purposes. We then need to determine the loss inducing characteristic (e.g. wind speed or ground shaking intensity) at each specific site (hazard module) and translate that into damage using mean damage ratios (vulnerability module). These processes result in ground-up losses, which are run through the financial model in order to determine the loss to various financial perspectives, such as gross loss, client loss (deductibles), reinsurance treaty losses, etc.



When an exceedance probability analysis is run, the output of the financial model is an event loss table (ELT). The ELT is a list of losses for each event that was analyzed by financial perspective. From the ELT we also get "non-cat statistics". These statistics include every financial calculation for all perspectives that occur prior to the application of any catastrophe reinsurance treaties. Some examples include: ground-up losses, gross losses, standard deviations by financial perspective, quota share pure premiums, surplus share losses, facultative reinsurance pure premiums, etc.

The ELT is then used as input into the exceedance probability engine (EP engine) to create the final EP curves. From the EP curves we get tail conditional expectation statistics (TCE), catastrophe reinsurance statistics (losses, pure premiums, standard deviations), and return period losses (e.g. 1-in-100 year return period loss).

This discussion will focus on the ELT, EP curves, return period losses, and cat statistics. For more information on tail conditional expectation, please refer to the TCE white paper that is available on RMS Owl (https://support.rms.com).

RISKLINK FINANCIAL MODEL - INPUTS

- Ground-up mean damage ratios (MDRs) and coefficient of variations (CVs) at the location coverage level for each modeled event
  - Equivalent to a ground-up event loss table at the location coverage level
- Annual frequency rates for each event
- Correlation weights

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The outputs from the vulnerability module feed the inputs to the financial model. These inputs are the mean damage ratio (MDR) and coefficient of variation (CV) for each location coverage affected by each modeled event in the analysis. The MDR is the percent of the coverage value that suffers a loss. The CV is a measure of variability around the MDR. These terms will be discussed in detail in Unit 4 and in the Uncertainty Measures course.

The calculated mean damage (loss) and uncertainty around the MDR is equivalent to the ground-up event loss table (ELT) at the location coverage level prior to the application of the financial model.

Outputs from the hazard model are also included. Specifically, the stochastic event information, such as the annual rate for each event and the event description are included in the ELT.

Finally, the correlation of damage between locations for a specific stochastic event is also calculated. The correlation weight (w) quantifies this correlation, which accounts for the influence of similar hazard and vulnerability characteristics for locations that are geographically close to each other. These inputs, which are used to examine the entire financial structure of the location, policy, or portfolio in question, will be discussed in detail in the following slides.

RISKLINK FINANCIAL MODEL – TASKS AND OUTPUT

- **Tasks**:
  1. Aggregate losses and standard deviations from the location coverage level up to higher aggregation levels using additional correlation assumptions.
  2. Fits a probability distribution (beta distribution) to model the severity of each individual event ground-up loss.
  3. Applies insurance/reinsurance structures to generate the losses and standard deviations for the non-ground-up financial perspectives.
  4. Generate exceedance probability (EP) curves.
- **Output**
  1. Event loss tables (ELTs) at all aggregation levels for all financial perspectives.
  2. EP curves at analysis level.

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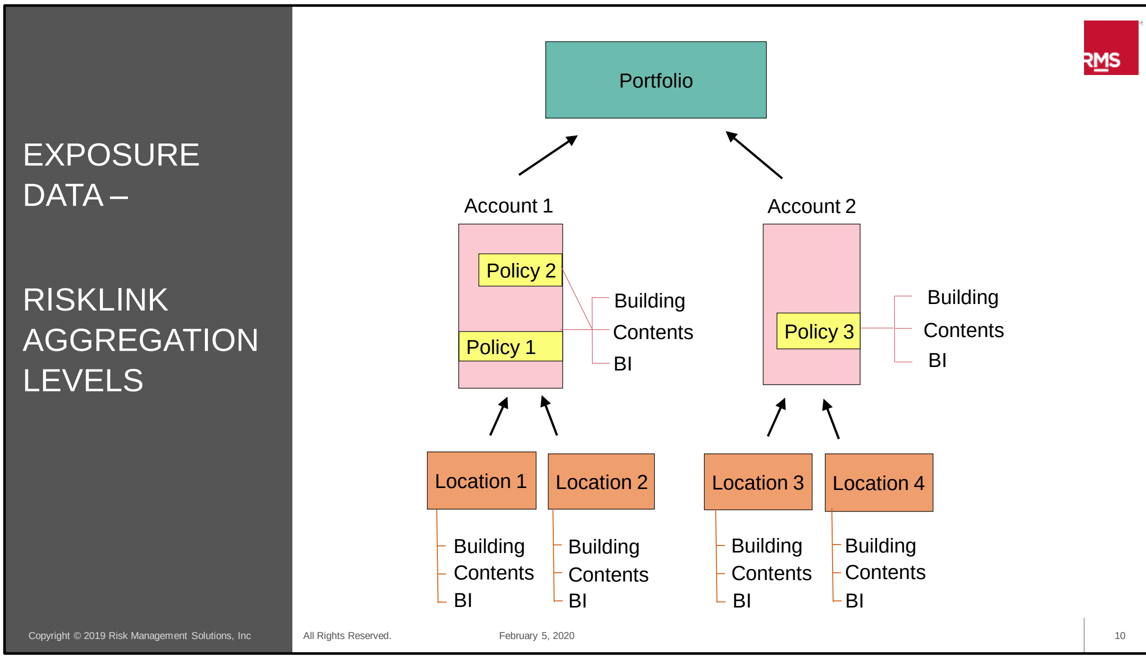
The financial model outputs an event loss table (ELT) for all financial perspectives at all aggregation levels (location, policy, portfolio). However, the user can control which of these financial perspectives on each respective aggregation level get written to the output database for later review. It is important to note that the financial model calculates all appropriate perspectives at each appropriate aggregation level, but it may not be stored in the database if the output settings were not selected in the DLM profile.

To create the event loss tables, the model must take the MDR, CV, event rate, and correlation weights and perform the following tasks:

1. Aggregate losses and standard deviations from the location coverage level up to higher aggregation levels using additional correlation assumptions.
2. Fit a probability distribution (beta distribution) to model the severity of each individual event ground-up loss.
3. Apply insurance/reinsurance structures to generate the losses and standard deviations for the non-ground-up financial perspectives.

The EP engine of the financial model uses the event loss tables to generate exceedance probability (EP) curves.

These processes and outputs, will be discussed in detail in later slides after an in-depth look at financial structures.



RiskLink manages exposure data by organizing it into three main levels: the location, the account, and the portfolio. A location is a specific building or a collection of buildings within a small geographic area such as a campus. An account is a collection of locations (or sites). Policies are insurance structures on the account. A portfolio is a collection of accounts.

The user may organize the accounts into portfolios so that each portfolio represents a different view or cut of the book of business. For example, a portfolio may represent all exposures for an insurer, a geographic area such as state, business written by a specific underwriter, or a line of business.

Within each main level are sub-levels. Within the location (or site) level is the location coverage level. Within the account level are the policy layer level and the policy coverage level. Within the portfolio level is the portfolio by cedant level.

Note that RiskLink analyses may be performed on a location, an account, or a portfolio - the three main levels. A location analysis only reflects financial information entered for the location. It does not reflect policy, account, or portfolio entries. Account analyses reflect location, policy, and account financial information. It does not reflect portfolio entries. Portfolio analyses reflect location, policy, account, and portfolio financial information. Since Risklink 8.0, in account and portfolio analyses, account and portfolio GR (gross) and RL (net pre cat)ELTs are allocated back down to account and location levels, so that for example, the output location level GR ELT (in an account or portfolio analysis) takes into account the effect of the policy structure.

Exposures organized into the three main levels and their respective sub-levels allow RiskLink to model various types of insurance and reinsurance structures.

NOTE ON AGGREGATE LEVELS

- There are aggregation levels in addition to those listed here:
  - Policy special conditions
  - Multi-building site
- They are no different than the other levels already mentioned but have been left out for the sake of simplicity.

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Note that there are two “aggregation levels” that are not fully covered in this unit: policy special conditions and multi-building sites. Policy special conditions are described in Unit 2, and the treatment of multi-building sites is covered in Unit 5. These two topics are termed “aggregation levels” in RMS publications because both methodologies require the aggregation of coverage values by geographic region or at the site level.

For more information on using these aggregation levels, please review the *RiskLink 11.0 DLM User Guide* or contact your RMS Account Manager.

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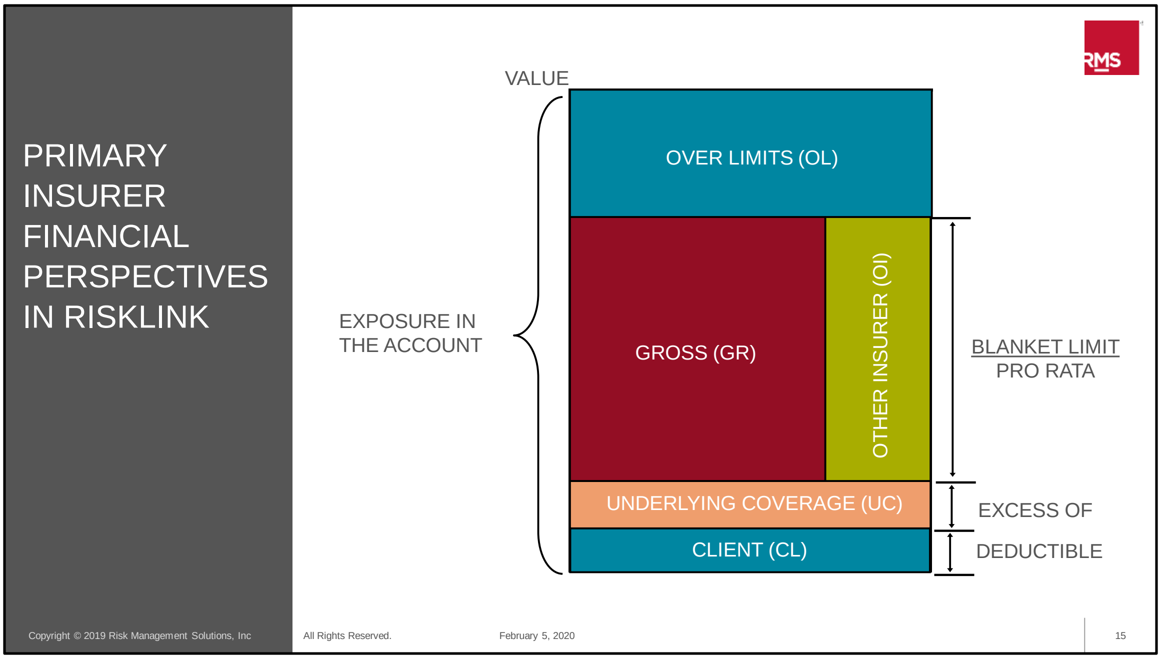
Now that we have discussed terminology and core definitions, we will examine how the ground-up losses are propagated to various primary insurance structures.

UNIT 2 – LEARNING OBJECTIVES

- Primary Insurance Structures
  - Diagram and explain the various financial perspectives within RiskLink
  - Recall the various ways in which insurance structures can be entered into RiskLink
  - Calculate the expected loss at the location coverage, location, policy, and account levels
  - Explain how various special insurance structures work

At the end of this unit you should have a concrete understanding of each of the four learning objectives listed on this slide.



By starting with the basic ground-up box for the account, we can proceed to add additional financial structures with the intent of eventually filling the whole ground-up box. For this discussion, we are assuming this account only has one policy.

We start with the lowest financial level possible, the deductible. The deductible, or client (CL) perspective, defined for an account always sits at the very bottom of the ground-up box. The height is determined by the deductible level defined for the account (deductibles are entered at the location, location coverage, policy, or policy coverage levels). The client perspective always spans the whole width of the ground-up box. In other words, there is no pro-rata application for deductible exposures.

The next box is called underlying coverage (UC). UC is not a necessary component of an account's financial perspectives. It only exists if there is a defined attachment point on a policy or if there are multiple policies on the account with some space between the policies. In this example the policy is defined as having an attachment point, thus the height of the UC box is the amount of the attachment point minus the deductible. Pro rata for UC is always 100%.

With the client and underlying coverage perspectives out of the way, we can move to the gross (GR) financial perspective. The height of the GR box as charted in the slide is the limit of the policy written for the account. The GR box excludes any exposures from deductibles or values above the policy limit, thus the gross financial perspective is net of the client and underlying coverage amounts and net of the value above the limit. As you can see, the policy does not cover the full width of the ground-up box. This means that the policy limit is a pro rata percentage of a total limit (e.g. 80% of $5,000,000).

The other insurer (OI) perspective is the remainder of the total limit that is not covered by the policy. The gross plus the other insurer perspectives make up a rectangle that fills the full width of the original ground-up box.

The over limits (OL) financial perspective is the final non-reinsurance layer. It takes into consideration any remaining ground-up exposure that is not covered by the perspectives defined below it. This means that if the combination of gross and other insurer boxes take all remaining space above the client and the underlying coverage, the over limits perspective will be zero for this account.

AGGREGATION LEVELS AND PRIMARY INSURANCE STRUCTURES IN RISKLINK

RiskLink Insurance Structure

Aggregation Levels

	Limits	Deduct.	Min/Max Deduct.	Attachment Point	Pro Rata
Portfolio	N	N	N	N	N
Account	N	N	N	N	N
Policy	Y	Y	Y	Y	Y
Policy Coverage	Y	Y	N	N	N
Location	Y	Y	N	N	N
Location Coverage	Y	Y	N	N	N

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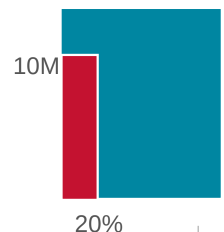
This table shows which primary insurance structures are applicable to each aggregation level in RiskLink. Of important note is the fact that the chart shows that no insurance structures are available for accounts. This is a consequence of RiskLink naming conventions and can be misinterpreted. In RiskLink, an account is a collection of policies and locations. A policy stores the deductibles, limits, reinsurance, and peril information for each financial layer of the insured account. This naming convention allows the user to enter multiple policy layers by account, whether the layers are stacked or the layers represent different financial terms for different perils (i.e., earthquake, windstorm). You can have one policy per account or multiple policies by account.

RISKLINK TERMINOLOGY: % DEDUCTIBLES AND PRO RATA

- % deductibles based on % of value; **not** % of loss, **not** % of limit
- If you want to calculate deductibles as a % of loss then:
  - If policy level deductible, use the pro rata capability.
  - If location level deductible, use reinsurance.
    - Workaround link on Owl
- Pro rata
  - A policy covering 20% of the layer $0-$10M can be coded as:

Limit = 2M	Limit = 20%	Limit = 2M
Part Of = 10M	Part Of = 10M	Part Of = 20%
Excess Of = 0	Excess Of = 0	Excess Of = 0



RiskLink calculates all of its percentage deductibles as a percentage of the underlying values for the policy. It does not calculate the deductible as a percentage of policy loss or as a percentage of the policy limit.

However, a percentage of loss deductible is equivalent to a pro rata policy. For example, if you have a 10% deductible that applies to the loss, then this is the same as a pro rata of 90%. That is, the policy will pay 90% of every loss, and 10% is paid by the insured.

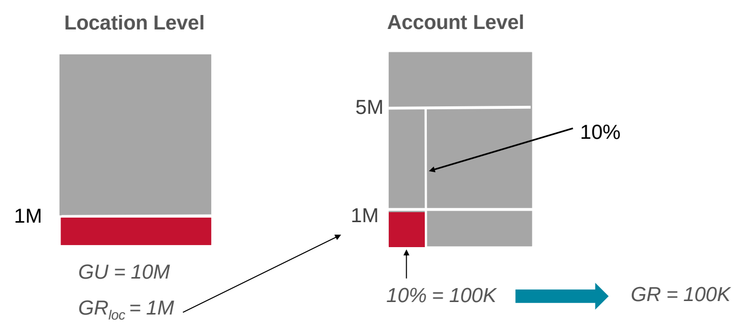
So, if you wish to enter a *policy level* percentage of loss deductible, you should employ the pro rata field. The results for gross losses and all financial perspectives upstream (pre-cat net, treaty losses, etc.) will accurately reflect this situation. However, a portion of the losses paid by the insured will show up in the other insurer financial perspective instead of the client loss perspective.

If you wish to employ a *location level* percentage of loss deductible, it is more complicated since RiskLink does not have location level pro rata capability. To implement location level percentage of loss deductibles, you can refer to the FAQ found in RMS Owl.

Note that you can code policy level pro rata one of three ways as noted on the slide. All three methodologies will calculate identical results.

POLICY PRO RATA EXAMPLE

- A single location account with a 1M site limit
- A 5M layer with 10% participation
- An event causes a 10M ground-up loss



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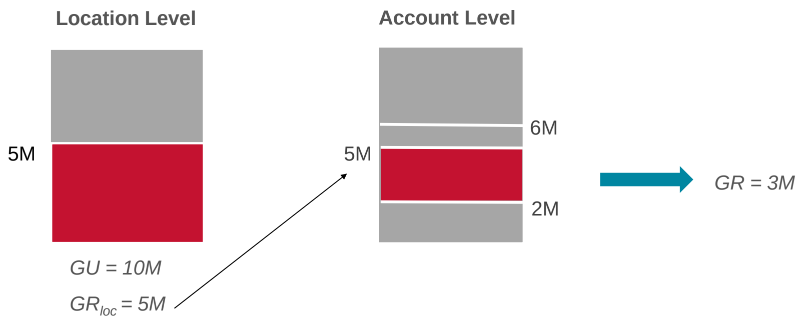
Before we begin the first exercise, we need to look at specific examples of the interaction between location level gross loss and policy level gross loss when there is a pro rata participation mechanism employed.

Let us assume we have an event that creates a total loss for a location valued at $10,000,000.

1. The location ground-up loss is $10,000,000 or 100% of the values.
2. The location gross loss is $1,000,000 due to site limits in place.
3. As noted, this location is under a $5,000,000 policy. Assume you are an insurer who participates 10% on this policy (i.e. 10% pro rata).
4. Since the $1,000,000 site limit is less than the $5,000,000 policy limit, we will use the $1,000,000 limit as our effective limit.
5. We then apply the 10% pro rata to the effective limit → 10% * $1,000,000 = $100,000.
6. So, the calculated policy gross loss is $100,000.

POLICY EXCESS LAYER EXAMPLE

- A single location account with a 5M site limit
- A 4M layer attaching at 2M with 100% participation
- An event causes a 10M ground-up loss



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We will look at another example, this time with the focus on the interaction between a location level gross loss and a policy excess layer.

Assume we have an event that creates a total loss for a location valued at $10,000,000.

1. The location ground-up loss is $10,000,000 or 100% of the values.
2. The location gross loss is $5,000,000 due to site limits in place.
3. As noted, this location is under a $4,000,000 excess of $2,000,000 policy. So, the policy covers losses from $2,000,000 to $6,000,000.
4. When comparing the $5,000,000 location gross loss to the policy layer, we first must take out the $2,000,000 attachment point. In other words, $5,000,000 (location gross loss) – $2,000,000 (policy attachment) = $3,000,000, which is subject to the $4,000,000 limit.
5. We now note that the $3,000,000 that is left is less than the $4,000,000 policy limit, so the entire $3,000,000 will be covered by the policy.
6. The calculated policy gross loss is $3,000,000.

DEDUCTIBLES AND LIMITS

- Deductibles and limits can be defined at many levels but only one (the effective limit/deductible) is used in the end at any given level.
  - Not additive, no inuring relationships
- Combined (building + contents) limits and deductibles are possible to code at both the location coverage level and the policy coverage level.
- % deductibles are based on % of value, **not** % of loss.

Deductibles and limits can be defined at various levels. RiskLink allows you to enter deductibles and limits at the location coverage, location, policy coverage, and policy levels as noted in the prior table. When deductibles and limits are entered at multiple levels, RiskLink does not interpret them to be additive, nor does RiskLink recognize any inuring priorities for them. RiskLink does allow combined deductibles and limits at the location coverage and policy coverage level. This allows for users to understand the impact of a combined building and contents financial structure, most often employed in personal lines and small business insurance products

CHOOSING THE EFFECTIVE DEDUCTIBLE/LIMIT

- Process of choosing the effective deductible/limit involves aggregating from lower levels to higher levels.
- RiskLink will always try to maximize the insurer benefit by choosing:
  – An effective deductible that satisfies all coded deductibles.
  – An effective limit that satisfies all coded limits.

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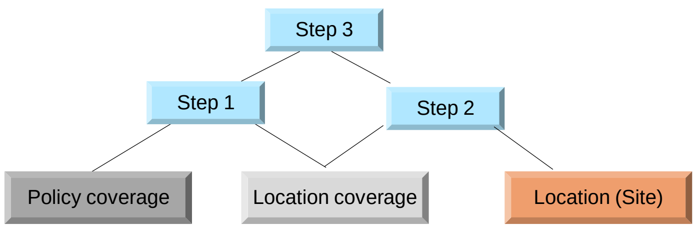
RiskLink, in general, chooses the combination of deductible and limit that maximizes the insurer benefit and satisfies all coded deductibles and limits. This is achieved by selecting the deductible that gives the greater client loss and the limit that generates the smaller gross loss.

STEPS FOR CHOOSING DEDUCTIBLE/LIMIT *(BELOW POLICY)*

- Step 1: Choose effective deductible/limit for policy coverage.
  - For each coverage, sum location coverage over all locations and compare to policy coverage.
- Step 2: Choose effective deductible/limit for location.
  - For each location, compare sum of location coverages to location.
- Step 3: Aggregate to policy level.
  - Sum coverage results from Step 1, sum location results from Step 2, compare.



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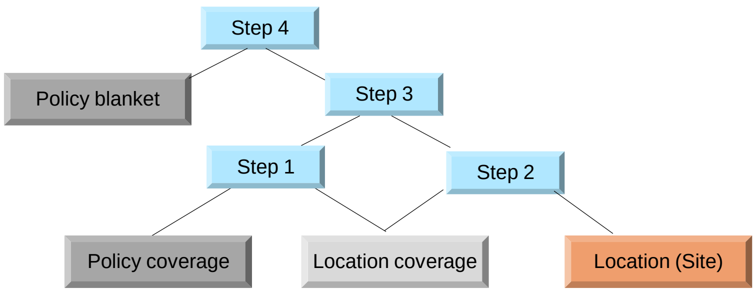
These are the steps employed to choose the limit/deductible combination that maximizes the payout but satisfies constraints imposed by deductibles and limits. The steps noted here are applicable for all aggregation levels prior to the policy level.

CHOOSING DEDUCTIBLE/LIMIT AT POLICY LEVEL

- Step 4a: Choose effective policy deductible.
  - Compare deductibles, choose larger (as at lower levels)
- Step 4b: Choose effective policy limit.
  - Apply policy financial structures to the loss in Step 3.
  - Treated differently because of attachment points and pro rata.



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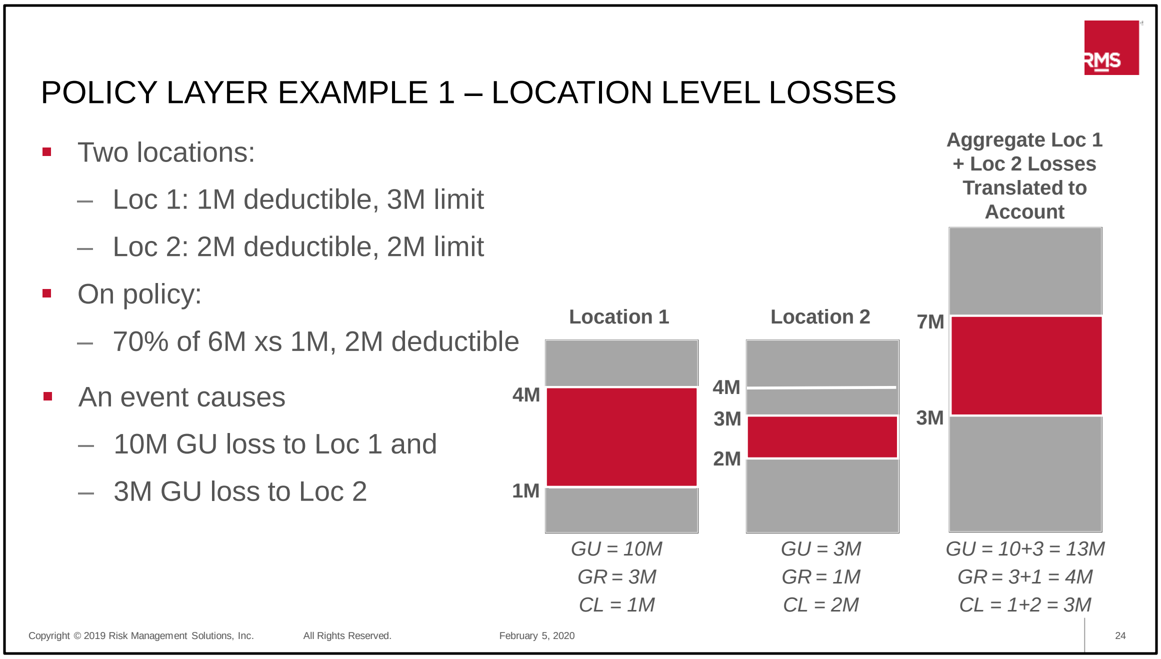
Once we have made our selections for the effective deductible, we then apply the policy financial structure to take into account any pro rata on the policy.

These steps will be examined in detail in the first exercise.



In this example we will show a policy with an attachment point, a pro rata limit, and a deductible. We will see how this policy structure interacts with the location level limits and deductibles.

Assume we have an event that causes a ground-up loss of $10,000,000 for location 1 and $3,000,000 for location 2. The following outlines the steps to calculate policy-level losses.

Step 1: Calculate CL and GR for Location 1

Client loss = min (deductible, GU) = min (1M, 10M) = $1,000,000

Gross loss = min (GU-deductible, limit)= min (10M-1M, 3M) = $3,000,000

Step 2: Calculate CL and GR for Location 2

Client loss = min (deductible, GU) = min (2M, 3M) = $2,000,000

Gross loss = min (GU-deductible, limit) = min (3M-2M, 2M)= $1,000,000

Step 3: Aggregate Location 1 and Location 2 results to determine losses subject to policy structure, translate results to policy/account level

Ground-up loss = Loc1 GU + Loc2 GU = 10M + 3M = $13,000,000

Client loss= Loc1 CL + Loc2 CL= 1M + 2M = $3,000,000

Gross loss= Loc1 GR + Loc2 GR = 3M + 1M= $4,000,000

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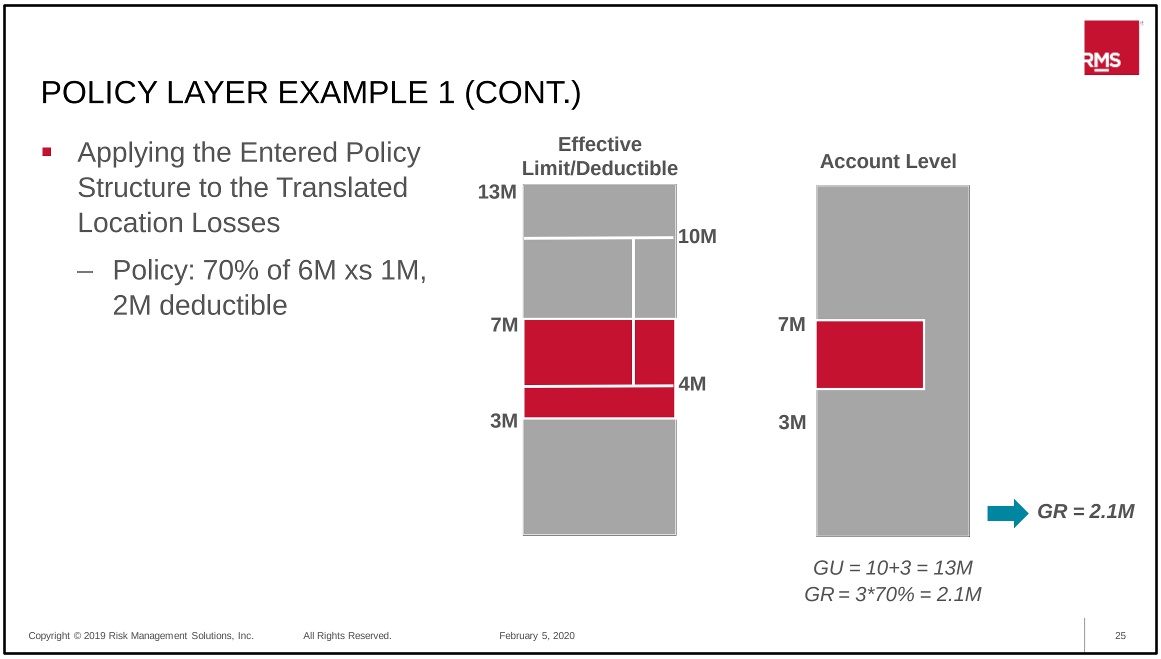


Step 4: Calculate policy-level deductible independently

Client loss = min (deductible, GU) = min (2M, 13M) = $2,000,000

Step 5: Choose the effective policy deductible

Compare the translated location client loss to the policy client loss, and keep the <u>larger</u>.

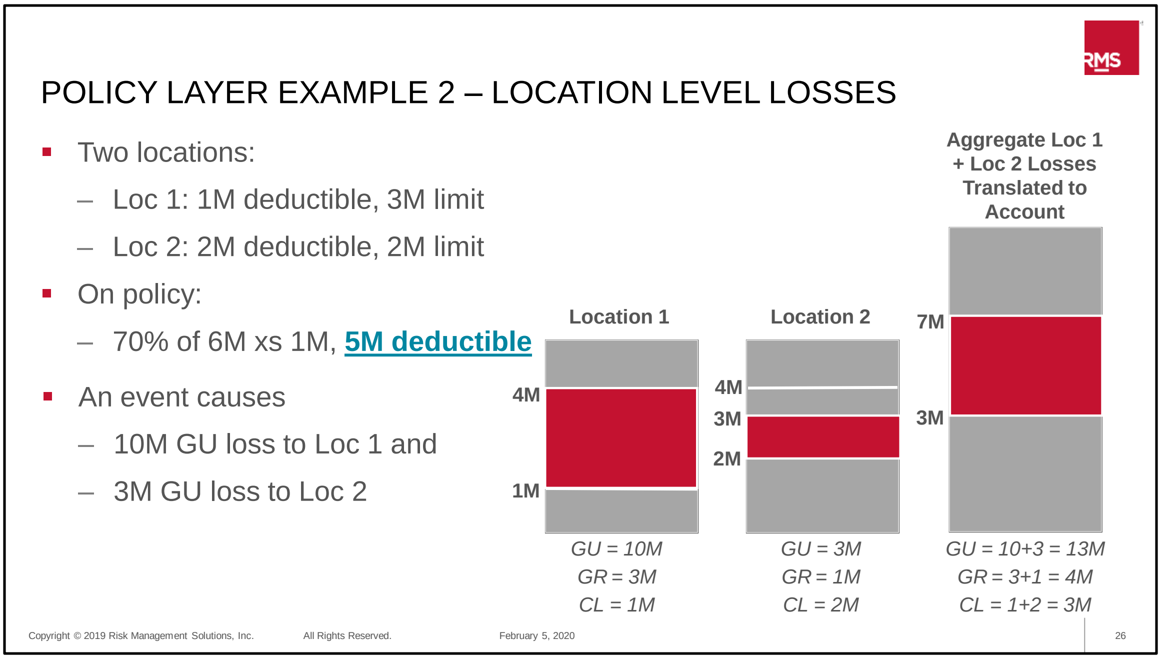
Effective policy deductible (i.e. policy CL) = max (location CL, policy CL) = max (3M, 2M) = $3,000,000

Step 6: Calculate the policy gross loss

1. The $4,000,000 gross loss from the location level covers losses from $3,000,000 (policy CL) to $7,000,000 (policy CL + location GR).
2. The $1,000,000 attachment point applies above the $3,000,000 client loss layer.
3. The policy has a limit of $6,000,000. The policy, therefore, covers losses from $4,000,000 (policy CL + policy attachment) to $10,000,000 (Policy CL + policy attachment + policy limit).
4. If we overlay the $4M gross loss layer from #1 onto the policy structure derived

in #2 and #3, we can see that the first $1M of gross loss from $3M to $4M falls into the attachment point layer, and the remaining $3M of gross loss is covered by the policy limit (layer from $4M to $7M). *See the box diagram on the left.*

5. Lastly, we apply the 70% pro rata to the loss calculated in #4. The final policy gross loss is 70% * $3M = $2,100,000. *See the box diagram on the right.*



This example is very similar to the previous one except that the policy deductible is increased to 5M. Same as in the previous example, assume we have an event that causes a ground-up loss of $10,000,000 for location 1 and $3,000,000 for location 2. The results of the first three steps are unchanged from example 1 since they only affect the locations.

Step 1: Calculate CL and GR for Location 1

Client loss = min (deductible, GU) = min (1M, 10M) = $1,000,000

Gross loss = min (GU-deductible, limit)= min (10M-1M, 3M) = $3,000,000

Step 2: Calculate CL and GR for Location 2

Client loss = min (deductible, GU) = min (2M, 3M) = $2,000,000

Gross loss = min (GU-deductible, limit) = min (3M-2M, 2M)= $1,000,000

Step 3: Aggregate location 1 and location 2 results to determine losses subject to policy structure, translate results to policy/account level

Ground-up loss = Loc1 GU + Loc2 GU = 10M + 3M = $13,000,000

Client loss= Loc1 CL + Loc2 CL= 1M + 2M = $3,000,000

Gross loss= Loc1 GR + Loc2 GR = 3M + 1M= $4,000,000

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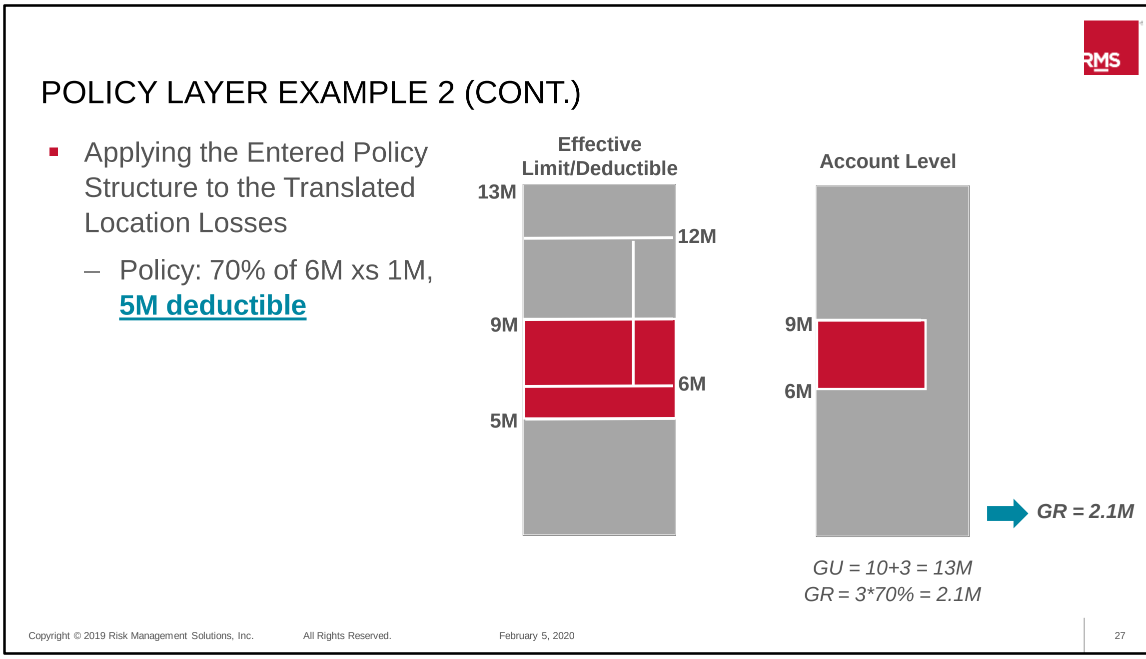


Step 4: Calculate policy-level deductible independently

Client loss = min (deductible, GU) = min (5M, 13M) = $5,000,000

Step 5: Choose the effective policy deductible

Compare the location client loss to the policy client loss, and keep the larger.

Effective policy deductible (i.e. policy CL) = max (location CL, policy CL) = max (3M, 5M) = $5,000,000

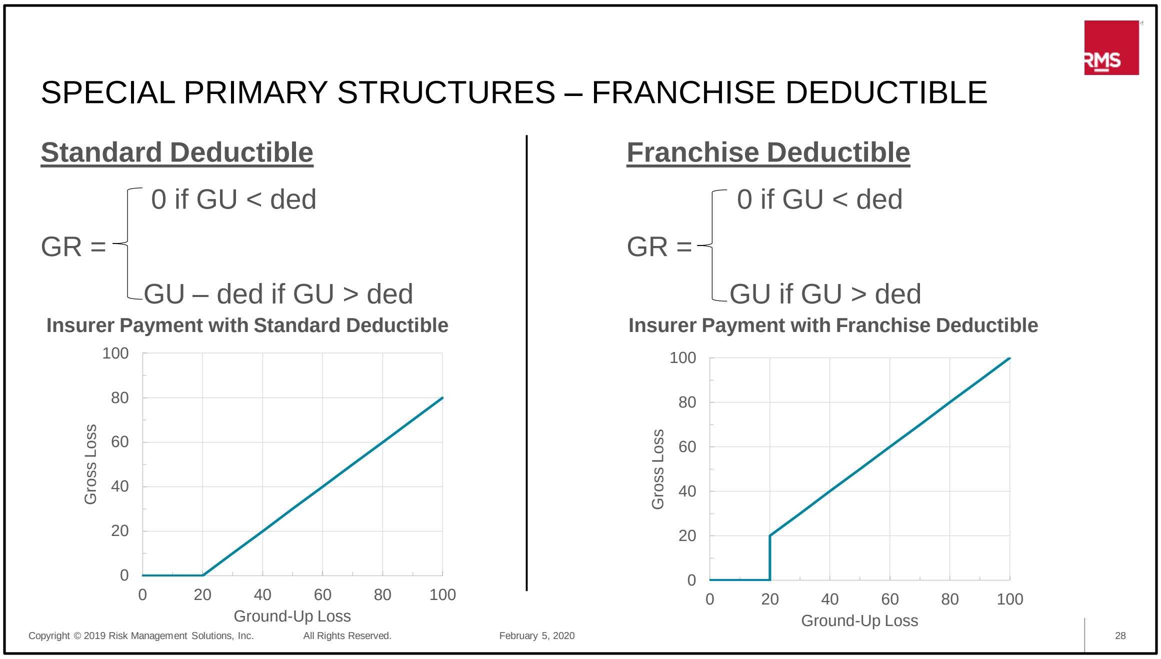
Note: The policy deductible is now chosen as the effective deductible vs. the location deductible from example 1.

Step 6: Calculate the policy gross loss

1. The $4,000,000 gross loss from the location level covers losses from $5,000,000 (policy CL) to $9,000,000 (policy CL + location GR).
2. The $1,000,000 attachment point applies above the $5,000,000 client loss layer.
3. The policy has a limit of $6,000,000. The policy, therefore, covers losses from $6,000,000 (policy CL + policy attachment) to $12,000,000 (policy CL + policy attachment + policy limit).
4. If we overlay the $4M gross loss layer from #1 onto the policy structure derived in #2 and #3, we can see that the first $1M of gross loss from $5M to $6M falls into the attachment point layer, and the remaining $3M of gross loss is covered by the policy limit (layer from $6M to $9M). *See the box diagram on the left.*

5. Lastly, we apply the 70% pro rata to the loss calculated in #4. The final policy gross loss is 70% * $3M = $2,100,000. *See the box diagram on the right.*

<u>Note</u>: The policy gross loss is unchanged from example 1 even though the effective deductible increased from $3M to $5M. This occurs because RiskLink places <u>both</u> the location gross loss and the policy structure on top of the effective deductible. In essence, once the effective deductible is chosen, it is no longer needed for the policy gross loss calculation.



Now that we have covered the basics of primary insurance structures, we move to the treatment of some special cases specific to certain regional insurance markets.

Franchise deductibles are a form of site deductible for which, if the losses do not exceed the site deductible, no losses are covered by the insurer. However, once the deductible is exceeded, all losses up to the limit are covered by the insurer, and the deductible becomes zero.

This deductible is different from a standard site deductible in that the insurer either pays zero (if the losses are less than the deductible) or the full loss amount (if the losses exceed the deductible).

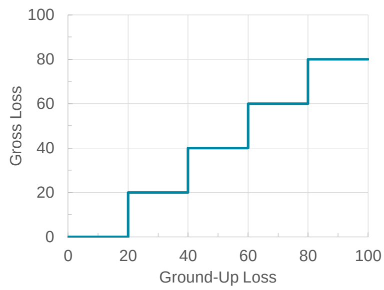
In a standard deductible, the insured pays the first losses until the deductible is satisfied, and then the insurer pays for the rest of the loss not covered by the deductible.

SPECIAL PRIMARY STRUCTURES – STEP & TOTAL LOSS POLICIES

Step Policy:

Gross loss is a step function of the ground-up loss; the different payouts (steps) will be determined by the range in which the ground-up loss falls.

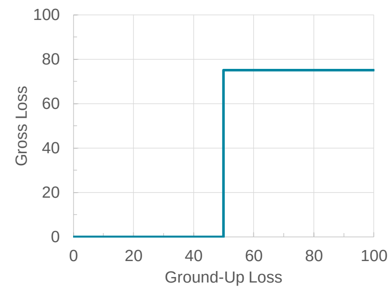
Insurer Payment with Step Policy



Total Loss Policy:

Binary policy such that if the ground-up loss exceeds a trigger point, the policy pays the full amount of the insured value, not exceeding a prescribed limit.

Insurer Payment with Total Loss Policy



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The step policy is an insurance payment structure that follows a step-like function, where the payment amount is a prescribed value over a certain interval and jumps to another prescribed value in an adjacent interval. The amount of payment is a function of where the ground-up loss falls within the trigger intervals. The policy can either be a *simple* step with one jump or it can be a more *complex* step with multiple jumps.

The total loss policy is a special case of the step policy with a single jump. The insurer pays nothing until the ground-up loss exceeds a specified trigger point (50% in the example above). Once this trigger is exceeded, the total policy limit is paid.

SPECIAL PRIMARY STRUCTURES – CALIFORNIA MINI POLICY

- Type of earthquake insurance policy written in California
- It was created in response to extremely difficult market conditions in the early and mid-1990s.
- Contents loss will not be paid until the building loss has exceeded the building deductible, minimizing insurer losses caused by small events.

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California has established standards for mini policies insuring earthquake on residential property in the state. Coverage standards for the mini policy are designed to limit contents and additional living expense loss in the interest of basic coverage availability. A unique feature of the mini policy financial structure is that contents loss is not covered until the building suffers loss greater than the building deductible, minimizing gross loss from smaller events.

SPECIAL PRIMARY STRUCTURES – POLICY SUB-LIMITS AND SUB-DEDUCTIBLES

- **Sub-Limit/Deductible**
  - Define a sub-limit and/or deductible that applies to a subset of locations covered by the policy
  - Example: $100M earthquake policy with a $50M sub-limit for locations in California
- **Policy Restriction**
  - Specify which locations are covered by the policy, effectively excluding all other locations
  - Example: An earthquake policy that covers only California locations

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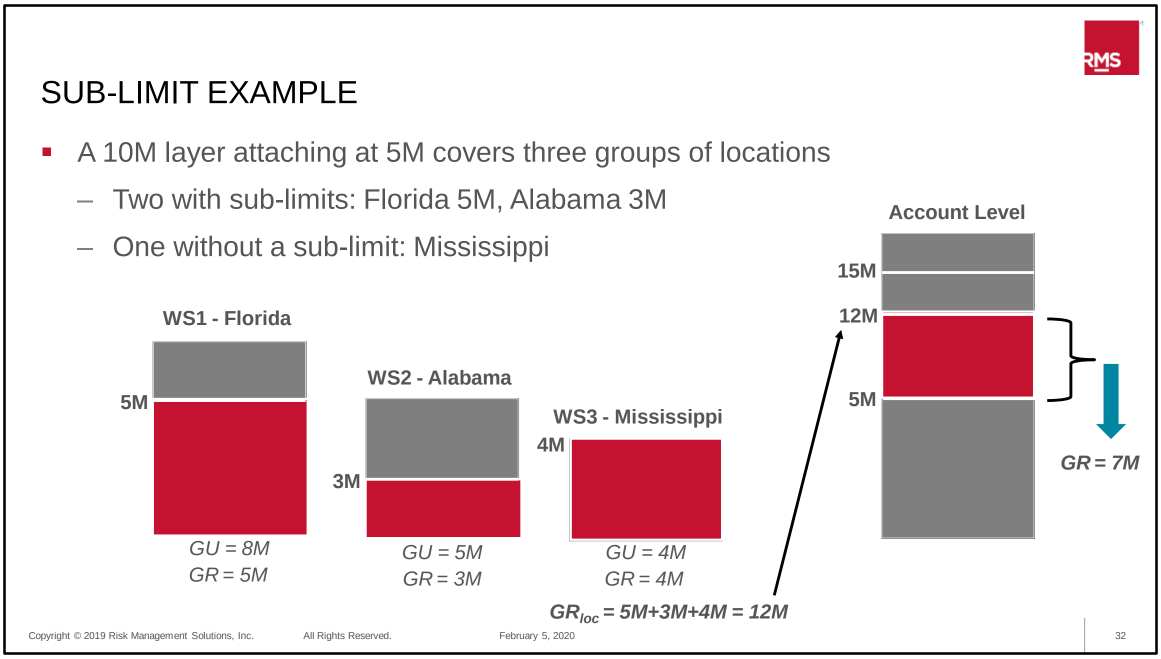
RMS refers to policy sub-limits, sub-deductibles, and policy restrictions collectively as *policy special conditions*. Special conditions are used to specify financial terms that apply to a subset of locations in an account.

A policy sub-limit or sub-deductible applies to locations in a specific geographic region (e.g. California), or with a certain construction type or occupancy. For example, a $100M earthquake policy may have a $50M sub-limit on California locations. A single policy can include multiple sub-limit conditions.

Another example is policy restrictions that specify which locations are covered by the policy (e.g. California), effectively excluding all other locations in the account not covered by the policy conditions. Only one policy restriction condition is allowed per policy.



Here is an example of the application of a sub-limit for U.S. locations in the RiskLink financial model.

Assume that WS1 refers to insured locations in Florida, WS2 refers to insured locations in Alabama, and WS3 refers to insured locations in Mississippi. As you can see, there is:

- $8,000,000 of Florida loss,
- $5,000,000 of Alabama loss, and
- $4,000,000 of loss in Mississippi.

In addition, there is a sub-limit of $5,000,000 on the Florida locations in aggregate and $3,000,000 on the Alabama locations in aggregate. There is no sub-limit on the aggregate Mississippi locations.

The sub-limits take effect prior to the policy limits. As shown in the formulas above, that equates to $12,000,000 of loss after the application of sub-limits and $7,00,000 of loss after the application of the policy attachment point and limits.

REMINDERS

- Ground-up loss (GU loss)
  - Mean damage ratio * coverage values(s)
- Client loss (CL loss)
  - Deductible paid by insured before policy pays out
  - Percentage deductibles = % * coverage value(s)
  - Min (GU loss, deductible)
- Gross loss (GR loss)
  - Capped at limits for each level (location coverage, combined, site, policy, etc.)
  - Min (GU loss – deductible, limit)

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Before proceeding with the exercise, recall the financial perspective terminology used by RMS as discussed in the presentation. In particular, recall those perspectives shown on this slide. For definitions of additional financial perspectives, review the *RiskLink 11.0 User Guide.*

EXERCISE 1

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Complete Exercise 1 and review the associated answers before continuing.

AGENDA

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The next section covers reinsurance structures and the financial model.

UNIT 3 – LEARNING OBJECTIVES

- Reinsurance Structures
  - Diagram and explain the various reinsurance financial perspectives within RiskLink
  - Identify the proper inuring order of multiple structures given the RiskLink hierarchy
  - Calculate the expected loss to reinsurance treaties and the loss net of all treaties.

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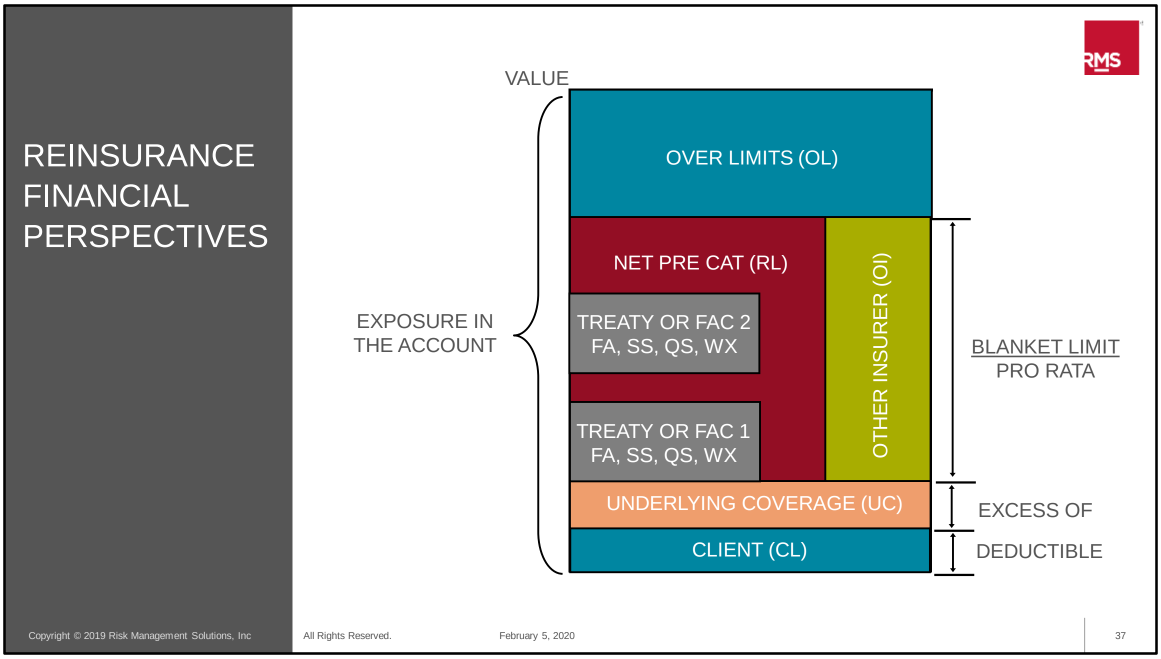
At the end of this unit you should have a concrete understanding of each of the three learning objectives listed on this slide.



The next financial perspectives we will discuss are the per risk treaty and cession reinsurance perspectives. The specific financial perspectives that fit this category are facultative (FA), surplus share (SS), quota share (QS), and working excess (WX). Any reinsurance used on an account will apply to the loss, standard deviation, and exposure amounts within the gross loss box. Reinsurance cannot apply to the other insurer, client, underlying coverage, or over limits exposures, or to their standard deviations or losses. There are a large variety of ways to attach reinsurance to an account. The graphic that we are working with here shows one of many possibilities.

The important thing to remember is that the Treaty1 or Fac1 defined here has no attachment point. It is defined as starting from 0 and working up.

Once the per risk reinsurance is applied to the gross amount we can subtract the reinsurance from gross to see how much exposure, loss, or standard deviation is left to work with. The amount remaining is called the net pre cat financial (RL) perspective.

PER RISK REINSURANCE
RISK SPECIFIC VS. RISK NON-SPECIFIC

- Risk Non-Specific
  - Location, policy and account levels
  - All treaty characteristics are common to all risks
  - Working excess and quota share treaties
- Risk Specific
  - Location and policy levels
  - Each risk has its own characteristics (layer amount, attachment point, % of layer)
  - Some characteristics are common to all risks (occurrence limit, inuring priority, line of business)
  - Facultative cessions and surplus share treaties

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One differentiating factor for per risk reinsurance is how the specific terms apply, whether they apply to specific risks or they apply to all risks. For per risk reinsurance, a risk can refer to locations, policies, or accounts.

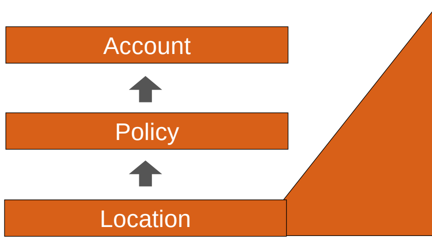
Facultative (fac) cessions are risk specific, since separate fac cessions can be defined for each location or policy in an account. For each fac cession, the limit (shown as layer amount), attachment point, inuring priority, and participation percentage (shown as % of layer) are definable quantities. In general, the difference between the attachment point and the sum of the attachment point and the limit is called the reinsurance layer. It is possible to have more than one fac cession for a location or policy.

Working excess and quota share treaties are labeled as risk non-specific, since the treaty is applied automatically to each exposure (i.e. location, policy, account) that meets the line of business, cedant information, and date criteria of the treaty. Location or account reinsurance apply when any policy in the account meets these criteria. Location-level treaties apply to every location in a qualifying account.

Surplus share is a hybrid of the fac cession and the quota share/working excess types of treaties. Like fac cessions, surplus share is available at the location or policy level only, and the per risk limit, attachment point, and % of layer are defined individually for each risk; therefore, it is noted as a risk specific treaty. However, surplus share reinsurance is modeled with properties similar to quota share and working excess treaties because details including occurrence limit, line of business, cedant, and inuring priority are defined on the treaty level and apply to all risks. A surplus share cession will not apply automatically just because it has been defined for a particular location or policy in the reinsurance cessions tab of the National Accounts screen in RiskLink. The surplus share cession must also be manually added to the RiskLink Analysis Builder.

PER RISK REINSURANCE: INURING PRIORITIES

- Inuring priority defines the order (if not simultaneous) in which different reinsurance treaties/contracts take loss
- There are some fixed levels of inuring priorities:



Priority	Treaty
1	Quota Share 1
2	Working Excess 1
3	Surplus Share 1
3	Facultative 1
4	Quota Share 2

- Within each level, user can assign a priority value for each treaty

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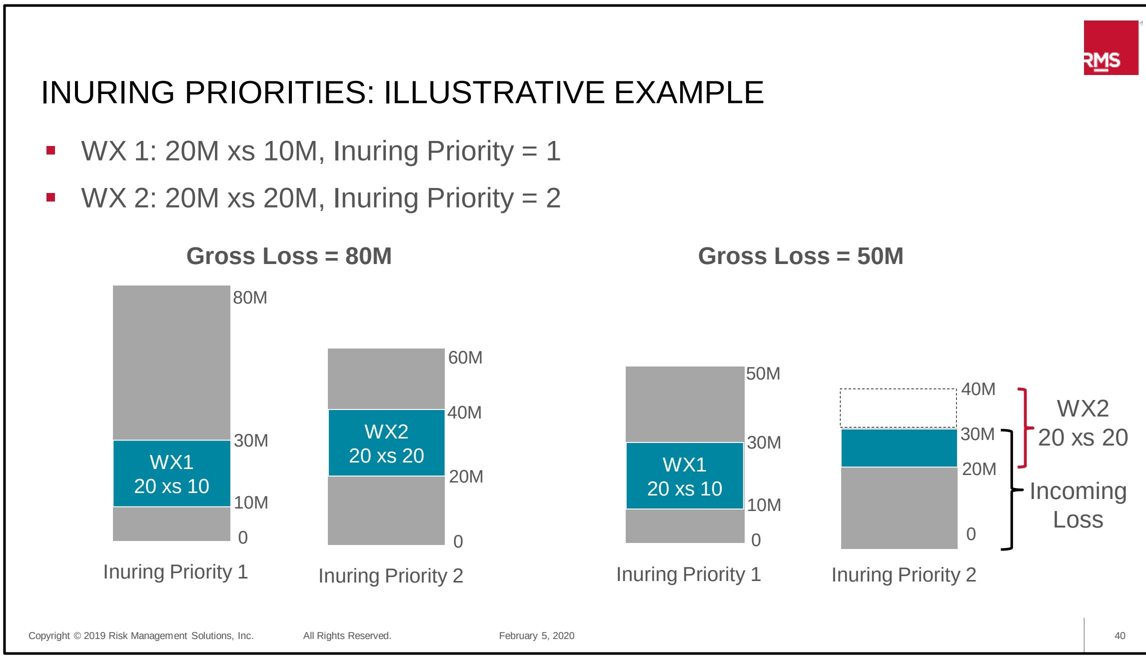
To provide complex and realistic reinsurance modeling, RiskLink offers flexibility in defining the order, or inuring priority, assigned to treaties. An inuring order defines the order that treaties take loss and what loss is subject to each treaty. In the example above, the priority numbers in the white box show that “Quota Share 1” takes loss first, since it has an inuring priority of 1 assigned to it. “Quota Share 1” then **inures to the benefit of** “Working Excess 1,” since that treaty is assigned the next highest inuring priority, namely 2.

These inuring priorities apply to all per risk treaties, facultative reinsurance, quota share, surplus share, and working excess. There are two levels of priority for these treaties used in RiskLink. The two levels are:

1. Exposure level. This is a fixed level of inuring priority within RiskLink. Treaties are first applied based on their exposure attachment level. Location treaties always inure to the benefit of policy treaties. Policy treaties always inure to the benefit of account treaties.
2. User defined priorities. After the exposure priority has been determined, losses are applied in the order that you set the inuring priorities. The inuring priority can be set to any number between 1 and 127. Priority “1” treaties take loss first; subsequent numbers take subsequent losses. A cession or

treaty with an inuring priority of “1’ inures to the benefit of a cession or treaty with next inuring priority greater than “1”.



To clarify the concept of inuring priority, we will look at the example on this slide. Given the treaties noted in the slide, we will see how the different gross losses flow through the reinsurance structure.

<u>Gross Loss = 80M</u>

1. Since the 80M is greater than (the attachment point + limit) of WX1 *(inuring priority 1),* the full limit of 20M limit will be covered by the treaty.
2. There is 80M – 20M = 60M gross loss left for WX2.
3. Since the 60M is greater than (the attachment point + limit) of WX2 *(inuring priority 2),* the full limit of 20M limit will be covered by the treaty.
4. Net loss pre cat loss is $80M_{GRLoss} - 20M_{WX1} - 20M_{WX2} = 40M_{RLLoss}$

<u>Gross Loss = 50M</u>

1. Since the 50M is greater than (the attachment point + limit) of WX1 *(inuring priority 1),* the full limit of 20M limit will be covered by the treaty.
2. There is 50M – 20M = 30M gross loss left that is now subject to WX2.
3. The 30M is less than (the attachment point + limit) of WX2 and more than the attachment point of WX2, so we calculate 30M gross loss – 20M attachment

point = 10M is covered by WX2.

4. Net loss pre cat loss is $50M_{GRLoss} – 20M_{WX1} – 10M_{WX2} = 20M_{RLLoss}$

INFORMAL EXERCISE

- **Question**: You are given the following four per risk treaties:
  - Policy Level Quota Share, Inuring Priority = 1
  - Policy Level Surplus Share, Inuring Priority = 2
  - Location Level Working Excess, Inuring Priority = 1
  - Account Level Working Excess, Inuring Priority = 1
- Establish the order in which the treaties will take loss
- **Answer**:
  - Location Level Working Excess, Inuring Priority = 1
  - Policy Level Quota Share, Inuring Priority = 1
  - Policy Level Surplus Share, Inuring Priority = 2
  - Account Level Working Excess, Inuring Priority = 1

To test your understanding of inuring priorities, go through the following quick exercise:

1. Cover up the bottom half of the slide.
2. Look at the four treaties noted on the top half of the slide.
3. Rank the treaties in order of their participation on the loss. Give the treaty that takes loss first a ranking of 1. Move through the treaties, until you get to the last treaty to take loss, which will have a ranking of four.

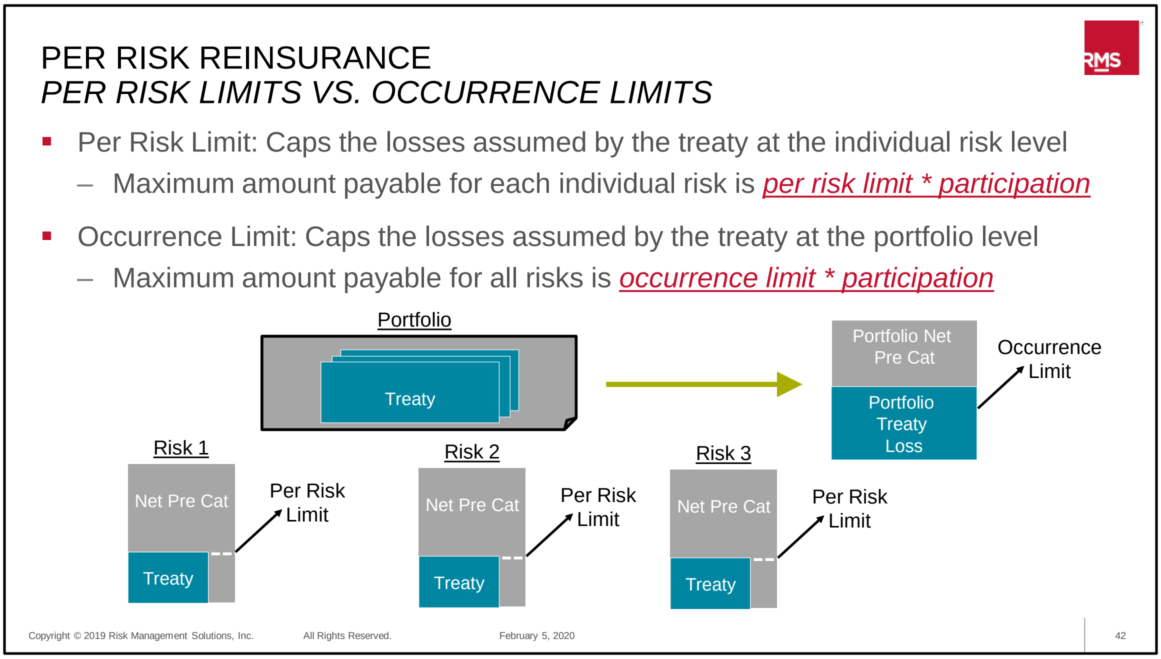
Do not read further until you complete the ranking

ANSWER

The first step is to examine the exposure level of each treaty. We note that the exposure level dictates that Location Level Working Excess is first (ranking of 1), Policy Level Quota Share and Policy Level Surplus Share are next (rankings of 2 and 3, but not necessarily in that order), and Account Level Working Excess is last (ranking of 4).

The next step is to look at inuring priorities within exposure levels. The only treaties of concern in this step are Policy Level Quota Share and Policy Level Surplus Share. Policy Level Quota

Share has an inuring priority of 1 and Policy Level Surplus Share has an inuring priority of 2. So, the Quota Share takes loss before the Surplus Share. Since we already identified that these 2 treaties would be assigned overall rankings of 2 and 3 in Step 1, we will assign the Quota Share a ranking of 2 and the Surplus Share a ranking of 3.



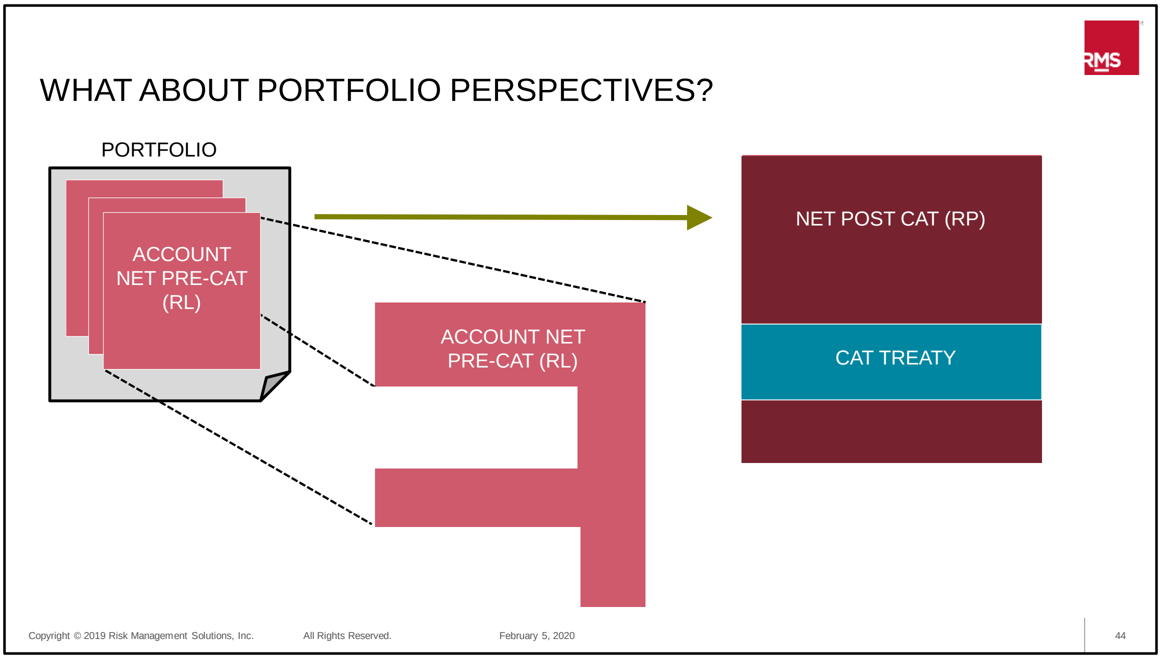
Quota share and working excess treaties use both per risk limits and occurrence limits in their treaty terms, or definitions. A per risk limit is defined by the attachment level of the treaty; for location-level treaties, it is a per risk limit per location. This per risk limit is the maximum loss the treaty will cover for each individual location, policy, or account for each individual event.

Occurrence limits are treaty limits that apply to the same event, but for all locations, policies, or accounts in aggregate. In other words, if a quota share or working excess treaty applies to multiple accounts in a portfolio, some or all of which take loss from a certain event, the ultimate treaty loss for this event will be the smaller of the sum of each account's treaty loss and the occurrence limit.

In RiskLink, account and location analyses do not have occurrence limit adjustments because RiskLink only applies occurrence limits at the portfolio level.

In the graphic in the slide, you see that three risks that take loss from an event are covered by the same treaty. The losses applied to the treaty from these three risks, taking into account the per risk limit, are summed and then compared to the treaty occurrence limit. As noted above, we compare the sum of the per risk losses and the portfolio level occurrence limit to determine the amount of loss covered by treaty.

*Note: Participation =% covered * % placed*



The portfolio net pre cat perspective is then used as a basis for applying portfolio reinsurance much like the gross perspective was used as a basis for applying the per risk treaties and cessions.

The treaty that applies directly to the portfolio net pre cat is the catastrophe treaty. Catastrophe (cat) treaties assume risk from the portfolio net pre cat risk. The remainder after the cat treaty(ies) are applied and the net result is called the net post cat (RP) financial perspective.

Another type of treaty called the corporate catastrophe treaty can also be applied to a portfolio. It applies after all cat treaties have been applied. The remaining exposure after the application of both the cat and corporate cat treaties is called the net post corporate cat (RC) financial perspective.

PORTFOLIO REINSURANCE

- Catastrophe treaties
  - Only occurrence limit
  - Include reinstatements
- Corporate catastrophe treaties
  - Catastrophe treaties with a lower inuring priority
  - Include reinstatements
- Stop loss treaties
  - Aggregate based trigger
  - Comes last in reinsurance inuring structure

Let's take a closer look at the treaty types mentioned briefly in the earlier slide. Portfolio level reinsurance is implemented through these three treaty types: catastrophe (cat), corporate catastrophe, and stop loss.

The cat treaty is the first true portfolio level treaty to be allocated loss from an event. For cat treaties, the occurrence limit is the only limit used when calculating losses. Cat treaties are independent of line of business. In other words, RiskLink will apply cat treaties to the whole portfolio, regardless of the underlying lines of business. When using RiskLink, cat treaties are assumed to include one reinstatement, although the flexibility is given to increase the number of reinstatements applicable to each cat treaty.

Reinstatements are provisions that put a limit on loss payments based on the number of occurrences or the aggregate losses for the period of the reinsurance contract. For example, an insurer who meets the occurrence loss limit will likely reinstate some or all of the contract limit by paying a reinstatement premium to the reinsurer. Reinstatements come in two forms: free and paid. Free reinstatements imply that the entire premium is included in the payment at the beginning of the treaty period. Paid reinstatements are collected at the time of reinstatement.

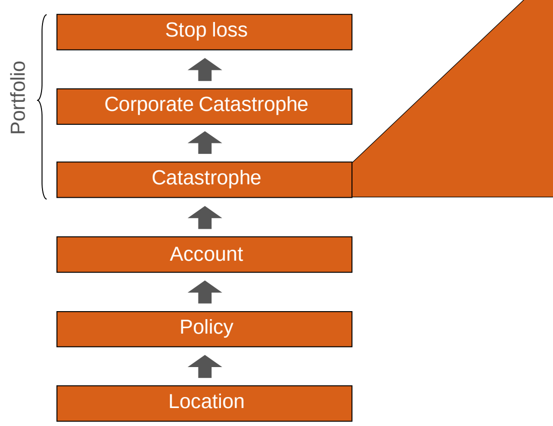
The corporate catastrophe treaty is very similar to a cat treaty in that it applies to the whole portfolio, regardless of the underlying lines of business. However, it only takes effect after the application of cat treaties. In other words, any cat treaty on the analysis inures to the benefit of the corporate cat treaties.

As discussed earlier, the application of cat treaties and corporate cat treaties get us to the post corporate cat financial perspective. Stop loss treaties apply to this financial perspective.

Stop loss is the final layer of reinsurance available and uses aggregate loss as the treaty trigger. Unlike other RiskLink treaties, stop loss is not modeled as an event based treaty. When losses from the net post corporate cat aggregate exceeding probability (AEP) curve losses are larger than the attachment point for the stop loss treaty, the stop loss treaty will take loss. For this reason, there are no event loss tables or EP curves generated for a stop loss treaty. Also, stop loss treaties will not be applied to the reinsurance gross or reinsurance net financial perspectives. A stop loss treaty is modeled on the whole portfolio and all lines of business within that portfolio. There is no distinction made for different cedants in a portfolio.

INURING PRIORITIES - PORTFOLIO REINSURANCE

- Fixed levels



Priority	Treaty
1	Cat 1
2	Cat 2
2	Cat 3
3	Cat 4
3	Cat 5

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Continuing from the per risk inuring priority order discussion, RiskLink also uses multiple priority levels when determining the order of treaty application. Using the same terminology used in our discussion of per risk inuring priorities, we look at multiple levels:

1. Exposure Level. This is a fixed level of inuring priority. Treaties are first applied based on their exposure attachment level. You can recall that location treaties always inure to the benefit of policy treaties and policy treaties always inure to the benefit of account treaties. We can now add that account treaties always inure to the benefit of cat treaties, which then inure to the benefit of the corporate cat treaties, which in turn, inure to the benefit of the stop loss treaties
2. User Defined Priorities. Priority “1” treaties take loss first; subsequent numbers take subsequent losses. A cession or treaty with an inuring priority of “1” inures to the benefit of a cession or treaty with next inuring priority greater than “1”. Stop Loss treaties can not have a user-defined priority assigned to it in RiskLink.

AGGREGATION LEVELS AND REINSURANCE STRUCTURES

Reinsurance Type

Aggregation Levels

	Per Risk Specific	Per Risk Non-Specific	Cat Treaties	Corporate Cat Treaties	Stop Loss Treaties
Group	N	N	Y	Y	Y
Portfolio	N	N	Y	Y	Y
Account	N	Y	N	N	N
Policy	Y	Y	N	N	N
Policy Coverage	N	N	N	N	N
Location	Y	Y	N	N	N
Location Coverage	N	N	N	N	N

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This chart shows the aggregation levels for each reinsurance type available. This does not mean that location reinsurance is available exclusively for location analyses, etc., but rather that these treaty types can be defined at the specified levels. For example, location reinsurance can be attached to a portfolio analysis. When the portfolio analysis is run, the location reinsurance will apply at the location level and these reinsurance results will be aggregated up to the portfolio level.

REINSURANCE: RISKLINK REINSURANCE GROSS (RG) AND REINSURANCE NET (RN) FINANCIAL PERSPECTIVES

- Each treaty has two % fields called “% share” and “% retention”
- These two fields will not affect the loss taken by the treaty
- RG Loss
  – ∑ Treaty Loss * % Share
- RN Loss
  – ∑ Treaty Loss * % Share * % Retention

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The reinsurance gross and reinsurance net financial perspectives are the last two pieces of the reinsurance model. Each of these perspectives summarize the overall reinsurance loss for an analysis. All reinsurance except fac cessions and stop loss treaties are included in this summary.

To understand the usefulness of this financial perspective, it is important to define two fields used in RiskLink: percent share and percent retention. <u>Percent share</u> defines the percentage of the placed treaty coverage that is assigned to the reinsurer modeling the portfolio. <u>Percent retention</u> defines the percentage of the reinsurer's share of the treaty losses not covered by retrocessional treaties (we will not be discussing the application of retrocessional treaties in this course).

Reinsurance gross (RG) loss is <u>not</u> simply the sum of all the reinsurance losses. As noted above, RG loss is the sum of treaty loss multiplied by its share percentage for all treaties that are attached to the analysis. Reinsurance net (RN) loss refines the summary of reinsurance one step further by including retention in the roll-up of each treaty’s loss. It is calculated as the sum of treaty loss multiplied by its share percentage multiplied by its retention percentage for all treaties that are attached to the analysis.

When looking at reinsurance results in RiskLink, it is important to remember that the reinsurance gross and reinsurance net loss perspectives are summarized over all treaties and include the share and retention amounts in the calculations. There is no individual treaty reinsurance loss result within the RiskLink results screen that takes share and retention levels into account, unless your analysis includes only one treaty.

UNITS 1-3 SUMMARY

- Financial model
  - Aggregates losses and standard deviations
  - Fits a probability distribution to model the individual GU losses
  - Applies insurance and reinsurance structures
- Primary insurance structures
  - Limits and deductibles can be coded at multiple levels at the same time, but only one limit and one deductible is used.
  - Limits and deductibles are chosen in a way such that the insurer benefit is maximized
  - Choosing policy limits is different
- Reinsurance structures
  - Per risk reinsurance
    - Applies at location, policy, and account levels
    - Can be risk specific or risk non-specific
  - Portfolio reinsurance
    - Applies at portfolio and group level
    - Comes last in inuring scale

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Please review these summary points for Units 1 – 3. If any of these points are unclear, we encourage you to go back to that unit to review the details before proceeding with this course.

EXERCISE 2

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Complete Exercise 2 and review the associated answers before continuing.

AGENDA

- Unit 1: Financial Model Definitions and Basic Concepts
- Unit 2: Primary Insurance Structures
- Unit 3: Reinsurance Structures
- **Unit 4: Expected and Distributed Modes**
- Unit 5: Aggregate Data
- Unit 6: Exceedance Probability (EP) Curves
- Unit 7: Year Loss Tables (YLTs) and EPs

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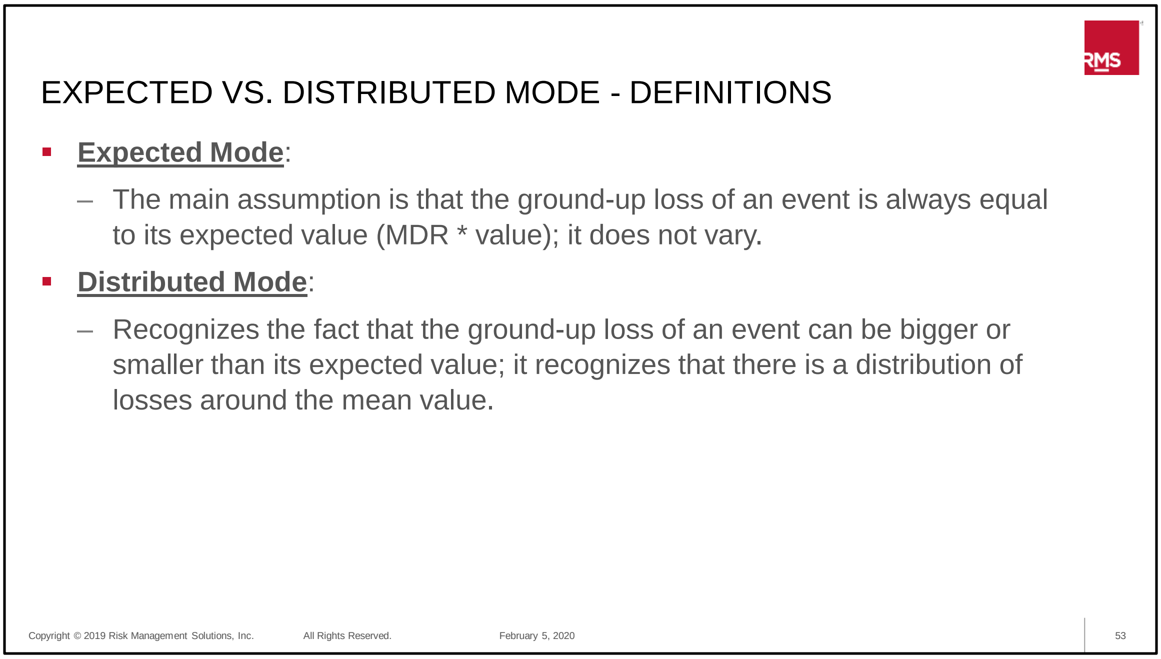
Moving on to unit 4, we will now discuss the two analysis mode options as well as the role of the beta distribution in the financial model output.

UNIT 4 – LEARNING OBJECTIVES

- Expected and Distributed Modes
  - Define expected and distributed mode
  - Explain appropriate applications for each
  - Discuss the benefits of using a beta distribution over other distributions
  - List the components of an ELT
  - Define, calculate, and apply the CV
  - Define and apply the MDR

At the end of this unit you should have a concrete understanding of each of the six learning objectives listed on this slide.

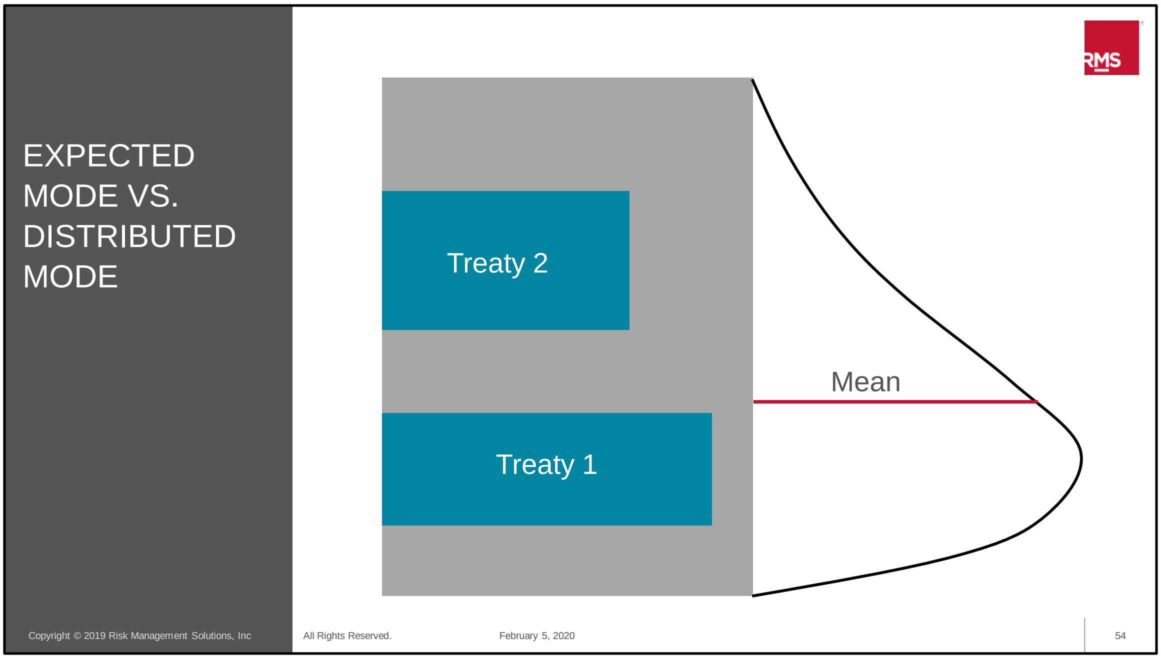


RiskLink allows you to choose between two analysis modes: expected and distributed.

The fundamentals of distributed loss are based upon the understanding that all analysis results produced from RiskLink have some uncertainty. Due to the inability to model the performance of physical structures perfectly when exposed to the various perils, we attempt to quantify to what degree the answers produced in the model may vary from the mean or “expected” value. This variation, expressed as standard deviation in the model, reflects the relative degree of uncertainty in the results.

When we express the answers from the model in terms of expected loss, we are choosing the point that corresponds to the mean of our uncertainty distribution. By expressing our answers in terms of expected loss, we do not account for the shape of our loss density distribution, which quantifies the probability of the loss being anything other than at the expected. Due to this inability to account for the full range of potential losses in expected mode, this mode should only be used in test scenarios, such as making sure that your layered treaties are taking loss as you would expect them to.

Distributed mode should be used in all analyses where the results will be used to make business decisions.



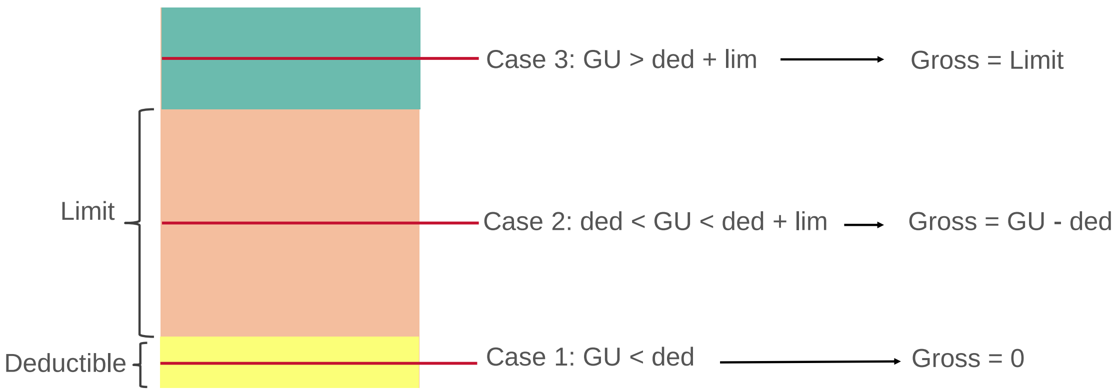
This graphic shows the difference between expected mode and distributed mode. The blue horizontal line on the right represents the mean loss of an event. In expected mode, the mean loss would be the only possible loss from this event. In this example, there would be a 100% loss to treaty 1 and zero loss to treaty 2.

The black line on the right represents a probability distribution of potential event losses based on modeled uncertainty measures (e.g. damage coefficient of variation or standard deviation). In statistical terms, this black line represents a loss probability density function. For the purposes of this course, we will simply call it a loss density curve (or function). There are many types of probability distributions, however, the one used for this purpose in RMS catastrophe models is called a beta distribution. We will provide more details on the beta distribution in a few slides.

In distributed mode, all potential losses along the black line and their associated probability would be considered. Thus, there would be less than a 100% loss to treaty 1, since there is a positive probability that the event loss is less than the treaty limit. There would be a potential loss associated with treaty 2, since there is a positive probability that the event loss is greater than the treaty attachment point.

Following are more detailed examples of the terms and concepts introduced on this slide.

LOSS CALCULATIONS – GROSS FINANCIAL PERSPECTIVE UNDER EXPECTED MODE



- **Expected Mode:** Absolute certainty that only one of the three cases above will occur, the other two will not.

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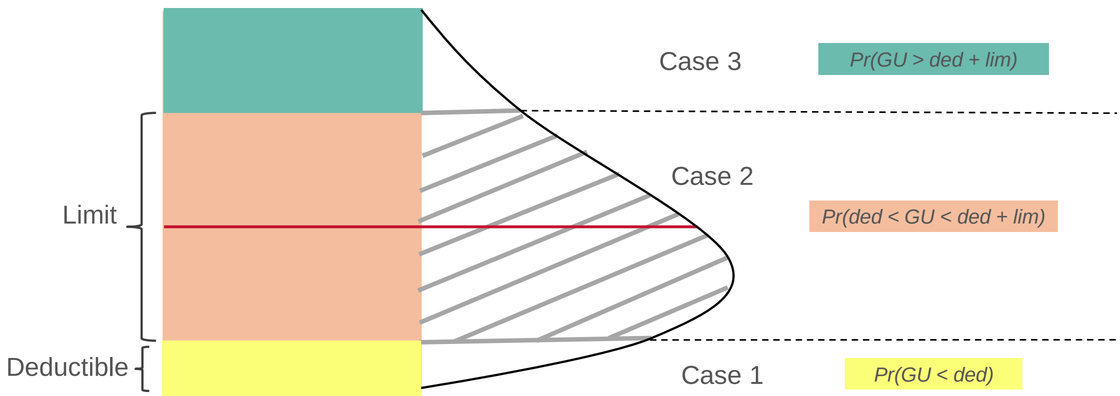
We start with the expected mode calculation of gross event losses for a simple policy. Three cases of modeled loss are shown on the diagram: 1) loss is less than the deductible, 2) loss is greater than the deductible, but less than the policy limit and deductible, and 3) loss is greater than the policy limit and deductible. Shown to the right of the diagram are the formulaic descriptions of the policy gross loss calculations for each case. Remember, policy gross event loss is the loss net of deductibles and policy limits. In case 1, the event loss does not penetrate the policy, thus gross loss is zero. In case 2 the policy gross event loss is the ground-up loss minus the deductible, and in case 3 the event gross loss is equal to the limits given that the loss exceeds the policy limit and deductible.

LOSS CALCULATIONS – GROSS FINANCIAL PERSPECTIVE UNDER DISTRIBUTED MODE



- **Distributed Mode:** Recognizes the fact that all three cases have a positive probability of occurring.

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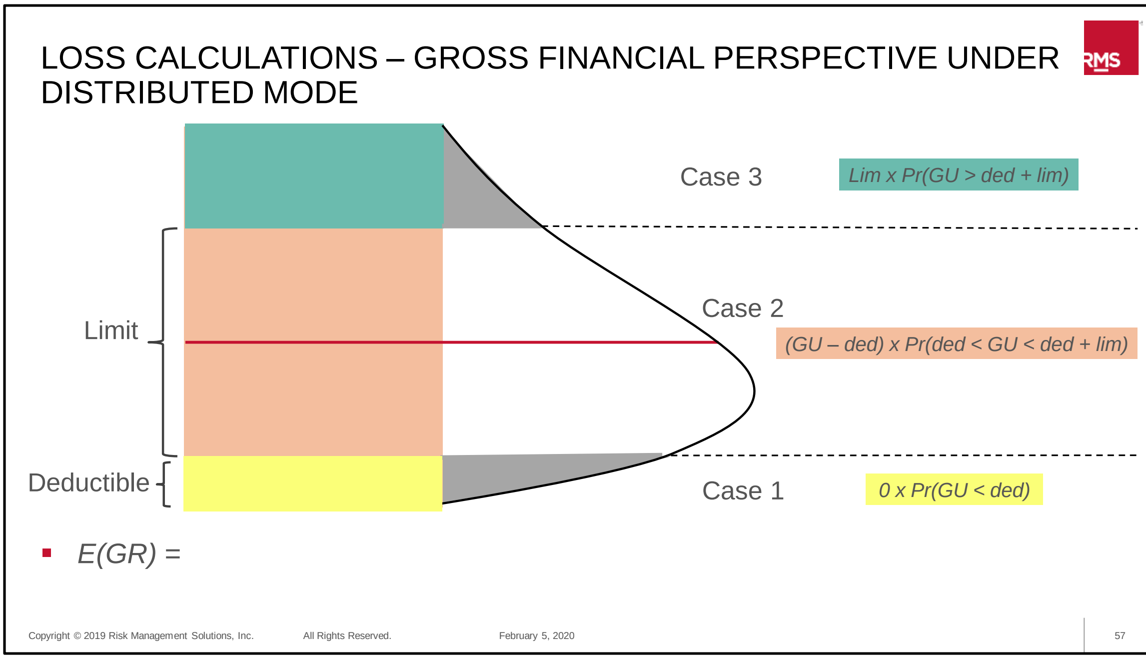
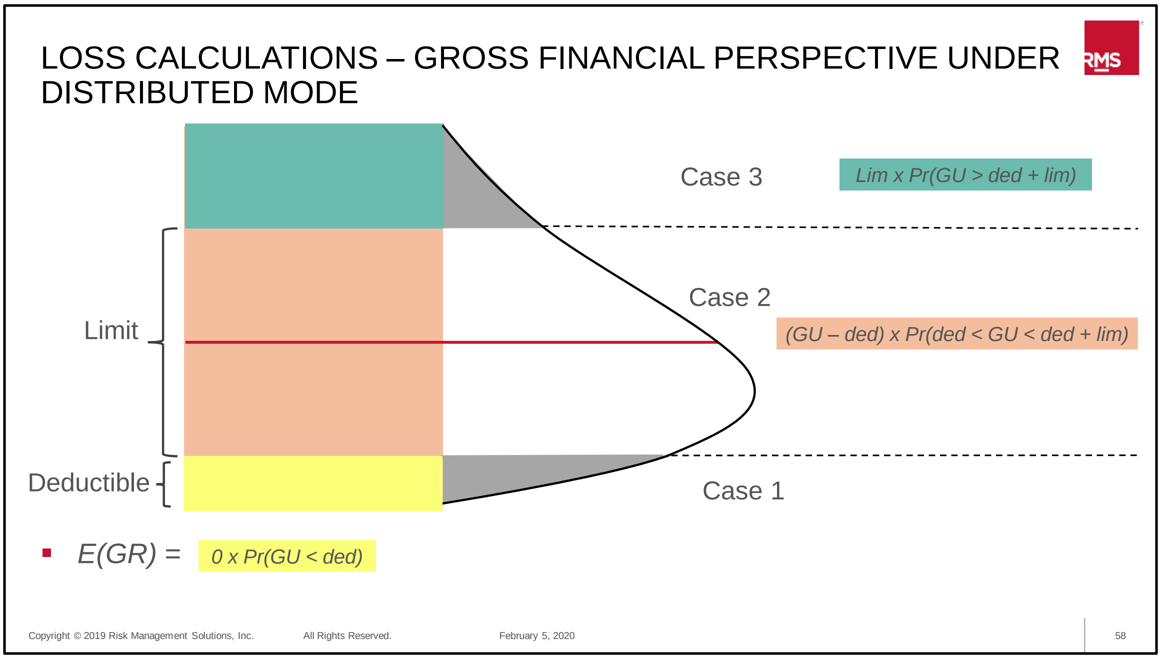
The start of calculating the distributed process is to overlay one or more financial structures onto the single event loss density curve. The loss density curve is used to derive the average loss and the standard deviation (or the measure of the variability around the mean). A cross section of the loss density curve can be matched up with each of the financial perspectives shown here. The formulas on the slide denote the probability (corresponding to the area under the loss density curve) that the mean ground-up loss is less than the deductible (case 1); greater than the deductible but less than the deductible plus policy limit (case 2); or greater than the deductible plus policy limit (case 3).



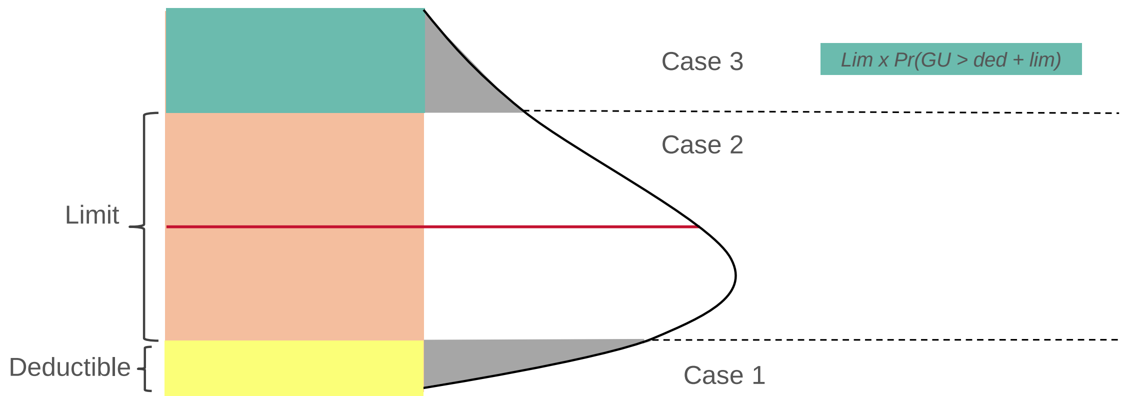
To illustrate the derivation of average loss and standard deviation noted in the previous slide , we will isolate a single financial perspective (gross) and go step by step through the appropriate calculations. This illustration will occur over the next several slides.

We will derive the expected loss, which will be denoted by *E(GR).*



The first step in the expected loss derivation is to examine the probability of the event loss being less than the deductible and applying a loss of 0 against that probability, noted by the formula in the green box.

LOSS CALCULATIONS – GROSS FINANCIAL PERSPECTIVE UNDER DISTRIBUTED MODE



- *E(GR) =* *0 x Pr(GU < ded)* + *(GU – ded) x Pr(ded < GU < ded + lim)*

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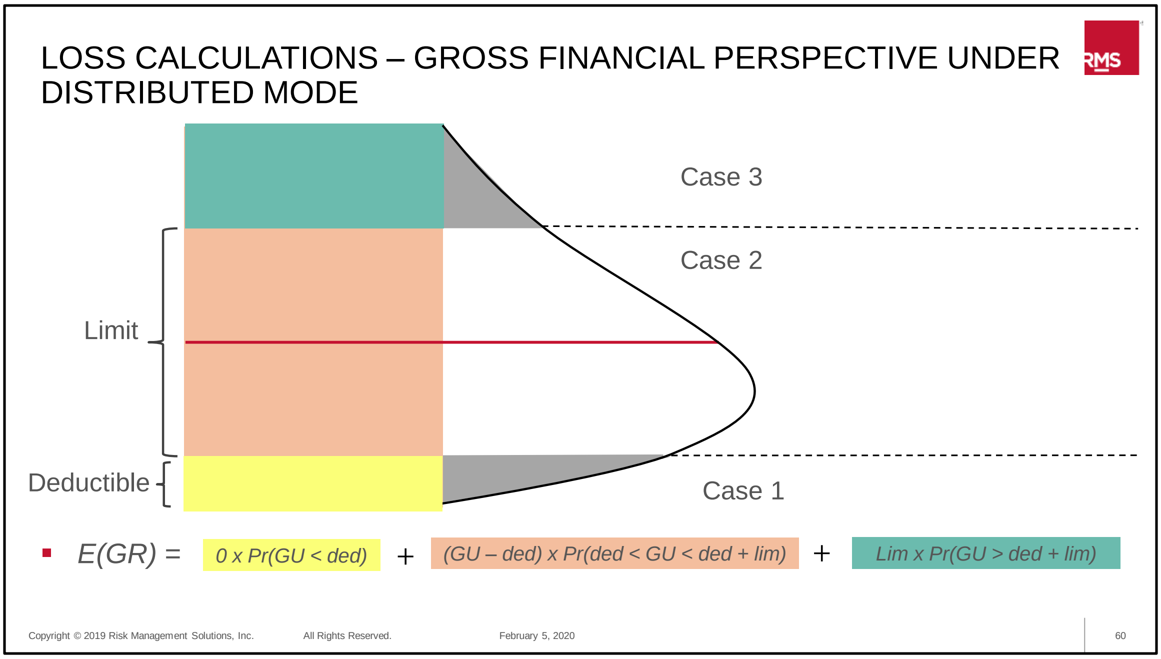
The next step is to examine the probability of the event loss being between the deductible and policy limit and apply the ground-up loss net of the deductible against that probability, noted by the formula in the yellow box.



Now we examine the probability of the event loss being greater than the deductible plus the limit and apply the ground-up loss net of the deductible and limit against that probability, noted by the formula in the blue box.

Finally, we add the three cases together to get the gross loss in distributed mode.

LOSS CALCULATIONS – GROSS FINANCIAL PERSPECTIVE UNDER DISTRIBUTED MODE

$$E(GR) = 0 \text{ x } Pr(GU < ded) + (GU - ded) \text{ x } Pr(ded < GU < ded + lim) + Lim \text{ x } Pr(GU > ded + lim)$$

$$E(GR) = 0 \times \int_0^{ded} f(x)dx + \int_{ded}^{ded+\lim} (x - ded) f(x)dx + \lim \times \int_{\lim+ded}^{\infty} f(x)dx$$

$$E(GR) = \int_{ded}^{ded+\lim} (x\text{-}ded) f(x)dx + \lim \times \int_{\lim+ded}^{\infty} f(x)dx$$

$$E(GR^2) = \int_{ded}^{ded+\lim} (x\text{-}ded)^2 f(x)dx + \lim^2 \times \int_{\lim+ded}^{\infty} f(x)dx$$

$$\sigma = \sqrt{E(GR^2) - E(GR)^2}$$

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You may recall that the mean for a formula is sometimes referred to as the first moment. To calculate the standard deviation, you need to use the first moment and the second moment. So, to use this method of moments, we have to restate the formula for *E(GR)* (expected gross loss) as integrals. This restated formula is noted in this slide, as is the formula for the second moment, as denoted by *E(GR²)*.

Now that we have the formulas for both of the moments, we can calculate the standard deviation, noted by sigma (σ).

EXPECTED VS DISTRIBUTED RESULTS

Ground-Up Loss = 60

Deductible = 10

Limit = 100

Financial Perspective	Expected Mode	Distributed Mode
Ground-Up	60	60
Client	10	6.86
Gross	50	31.39
Over Limit	0	21.75

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We have seen the difference between expected mode and distributed mode through graphs and calculations. Now, we will look at some numbers. Assume a ground-up loss of $60 applies to a policy with a $10 deductible and a $100 limit.

Expected mode calculations are straight forward. The ground-up loss is greater than the deductible ($60 > $10), so the entire deductible will be filled. A client loss of $10 is shown in the table. There are $50 dollars of loss left, which is less than the $100 limit, so the policy limit covers the entire amount. This is shown by the $50 gross loss and the $0 over limit loss.

Of course, there is uncertainty in that $60 loss estimate. That loss could create $120 worth of loss due to poor construction, or it could create $5 of loss if the ground shaking is less than expected at that particular geographic location. The distributed methodology considers this uncertainty and could yield a distribution of loss as shown in the final column of the table. There is a chance that the loss is less than the deductible – shown by a loss amount of $6.86, which is less than the $10 stated deductible. In addition, it is possible that the loss is greater than the limit + deductible, as shown by an over limit loss amount of $21.75.

Note that the ground-up losses for both modes are the same, since uncertainty is not reflected in the ground-up loss, but only in perspectives above the ground-up perspective. Also note that the sum of the various loss perspectives for both the expected mode and distributed mode both equal the original ground-up loss
(10 + 50 = 6.86 + 31.39 + 21.75 = 60).

BETA DISTRIBUTION

- Use to describe the distribution of losses for a particular event.
- Chosen because:
  - It is a finite distribution with domain from 0 to 1.
    - This is important as our damage ratios range between 0 and 1.
  - Can describe a wide variety of curves, and is often used to mimic other continuous distributions

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Before we can continue with our understanding of the distributed mode, it is important to spend some time on the beta probability density function (or curve). The beta density curve is a name given to a family of curves with similar properties.

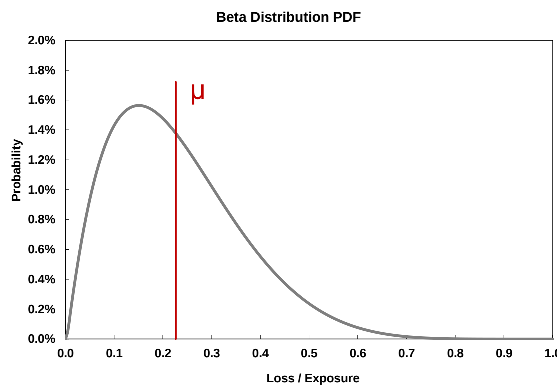
One of the important properties of beta curves is that they have a domain from 0 to 1. This is important because our damage ratios – the amount of damage stated as a percentage of replacement cost value – can only range from 0% to 100%, or from 0 to 1. If we chose another, infinite distribution, we could end up with losses in excess of the replacement cost values, which is clearly impossible. In addition, the beta density curve is very flexible and allows us to mimic a wide variety of loss curves.

BETA DISTRIBUTION

Event ID	Rate	Loss	St.Dev	Exposure	Mean (μ)	CV	α	β
1	0.000091212	36,250	21,207	160,000	0.226564	0.585026	2.03	6.94

$$\mu = \frac{Loss}{Exposure} \qquad CV = \frac{St.Dev.}{Loss}$$

$$\alpha = \frac{(1-\mu)}{CV^2} - \mu \qquad \beta = \frac{\alpha(1-\mu)}{\mu}$$



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The output of each exceedance probability analysis in distributed mode is an event loss table (ELT) with the necessary information to examine the loss density distribution as a beta curve. We can do this by understanding the data elements in the ELT and the data elements necessary to calculate the parameters of a beta curve.

The output includes the event ID, event rate, mean loss, standard deviation around the mean loss, and the exposure at risk. The table in this slide shows this information for event ID 1 in light blue. From these fields we can calculate the mean damage ratio (MDR) by dividing the mean loss by the exposure at risk. The MDR is sometimes called ‘the mean’ and therefore denoted by the Greek Letter, mu (μ). We can also calculate the coefficient of variation (CV) by dividing the standard deviation by the mean loss. The mean and CV for event 1 are noted in the yellow boxes.

The two parameters that characterize a beta distribution, and define its shape, are noted by the Greek letters alpha (α) and beta (β). To calculate α, we need to use the mean and CV we calculated in the previous step (yellow boxes). The formula for α is noted in the box under the green header on the left side of this slide and the calculated value is shown in one of the green cells in the information for event 1. To calculate β, we need to know the mean (μ) – see the yellow box - and α (green box). The formula for β is noted in the box under the green header on the left side of this slide and the calculated value is shown in one of the green cells in the information for event 1.

Once these two parameters are calculated, you can graph the beta distribution or get a tabular view of the distribution using various statistical tools, such as Microsoft Excel. We will work through explicit examples of different beta distributions in the upcoming exercise.

AGENDA

- Unit 1: Financial Model Definitions and Basic Concepts
- Unit 2: Primary Insurance Structures
- Unit 3: Reinsurance Structures
- Unit 4: Expected and Distributed Modes
- **Unit 5: Aggregate Data**
- Unit 6: Exceedance Probability (EP) Curves
- Unit 7: Year Loss Tables (YLTs) and EPs

In unit 5 we will discuss aggregate data and how it is handled within the RiskLink model.

UNIT 5 – LEARNING OBJECTIVES

- Aggregate Data
  - Provide two common situations where aggregate data is coded as one location.
  - Explain what happens to the standard deviation when data is aggregated and why.
  - Demonstrate where to code insurance structures to most accurately reflect the diversification benefit given a specific scenario.

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At the end of this unit you should have a concrete understanding of each of the three learning objectives listed on this slide.

AGGREGATE DATA – LOCATIONS WITH MULTIPLE BUILDINGS

- Locations are coded as containing more than one building for insured risks that:
  - Cover a complex of building (e.g. shopping mall or college campus)
  - Are aggregated to a region (e.g. postal code or county)
- Using aggregate data is only as good as the homogeneity of the data the aggregate location is representing.
- Coding more than one building in a location will reduce the location level standard deviations.
  - Law of large numbers
  - Increasing the number of buildings at a location increases the diversification and reduces the standard deviation (risk) at the location.

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Sometimes we may need to look at a situation where you have aggregate exposure data at one location.

Aggregate data in RiskLink is defined as a single location representing two or more risks. The following are two common situations where aggregate data is coded as one location in RiskLink:

1. The risks are confined to a small geographic region and are homogenous (i.e. construction class, occupancy, year built, and number of stories are the same). The validity of the data is very dependent on the homogeneity of the underlying specific data. For instance, 100 wood frame, single story buildings can be validly aggregated. However, ten wood frame, ten masonry, ten steel low rise, and ten steel high rise buildings lose their validity when aggregated.
2. The data provided to the underwriter or risk manager lacks detailed information such as street address and construction type for a group of risks, such as a college or hospital campus or a shopping mall. As noted above, it is still best to aggregate locations with similar construction characteristics, if possible.

Clearly, there is a significant difference if you have one building valued at $1,000,000 and 100 buildings valued at $10,000 each. How do we model this aggregate situation accurately? The mean loss will be very similar, since the MDR does not vary for aggregate or multiple locations being impacted by the identical hazard. However, there is a diversification benefit to having 100 locations spread throughout a geographic area, say postal code, as opposed to having one location.

As buildings increase within the location there is a diversification of the secondary uncertainty associated with that location. Hence, a standard deviation for an aggregate location will be smaller than one for a location with one building for any given event.

AGGREGATE DATA – SCALING DOWN THE STANDARD DEVIATION

- RiskLink reduces the standard deviation by multiplying it by a scaling factor.
- This factor is determined by the number of buildings and by the correlation weight specific to the peril/region being analyzed.

$$scaling\_factor = \frac{(w \times N) + \left((1-w) \times \sqrt{N}\right)}{N}$$

N = Number of buildings in the location

W = Correlation weight

- If N = 50 and w = 20%, scaling factor = 31%

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To account for this decrease in standard deviation, RiskLink uses a scaling factor. The factor is based on the number of buildings at the location, represented by N, and the peril region correlation weight, represented by *w*. (For a more detailed discussion of the development of the correlation weight, refer to the Uncertainty Measures course.) By definition, *w* is always less than 1.0. Since N is in the denominator of the equation and *w* is less than 1.0, the scaling factor will always by less than 1.0 as well. So, you can see how the standard deviation would always be decreased.

The following will verify this claim. For the following cases, we will assume that the correlation weight being used is for California EQ, where *w* = 0.20.

Case #1: 1 location

Scaling factor = [(0.20 x 1.0) + ((1-0.20) x √(1))] / 1.0 = [0.20 + (0.8 x 1.0)] / 1.0 = 1.0 / 1.0 = 1.0

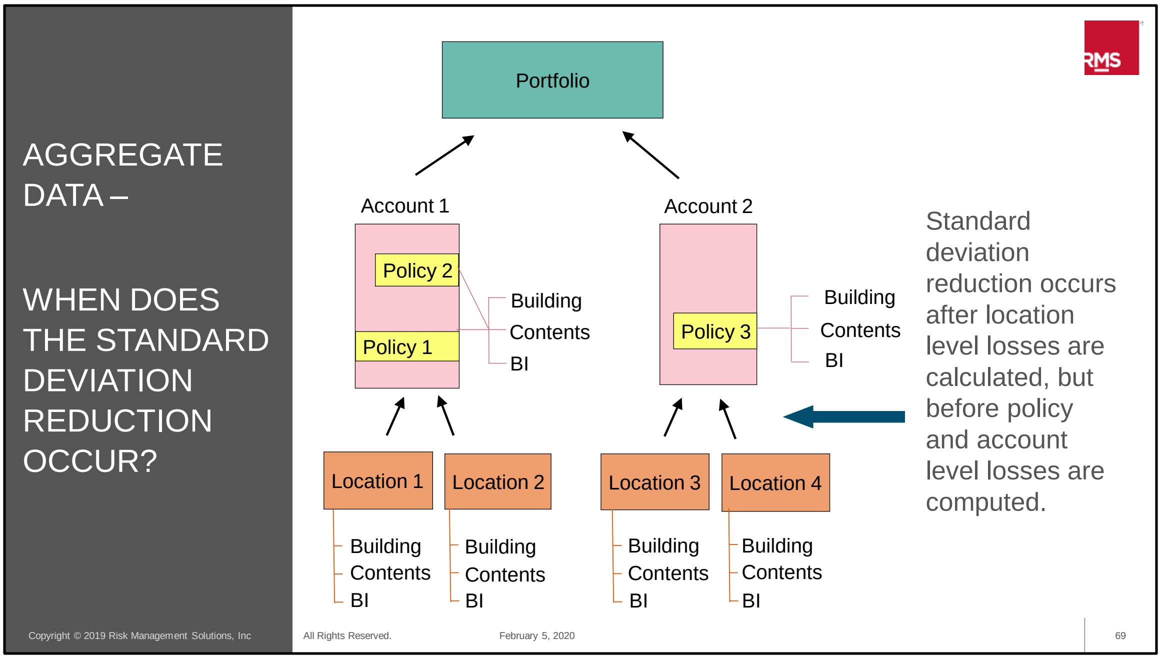
This is the answer that we would expect, since there will be no adjustment to the standard deviation for one location.

Case #2: 50 locations

Scaling factor = [(0.20 x 50) + ((1-0.20) x √(50))] / 50 = [10 + (0.8 x 7.07)] / 50 = 15.66 / 50 = 0.31

So, the standard deviation would be scaled down by 31%.

In exercise 3, we will see how scaling affects the standard deviation and results.



The variable *w* used in the scaling factor calculation is derived partly from average proximity of locations affected by an event, which will be discussed further in the Uncertainty Measures course. Also, as noted earlier in this course, the MDR does not vary for aggregate or multiple locations being impacted by the identical hazard. So, it is logical to apply the diversification benefit of locations with multiple buildings, and the corresponding reduction in standard deviation, after the MDR has been applied to the locations and the mean losses are calculated.

So, all losses to the policy, account, and portfolio will recognize the impact of multiple buildings on the locations.

Therefore, it is important to note that you will not see the adjusted standard deviation in location coverage loss or location losses in the ELT. You will only see the adjusted standard deviation in policy, account, and portfolio ELTs and statistics.

AGGREGATE DATA – WHERE TO CODE INSURANCE STRUCTURE

- If the insurance structures actually covers a complex of buildings, the limits and deductibles should be coded at the policy level.
  - Gross loss calculation will occur after the standard deviation is reduced.
- If there is an insurance structure per building (postal code resolution, for example), the limits and deductibles should be coded at the site level
  - Gross loss calculation will occur before the standard deviation is reduced.

When entering aggregate data, it is important to know where to code various insurance structures in order to accurately assess the impact of diversification. There are two situations to consider:

1. Aggregate data where all buildings on the location are covered under one insurance policy: This is the situation where there are a number of separate buildings on a similar geographic space and all buildings are held under a single insurance policy. An example of this might be a college campus. Assuming the buildings are on similar ground and are of similar construction, the group of buildings can be assumed to be geocoded at one place with one set of construction, occupancy, and modifier values. In this situation, apply limits and deductibles after the correlation adjustment is made to the ground-up loss distribution. In other words, apply the limits and deductibles at the policy or policy coverage level. The correlation adjustment represents a diversification benefit and the aggregate location represents a stock portfolio. A risk benefit is gained for having multiple buildings on a site rather than a single large building.
2. Aggregate data where each building has its own insurance limits and deductibles: In this situation, the aggregate data being entered is based on a geographic region (like postal code, county, etc.) and the buildings on the location fit into this geographic region. An example of this case would be residential single-family dwellings by county in the state of California. Here, the location would be geocoded at the county level,

using average soils, etc. that are representative of each county. The important feature of this type of aggregate data is that each building is its own insurance entity from a primary carrier's point of view. Each building has a limit and a deductible that apply if an event occurs. To account for this, apply all limits and deductibles to the location or location coverage level.

EXERCISE 3

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Complete Exercise 3 and review the associated answers before continuing.

AGENDA

- Unit 1: Financial Model Definitions and Basic Concepts
- Unit 2: Primary Insurance Structures
- Unit 3: Reinsurance Structures
- Unit 4: Expected and Distributed Modes
- Unit 5: Aggregate Data
- **Unit 6: Exceedance Probability (EP) Curves**
- Unit 7: Year Loss Tables (YLTs) and EPs

The various EP curves in RiskLink are detailed in unit 6.

UNIT 6– LEARNING OBJECTIVES

- Exceedance Probability (EP) Curves
  - Define the two types of EP curves available in RiskLink.
  - Identify the inputs into the EP engine.
  - Explain how event frequency can affect an EP curve.
  - Define return period loss.
  - Define the relationship between a return period and a probability of exceedance.

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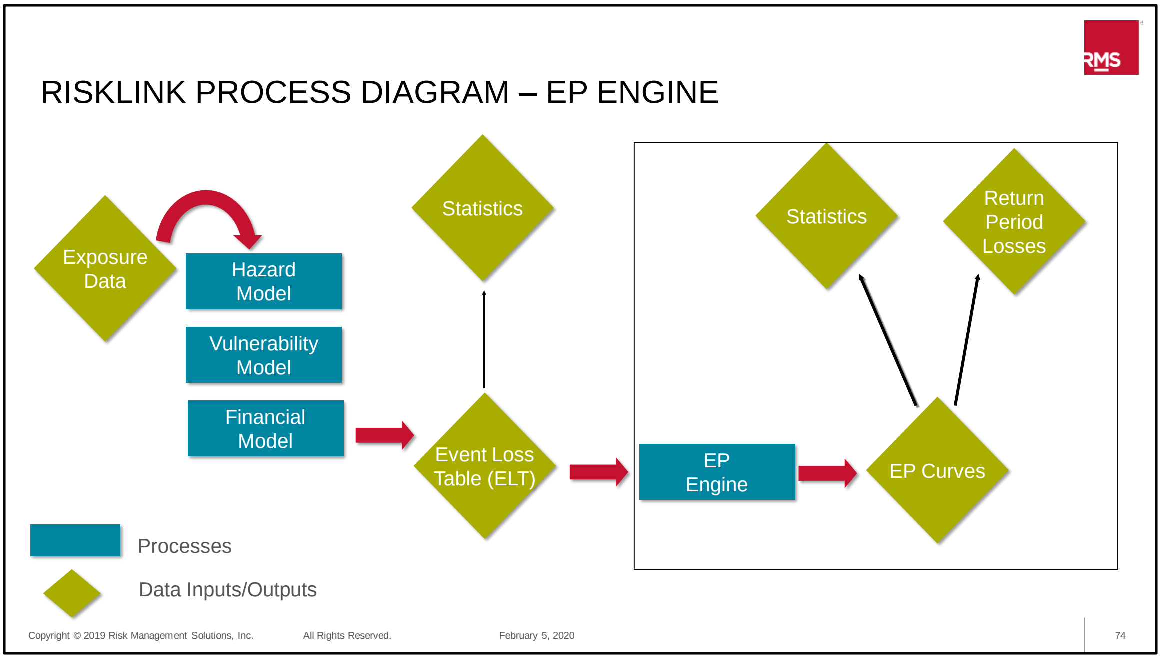
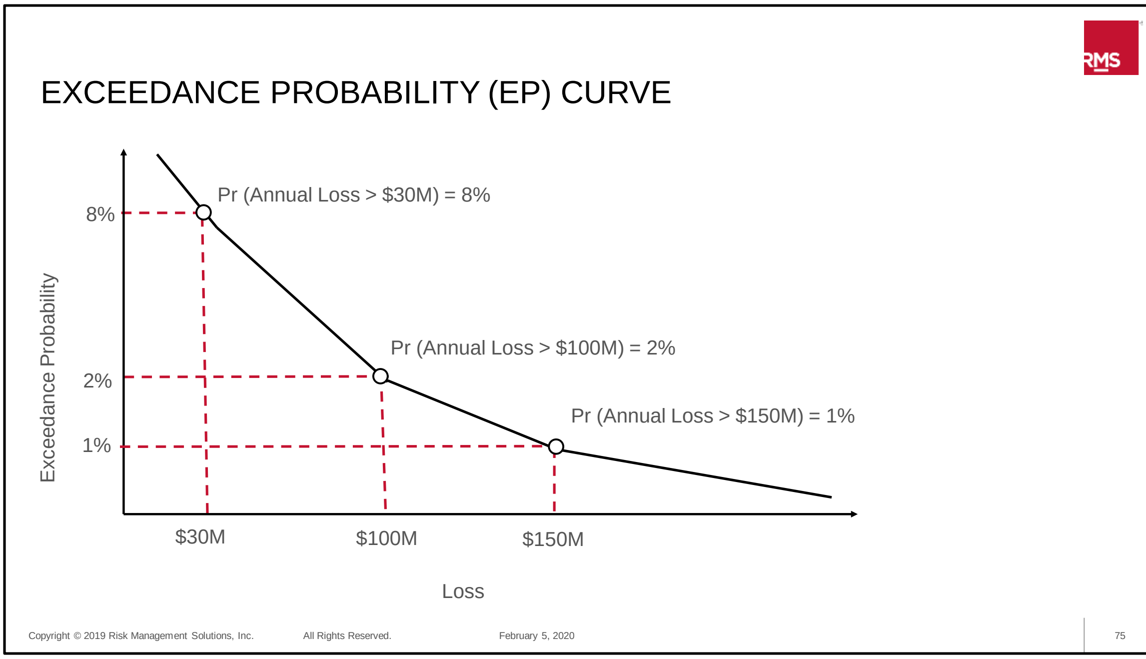
At the end of this unit you should have a concrete understanding of each of the five learning objectives listed on this slide.



Now that we have created our ELT for all loss perspectives using the techniques discussed earlier, we can see how the EP engine uses that information to create EP curves, return period losses, and other statistics.

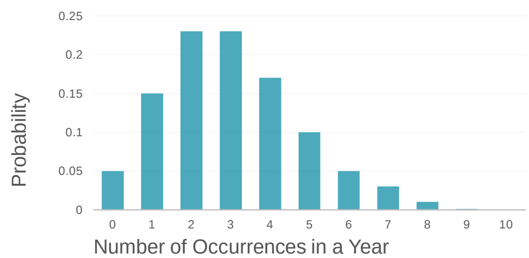


The EP engine creates exceedance probability, or EP, curves. EP curves are cumulative distributions showing the probability that losses will exceed a certain amount, from either single or multiple occurrences. These losses are expressed in the occurrence exceedance probability (OEP) and the aggregate exceedance probability (AEP) curves.

AEP and OEP curves are two different curves that have two distinct uses and offer different information. Both curves show the probability that losses will exceed a given threshold. What these losses represent is the key to understanding the difference between the AEP curve and the OEP curve. Before we delve into the differences between these two curves, we need to understand the frequency and severity inputs into the EP engine.

INPUTS TO THE EP ENGINE – FREQUENCY DISTRIBUTION

- Frequency distribution
  - The distribution of the number of event occurrences in a year.
  - Assumed to be a Poisson distribution.
  - The parameter λ of the Poisson distribution is the sum of the annual rates for all events in the ELT.



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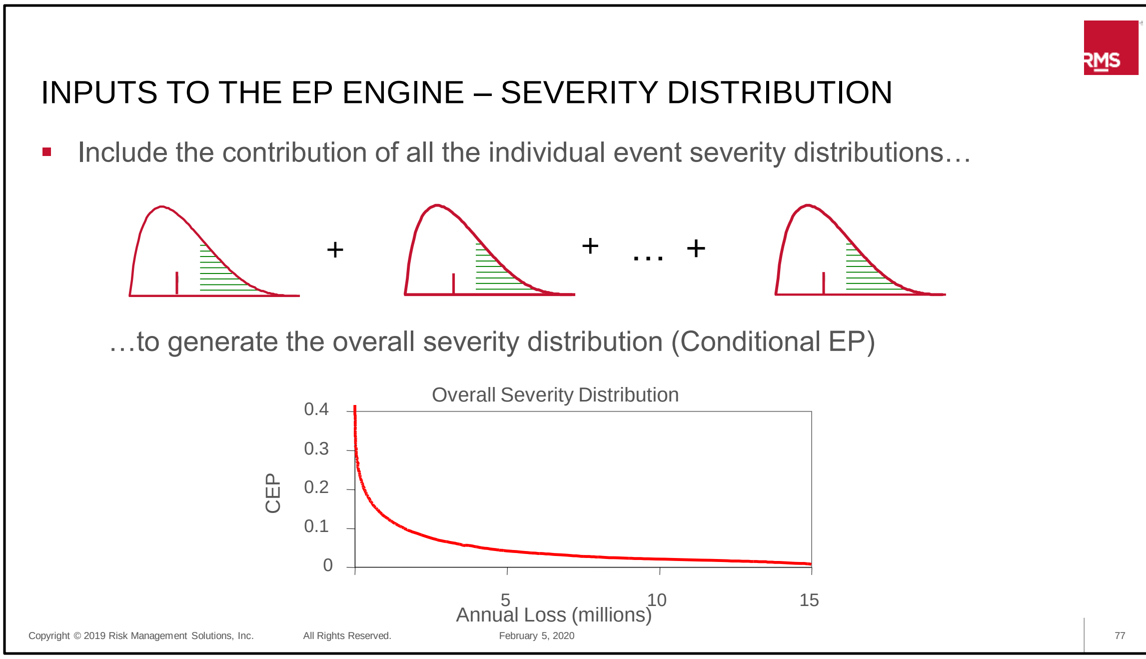
The first input needed by the EP engine within the financial model is the frequency distribution, which is the distribution of the number of event occurrences in a year. We currently work under the assumption that the occurrence of one event is independent of the occurrence of another event. So, a hurricane making landfall in July has no impact on the chance of another hurricane making landfall in September.

A Poisson distribution measures the probability of having a certain number of events in a year (say, four) given an annual average number of events (say, three). The graph above shows the Poisson distribution for an average, or mean, of three. Given that mean, the probability of four events is approximately 16%.

The parameter that describes a Poisson distribution is represented by the Greek letter lambda (λ). The parameter λ is calculated as the sum of the annual rates for all events in the event loss table (ELT) that may affect a given exposure.



The second input for the EP engine is the severity distribution, that is the distribution of the size of losses, given that an event has occurred. The severity distribution is modeled as a discrete distribution. First, the maximum loss is determined; then 16,384 equally spaced points are generated between 0 and this maximum loss. Both the determination of the maximum loss and the generation of the 16,384 loss points are based on the information in the event loss table.

For each loss point, we calculate the conditional probability that losses from an occurrence equal or exceed that amount. This calculation takes into account the secondary uncertainty, defined as the uncertainty in the size of loss given that a specific event has occurred. This secondary uncertainty is reflected by the spread (standard deviation) of the loss around its mean as previously discussed.

Why 16,384 points? The more points, the better the accuracy. However, too many loss points become cumbersome to calculate and use. Since the Fast Fourier Transform (FFT) algorithm requires that the number of points be a power of two, we concluded that the optimal choice was a severity distribution consisting of 2 to the 14th power, or 16,384 points.

The FFT is the algorithm that performs the convolutions of the severity distribution; for the AEP curve computation the severity distribution needs to be convolved to take into account the possibility of multiple events in a year.

EXCEEDANCE PROBABILITY DEFINITIONS - OEP

- **Occurrence Exceedance Probability (OEP)**
  - Probability that the single largest event loss in a year will exceed a loss threshold.
  - Used to estimate probabilities for occurrence-based structures.
    - Probability of activating or exhausting a policy.
    - Probability of activating a reinsurance treaty.
    - Probability of exhausting a reinsurance occurrence limit.

An occurrence exceedance probability (OEP) is the probability that at least one event will occur that causes losses above a certain amount. The OEP curve is able to show the full range of probabilities and their associated loss amounts graphically. Since the OEP curve works with individual occurrences in a year, each point on the OEP curve shows a loss amount and the annual probability that the losses for at least one occurrence will exceed that amount.

Since the OEP curve is the cumulative distribution for the largest occurrence in a year, it can be used to analyze occurrence-based situations. For example, we can calculate the probability of activating and exhausting occurrence-based contracts such as a policy or reinsurance treaty from OEP curves. In addition, the OEP curve can provide statistical information on single event covers.

EXCEEDANCE PROBABILITY DEFINITIONS - AEP

- **Aggregate Exceedance Probability (AEP)**
  – Probability that the aggregate event losses in a year will exceed a loss threshold.
  – Considers the probability of having multiple occurrences in one year.
  – Used to estimate probabilities of aggregate-based structures
    - Stop loss treaties
    - Reinstatements
    - Capital adequacy

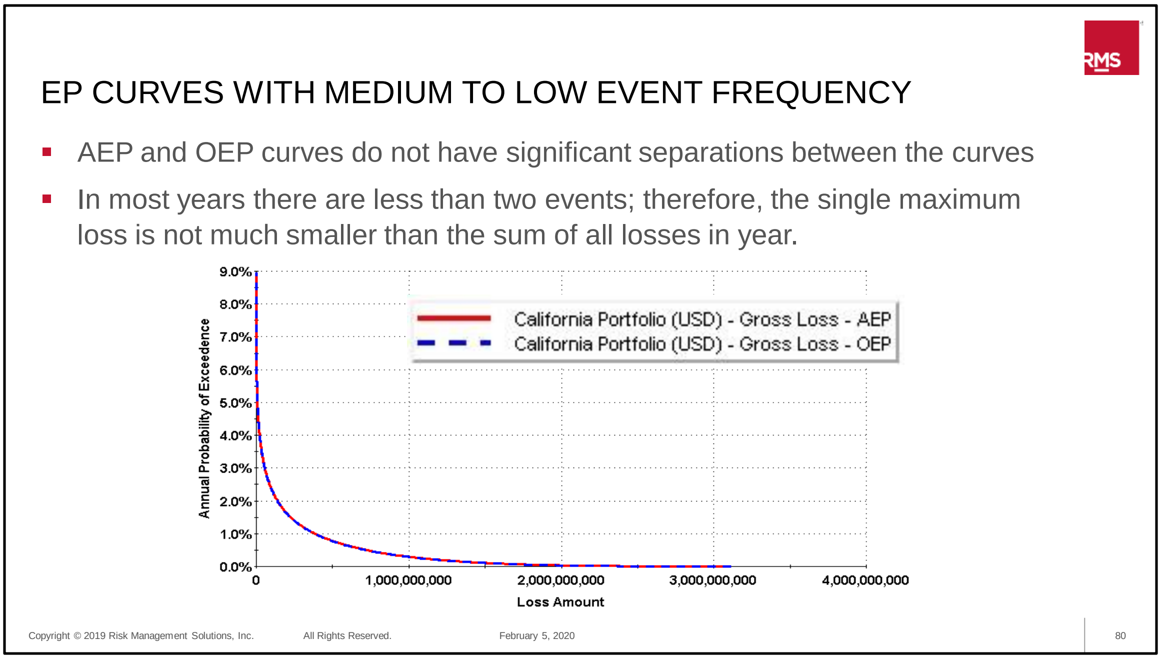
Unlike the OEP curve, which is calculated on an occurrence basis, the AEP curve is calculated on an aggregate basis, showing the probability that aggregate losses in a year (i.e. the sum of the losses from all occurrences in a year) will be greater than a given loss threshold. Since the AEP considers the possibility of multiple events, the AEP loss for a given threshold probability will always be greater than or equal to the OEP loss. Similar to the OEP curve, the AEP curve shows the full range of probabilities and their associated loss amounts graphically for aggregate losses.

Since the AEP curve expands our risk quantification capabilities to include aggregate loss analyses, we can now examine loss transfer mechanisms based on aggregate event losses. For example, reinstatement limits in catastrophe treaties work like aggregate limits instead of occurrence limits. An AEP curve for the individual catastrophe treaty allows us to properly quantify the pure premium (also known as average annual loss) and standard deviation for a catastrophe treaty with a reinstatement provision. The AEP curve also allows us to provide statistical information on aggregate stop loss treaties. Furthermore, the area under the AEP curve equals the pure premium since the pure premium statistic incorporates all losses incurred during a one year time period.

Another use of the AEP curve applies to analysis of capital or surplus adequacy. One goal of insurance and reinsurance risk management is to ensure surplus adequacy. History has shown us that natural catastrophes are a significant and dangerous threat to surplus. This threat can be in the form of one very large occurrence or multiple smaller occurrences. The

AEP curve can be used to analyze the probability of different levels of total aggregate hits to surplus in a one-year time period.

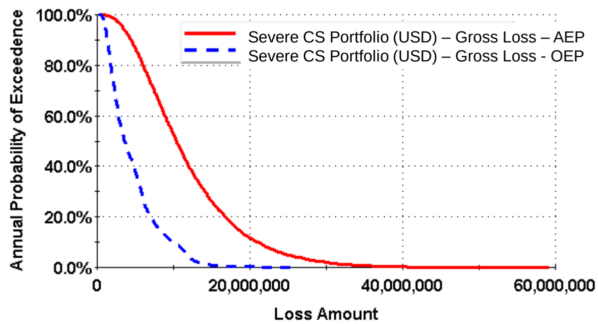
AEP curves can be used to estimate the probability of activating or exhausting various aggregate-based structures such as stop loss treaties or reinstatements.



When the relative frequency of events in a peril is not very large (e.g. earthquake), the AEP curve for a perspective is oftentimes relatively close to the OEP curve for that same perspective. The extension of the tail for the AEP curve shows that there is some possibility for multiple events in a year. But it is not as great as it may be for other perils and/or regions.

EP CURVES WITH HIGH EVENT FREQUENCY

- When the overall event frequency increases, the separation between AEP and OEP increases.
- In a typical year, more than one event occurs; the sum of the losses in a year is significantly greater than the single maximum loss.



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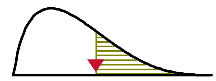
In contrast, this portfolio is located in a region that experiences severe convective storm activity. Damage-causing severe convective storms generally occur with higher frequency than damage-causing earthquakes. This increase in frequency of events is demonstrated in the large separation of the AEP and OEP curves.

This implies that, given the high probability of multiple events in a year, the aggregate loss can be significantly different than the occurrence loss for a given probability of exceedance. The higher frequency also causes the difference in AEP and OEP tails to be larger than the difference in tails from the earthquake peril example on the previous slide.

OEP CALCULATION – NUMERICAL EXAMPLE



Event	Rate	Mean Loss	Std Dev	Exposure	Pr(L_i>75)	Exc. Rate
1	0.02	90	19	990	0.7783	0.0156
2	0.01	100	20	1,000	0.9023	0.0090
3	0.04	80	17	970	0.5925	0.0237
4	0.09	20	12	920	0.0012	0.0001
5	0.03	70	18	980	0.3632	0.0109

Σ Exc. Rate = 0.0593

OEP(75) = $1 - e^{-0.0593}$
= 5.76%

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We will use this numeric example to illustrate more clearly how an OEP is calculated.

The light blue portion on the left of this table shows an event loss table similar to that output in RiskLink. For each event we have the annual rate of occurrence, the mean loss, the standard deviation of the loss, and the amount exposed to the event. The standard deviation is our measure of the secondary uncertainty for the event.

Assume that we want to calculate the probability of an event exceeding $75. For each event, the beta distribution is applied to characterize uncertainty around the mean damage ratio. Thus, the probability that the loss is greater than $75 is calculated from the beta distribution. The first column of the darker blue segment shows this probability for each event. You can duplicate the numbers on this slide using the BETADIST function in MS Excel.

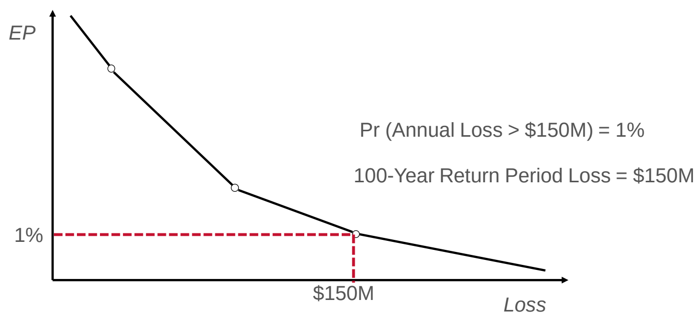
The last column shows the 'exceedance rate' for each event. This is the annual event rate multiplied by the event probability of exceeding a loss of $75 and represents the annual contribution of each event to the total probability of exceeding $75.

Finally, sum of the exceedance rates is shown at the bottom of the two dark blue columns. Since the Poisson distribution is often (but not always) used to characterize the frequency of events, the formula for the Poisson distribution is used to compute the probability of exceeding $75 = 5.76%.

We could then plot the point (5.76%, $75) on the OEP curve. We will get a complete curve by completing a similar methodology for various loss thresholds. In fact, as noted earlier, RiskLink will perform a similar calculation for 16,384 such points.

RETURN PERIOD LOSS - DEFINITION

- A return period is a period of years (e.g. 100 years)
- A return period loss is the loss whose exceedance probability is the reciprocal of a given return period.
- A return period loss corresponds to a point on a loss curve.



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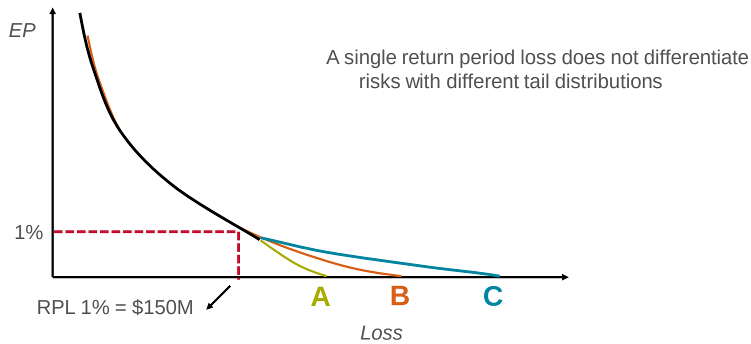
A return period loss is a loss that corresponds to a point on a loss curve (i.e. an OEP or AEP curve). The exceedance probability is the reciprocal of the return period specified as one in X number of years.

In other words, saying “the 100-year AEP return period loss is $150M” is similar to saying “the probability of having multiple occurrences with aggregate losses exceeding $150M in one year is 1%” (where 1% = 1/100).

Since the loss curve includes secondary uncertainty, the return period loss includes uncertainty as well.

RETURN PERIOD LOSS - DEFINITION

- A return period is a percentile of the loss distribution
- A return period loss is also known as the Value at Risk (VaR), a familiar statistic to the banking industry



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The return period loss is a percentile of the loss distribution. So another way of stating the example of the previous slide would be to say "the $150 million aggregate loss represents the 99th percentile of the annual loss distribution."

The risk metric, "value at risk" (VaR) used in the banking industry is often used synonymously with return period loss. It is worth mentioning a couple of points to keep in mind when using return period losses. First, it is critical to use the terminology correctly. For example, if we were to say the 100-year loss was $150 million, what does that mean? It is important to include the type of loss curve being used, and if the curve does or does not include secondary uncertainty. What it does NOT mean is that over the next 100 years there is a 100% probability of exceeding $150 million. These loss curves are almost always based on a one year perspective.

Second, as a single point on a loss curve, the return period loss does not differentiate risk in the tail of the distribution. Curves A, B, and C all have the same 100-year return period loss, but the area underneath the curves is very different. The potential severity of losses for curve C are greater than for curve A.

Finally, it is important not to confuse return period losses with individual event return periods. The return period loss is calculated based on contributions to loss from <u>multiple</u> events that could affect an account or portfolio.

UNITS 4-6 SUMMARY

- Expected Mode: Works only with the mean ground-up losses assuming no variability (i.e. standard deviation).
- Distributed Mode: Recognizes that the ground-up loss can be bigger or smaller than its mean value.
- The beta distribution is fit in order to model this uncertainty.
- If a location has multiple buildings, the less-than-perfect correlation between these buildings will lower the ground-up standard deviation.
- EP curves:
  - OEP: Occurrence-based EP curve
  - AEP: Aggregate-based EP curve
  - Return Period Loss: Point on an EP curve that describes the likelihood of exceeding a loss threshold.

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Please review these summary points and key topics that were covered in Units 4 - 6. If any of this information is unclear, we encourage you to go back to that unit to review the details before concluding your study of this course.

AGENDA

- Unit 1: Financial Model Definitions and Basic Concepts
- Unit 2: Primary Insurance Structures
- Unit 3: Reinsurance Structures
- Unit 4: Expected and Distributed Modes
- Unit 5: Aggregate Data
- Unit 6: Exceedance Probability (EP) Curves
- **Unit 7: Year Loss Tables (YLTs) and EPs**

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The final unit will discuss year loss tables and compare them to ELTs.

UNIT 7– LEARNING OBJECTIVES

- Year Loss Tables (YLTs) and EPs
  - Understand what YLTs are and the problems to which they are well-suited
  - Understand the differences in how frequency and severity are represented in a YLT relative to an ELT
  - Calculate AAL, OEP and AEP metrics using YLTs
  - Show the standard sampling error for simulated YLTs

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At the end of this unit you should have a concrete understanding of each of the four learning objectives listed on this slide.

WHAT IS A YLT (AND WHY SHOULD I CARE)?

Year Loss Table (YLT): A set of simulated years with event and sampled losses

- Advantages
  - Can readily incorporate seasonality, clustering, or other non-Poisson event distributions
  - Can explicitly model reinstatements, aggregate deductibles, hours clause, and other multi-event or time-based contract terms
  - EP mathematics are simpler than with ELTs
- Disadvantages
  - Sampling uncertainty
  - Not all events may be well-samples (catastrophe response use case)

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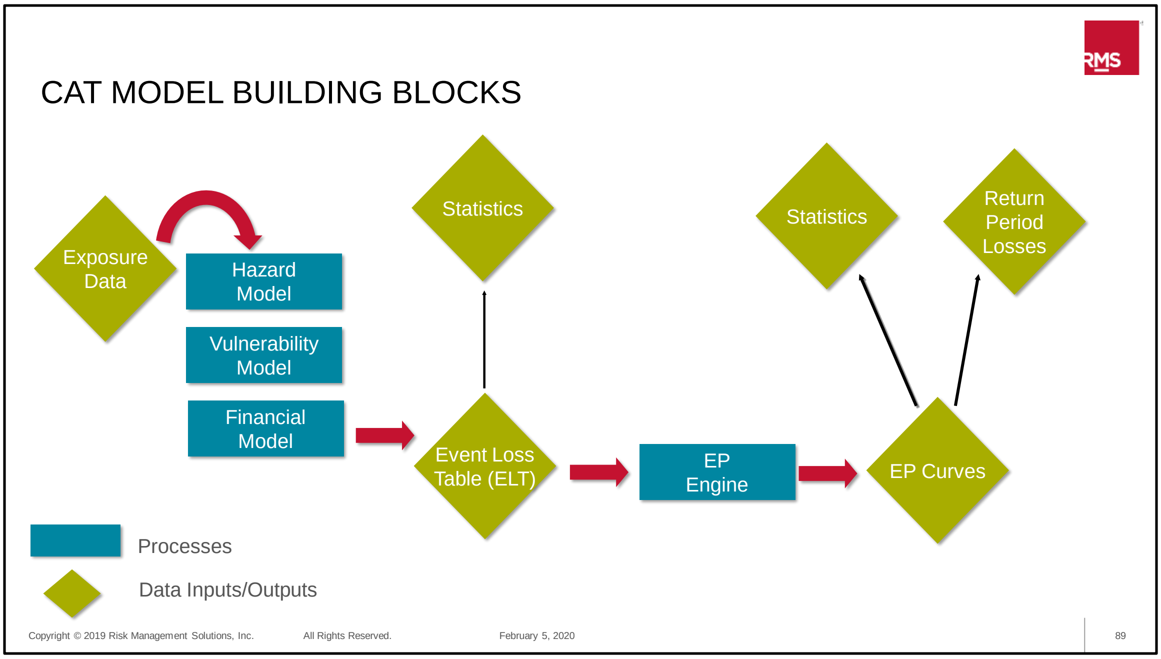
The Year Loss Table, or YLT, is an alternative way to represent modeled loss output that differs from the ELT approach we discussed in Units 4-6. While the ELT is a list of events with their mean loss and distribution and an annual probability, the YLT provides a set of simulated years with associated events and their sampled loss.

Placing events and their associated losses into the context of a timeline has several distinct benefits. Because events include a date within the simulated year, modelers can incorporate seasonality or clustering of events. With this temporal specificity, it becomes much more straightforward to evaluate contract terms that consider multiple events, such as reinstatements or aggregate deductibles. As we will see when we go further into the session, the mathematics of computing EP metrics are much less involved than with ELTs.

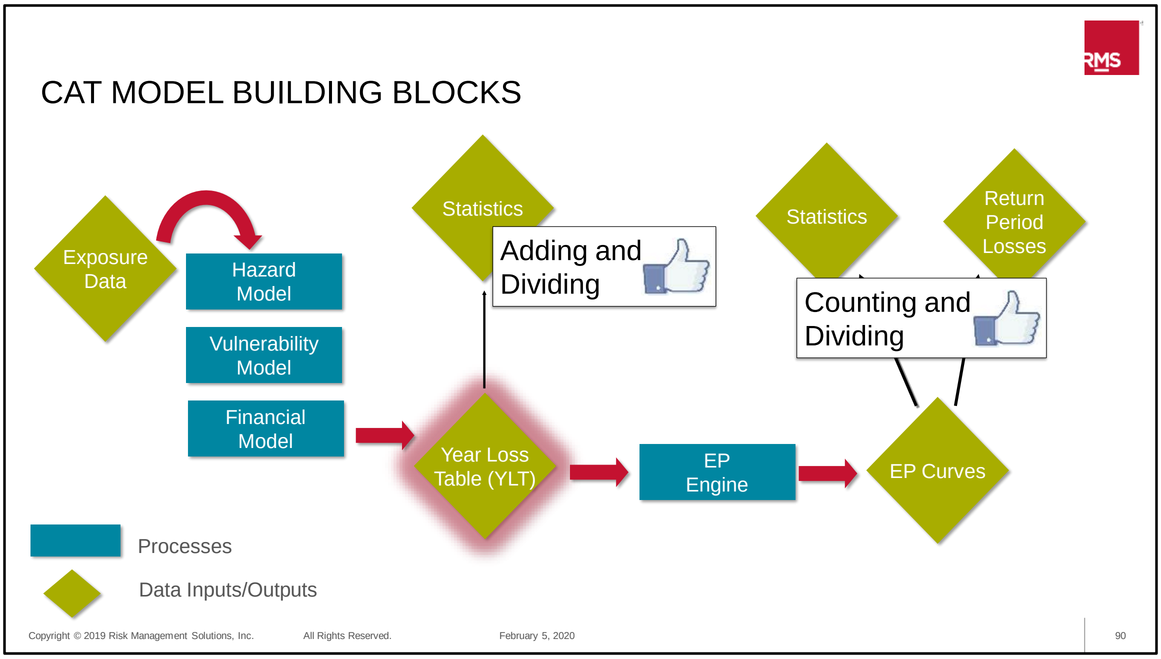
There are some limitations associated with the YLT-based approach. An additional uncertainty is introduced in the sampling of the event losses, which can influence the number of simulations required. Similarly, some time-sensitive use cases for event response draw on results for specific events that have already been run. YLTs may not have a robust set of these events, only a few samples.

As has been stressed throughout this program, the goal is to help you understand the concepts so as to evaluate which approaches and tools are appropriate for a given application.

[OPTIONAL NOTE: A variant of the YLT is the PLT, or Period Loss Table, in which the simulation period is multiple years in length rather than one year. This allows for modeling of multi-year contracts that would otherwise extend outside the YLT.]



By now you should be familiar with this figure from the previous units of the Financial Modeling course. This approach is based on the RiskLink analytical framework, in which statistics and EP losses all require the calculations using the beta distribution.



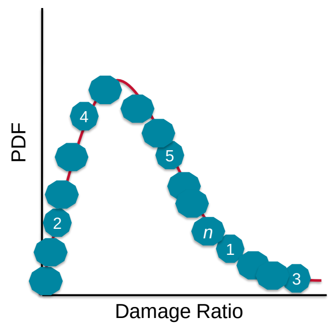
When a model uses a simulation-based approach, the Event Loss Table is switched out for a Year Loss Table. The flow through the hazard, vulnerability, and financial modules incorporates one or more simulations that generate a discrete loss for an events when they appear in the YLT.

The same average annual loss and OEP / AEP / TCE statistics can be calculated from the YLT, but the process is much simpler than with the ELT. Instead of integrating beta distributions to derive probabilities, the calculations involve adding losses and dividing by a number of years or counting event losses above thresholds and dividing by number of years.

We'll come back to how these are performed, but the first step is to understand what goes into a YLT and how it relates to the ELT.

EVENT SIMULATION

- Simulation is the act of sampling from a defined probability distribution to gain a detailed understanding of what happens within each sample and across the total number of samples.



Sample	DR
1	0.67
2	0.09
3	0.93
4	0.21
5	0.42
n	0.61

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Earlier in the Financial Modeling course we discussed the beta distribution as an example of a probability density function, a mathematical relationship that describes the relative likelihood for a random variable to take on a given value. When we use simulation, we are drawing samples from a given PDF and using those individual samples as inputs for our downstream processes.

In this example, we are drawing samples from a distribution of damage ratios. For any given draw we are most likely to be near the peak of the distribution, but given enough draws we will represent the entire function, including the low and high values. Drawing a point value means that downstream calculations become much more straightforward to carry out than when you are trying to carry along the portions of the distribution, but the downside is that you need many samples to capture the full behavior.

ANALYTICAL VS. SIMULATION

	Frequency	Severity
Distribution	Poisson Negative Binomial Etc.	Beta
Mean	λ – mean number of event occurrences / year	μ – mean damage ratio
	Primary Uncertainty	**Secondary Uncertainty**

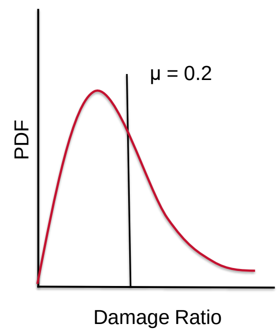
Before we explore the details of simulating a YLT, we will review some basic inputs of a loss model. The foundation of these models include the frequency of loss-causing events and their severity. For frequency, we refer to lambda (λ) as the mean number of event occurrences per year. We also need to assume some kind of distribution to define events per year, which could be a Poisson, negative binomial or other depending on the characteristics of the peril. Severity in our case is treated with a beta distribution around the mean damage ration mu (μ).

As we'll discuss further in the Uncertainty Measures course, these two aspects of the model relate to the primary uncertainty, whether the event will occur, and secondary uncertainty, the range in damage given that an event has occurred.

ANALYTICAL VS. SIMULATION

Frequency | **Severity**

# of Event Occurrences / Year (x)	Probability Function Pr(X=x)
0	0.1353
1	0.2707
λ = 2	0.2707
3	0.1804
4	0.0902
5	0.0361
6	0.0120
7	0.0034



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The average rate of occurrence is just that: an average over many year or simulated years. While the average may be a fractional value, a fractional event has no meaning; within any given year, there can only be a discrete number of events. Here we see a frequency distribution with an average of 2 events/year. That value, however, can be related to years that have one or no events, as well as more than two. The summed product of this distribution is two. Put another way, if we take this distribution over a 100-year period, we would expect only about 27 of those years would have two events.

Other distributions could be skewed toward multiple events in a year. This forces the distribution to have more years with few or no events but allows for large clusters.

SEVERITY AND FREQUENCY DISTRIBUTIONS IN THE ELT

- Used in the analytical approach, the event loss table (ELT) is a tabular representation of event occurrences and losses.

Frequency

$\lambda =$ *Sum (rates)*

Event ID	Rate	Loss	Std. Dev.	Exp. Val.
12345	0.006	5,122	2,574	427,162
12346	0.009	11,315	10,496	118,413
:	:	:	:	:
15512	0.001	61,568	34,927	622,172
15513	0.01	1,910	231	80,866
35897	0.003	7,943	3,111	126,524

Severity

$$\mu = \frac{Loss}{Exposure} \qquad CV = \frac{Std.\ Dev.}{Loss}$$

$$\alpha = \frac{(1-\mu)}{CV^2} - \mu \qquad \beta = \frac{\alpha(1-\mu)}{\mu}$$

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Given that background, we'll first return to the Event Loss Table. The ELT provides a representation of both event rates and losses.

The frequency of the model for a given peril region can be calculated as the sum of the rates over all events. An example of this value is illustrated in the statement, "The model estimates an average of 3.1 hurricanes affecting the country per year."

Severity is treated with the beta distribution, its parameters shown here as a function of the loss, standard deviation, and exposed value.

SEVERITY AND FREQUENCY DISTRIBUTIONS IN THE YLT

- The Year Loss Table (YLT) is made up of many simulated years, each with simulated event losses.
- We cannot understand from a single simulated year what the primary or secondary uncertainties are.

Simulation Year	Event Date	Event ID	Loss
2	Apr 13 17:32	2445	65,123

- Just as in reality, we must look across many simulated years to appreciate the frequency of occurrences and the range of possible losses.

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In building a YLT, we generate many simulated years on the basis of these same data used in the ELT approach, but with an important difference.

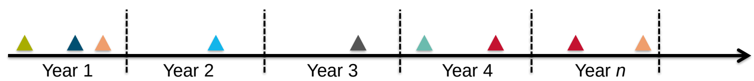
Because each year represents a draw from the frequency and severity distributions, any single instance loses its information on primary and secondary uncertainty. In the simulation year shown here, we have the event date and a sampled loss, with no further information on the long-term frequency of the event or what potential losses could occur.

In order to recapture the original distributions for frequency and severity, we must integrate over many simulated years.

SAMPLING FREQUENCY

# of Event Occurrences / Year (x)	Probability Function Pr(X=x)
0	0.13
1	0.28
λ = 2	0.27
3	0.18
4	0.09
5	0.04
6	0.01
7	0.00

- Simulated years and losses are compiled and estimated based on sampling from the frequency and severity distributions.
- Assume that a peril follows a Poisson distribution which says that there is a probability that a certain number of events will occur in some time period (i.e. 1 year)



▲ Event occurrence

$$\lambda = \frac{\text{Count (\# Events)}}{n \text{ years}}$$

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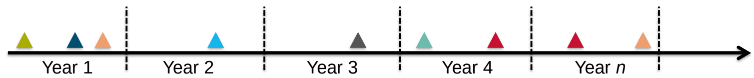
This lies at the heart of the YLT: a set of years and event losses are sampled such that they represent these distributions. The first step is to assign events to simulated years.

Using the total event rate for the peril and (in this case) a Poisson distribution, we can estimate the probability of 0, 1, 2, or more events occurring within a simulated year.

For each year, a number of events are drawn on the basis of this probability distribution. The number of years in the simulation determines how many total events will be allocated across the timeline, as the total count divided by the number of simulated years should match the average event rate.

FREQUENCY IN THE YLT



Year	Event Date	Event ID	Loss
1	Jan 01 14:33 Jan 27 05:47 Oct 08 23:15	15512 2345 1712	86,096 84,020 61,316
2	Apr 13 17:32	2445	65,123
3	Feb 12 17:18	3123	26,522
4	Feb 23 11:29 Dec 03 09:45	3012 11812	8,602 29,931
:	:	:	:
n	Aug 20 15:24 Oct 30 13:20	11812 1712	68,567 21,946

- The year loss table (YLT) is a tabular representation of the above timeline.
- Frequency is implied by the occurrence (or non-occurrence) of events across all simulated years.

$$\lambda = \frac{\text{Count (\# Events)}}{n \text{ years}}$$

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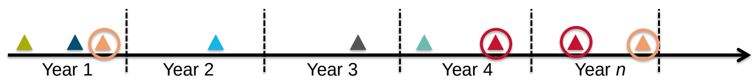
The YLT is a tabular representation of the timeline of simulated years. Within a given year, the event or events are assigned date stamps; these could be random or follow a seasonal distribution, such as for hurricane.

Frequency for individual events is implied through the same relationship as we saw for the full YLT, in that the rate is equal to the number of occurrences divided by the number of years in the simulation.

This does, however, provide our first insight into the potential for sampling uncertainty. Events with very low rates may not appear in a simulation set if there are insufficient years, or their implied rates may differ from the actual. Take, for example, an event with a 1-in-100,000 rate in a 50,000 year simulation. That event may not appear at all, or if appears one time the implied rate would be 1/50,000 – twice its 'true' rate. There are techniques modelers can use to enhance the sampling to maximize the spread of events that are included in the YLT, but these are never exact.

EVENT OCCURRENCES IN THE YLT



Year	Event Date	Event ID	Loss
1	Jan 01 14:33	15512	86,096
	Jan 27 05:47	2345	84,020
	Oct 08 23:15	1712	61,316
2	Apr 13 17:32	2445	65,123
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4	Feb 23 11:29	3012	8,602
	Dec 03 09:45	11812	29,931
:	:	:	:
n	Aug 20 15:24	11812	68,567
	Oct 30 13:20	1712	21,946

- **Question**: Can the same event occur in different years?
- **Answer**: Yes – the frequency of occurrence of the same event across a YLT should equal the rate for that event in the ELT.
- Further, event 1712 causes different losses in year 1 and in year *n* because of **severity sampling**.

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The idea that an event might not appear in a YLT raises a related question:

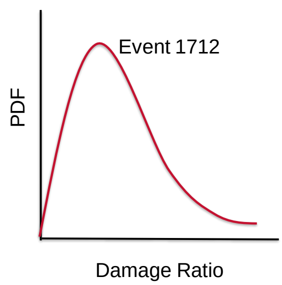
Can the same event occur multiple times, in different years?

Yes, certainly. The relativities laid out in the ELT rates require it; if one event has 10x the rate of another, it should (on average) appear 10x as often in the simulation set. This is not to imply that the same event is occurring over and over again. The timeline shown here displays the simulated years progressing linearly, as if year 101 supposedly happens 100 years after year 1. A more appropriate means of thinking about the simulated years is that they are different realizations or outcomes that could happen next year.

This becomes clearer in the example of event 1712 above, in that the losses for the event cause different losses in year 1 and year n due to severity sampling – the draw in year 1 yields a much larger loss than in year n.

SEVERITY SAMPLING AND EVENT ID 1712

- The beta distribution says there is a probability that the actual loss can be higher or lower than the mean.



Beta Parameters	
μ	0.040
α	1.946
β	46.393
Exp. Value	1,943,519

- Sampling from event 1712's distribution at various quantiles will provide a range of losses within the YLT.

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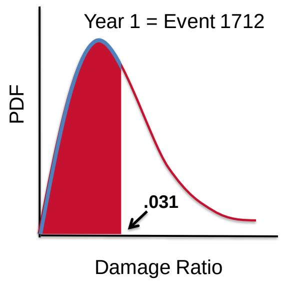
Let's go back to the ELT content to understand this. Our ELT record for event 1712 would allow us to calculate the mean damage ratio μ of about 4% with the beta distribution parameters α and β.

This beta distribution and the event exposure give us the probabilities for losses higher or lower than the mean. Each time event 1712 occurs in the YLT, we sample a quantile from the distribution to get a loss for that particular realization.

SEVERITY SAMPLING

Simulation Year	Event ID	Quantile
1	15512 2345 1712	0.7843 0.2385 0.4626
2	2445	0.5308
3	3123	0.3142
4	3012 11812	0.9523 0.5253
:	:	
n	11812 1712	0.8893 0.1537



μ	0.040
α	1.946
β	46.393
Exp. Value	1,943,519 *x .031* = ***61,316***

Simulation Year	Event ID	Loss
1	15512 2345 1712	86,096 84,020 61,316
2	2445	65,123
3	3123	26,522
4	3012 11812	8,602 29,931
:	:	:
n	11812 1712	68,567 21,946

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This highlights an additional intermediate step in the implementation of YLT severity sampling: the Year Event Quantile Table, or YEQT. An example is shown on the left. For every event that appears in the simulation set, a quantile between 0 and 1 is sampled and stored. This YEQT can then be used with an ELT to generate the losses stored in the YLT.

In the example here, event 1712 was assigned a quantile of 0.4626 in year 1. The beta distribution parameters for a specific exposure are provided in the center, with a mean damage ratio of 0.040, or 4%. Using this beta distribution, we find that the 0.4626 quantile…

…falls at a damage ratio of 3.1%, slightly below the mean of 4%.

We can then apply this damage ratio to the exposure to get the loss for this sampled event.

Repeating for all events in the simulation, we can then create the YLT. This is part of how the YLTs can be operationalized. The YEQT is compiled and stored for a model, independent of any exposure or results. The ELT provides results specific to a given contract or portfolio; the YEQT then provides the mapping to generate the associated YLT.

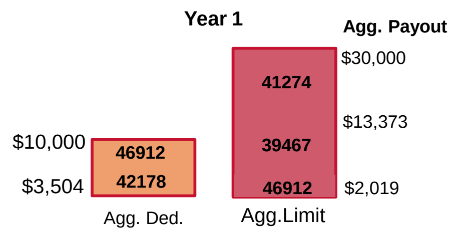
FINANCIAL MODELING

YLT

Year	Event	Loss ($K)
1	42178	3,504
	46912	8,515
	39467	11,354
	41274	18,471
2	48431	9,161
3	-	-
4	44127	4,151
	41299	6,154
	43412	15,494

Contract

Occurrence Layer	Unlimited xs 0
Percent Covered	100%
Agg. Deductible	10,000
Agg. Ded. Layer	Unlimited xs 0
Aggregate Limit	30,000



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Let's look at how the YLT can be applied to a contract with aggregate terms. In this contract, there are no occurrence limits or deductibles, but there is an aggregate deductible of 10,000 that must be satisfied before the contract will pay loss up to its 30,000 limit. Our YLT gives us the ground-up losses that feed this contract.

Year 1 was busy, with four loss-causing events. We first have to fill up the deductible before the contract pays out.

The first event, 42178, causes $3504 of loss, which goes into the aggregate deductible.

The second event, 46912, causes $8,515 of loss, which also goes into the aggregate deductible, but fills up the amount.

The deductible is $10,000…

…which means that the $2,019 in excess of that amount becomes our first payout toward the aggregate limit.

The third event, 39467, causes $11,354 of loss, all of which is added to the aggregate payout.

Finally, the fourth event, 41274, causes enough loss to blow out the top of the contract, yielding a limit loss of $30,000.

As we look at other years shown here, years 2 and 3 either have no events or insufficient loss to satisfy the deductible, whereas year 4 is another multi-event instance that results in a payout for part of the second and all of the third event. There are two additional points to note here. All of the calculations here were done in expected mode, as the sampling of loss uncertainty took place in creation of the YLT. The other point is that these aggregate terms are essentially impossible to model using only ELTs in the analytical framework, as this approach does not contemplate how many events occur in a given year or the order in which they occur.

AAL: ADDING & DIVIDING

Year	Event	Loss
1	46512 35468	64,128 21,548
2	48512	84,521
3		0
4	37546 31458	6,489 26,451
5	41245 45211 44718	31,244 64,845 2,315
6		0
7	33514	9,954
8	43299	64,887

- The AAL is defined as the expected value of the aggregate loss distribution.
- In a simulated (YLT) framework, AAL is the sum of all the losses across all years divided by the total number of years simulated.

$$AAL = \frac{\textit{Sum (Event Losses)}}{\textit{Total Number of Years}}$$

$$AAL = \frac{\$376{,}382}{8} = \$47{,}048$$

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Now let’s look at how the financial model works in calculating other metrics with YLTs, starting with average annual loss (AAL).

As defined, the AAL is the expected value of the aggregate loss distribution. In the ELT framework, it was calculated as event loss times event rate, summed over all events.

In the YLT framework, AAL is literally the average annual loss – it is the sum of all losses across all years, divided by the number of years simulated.

Here we have a sample YLT on the left, which we’ll use for the next several examples. The average annual loss is the sum of all losses, $376,382, divided by the eight years in the simulation. Note that this count does include the years with no loss.

OEP: COUNTING & DIVIDING

Year	Event	Loss	Max Loss
1	46512 35468	64,128 21,548	**64,128**
2	48512	84,521	**84,521**
3		0	0
4	37546 31458	6,489 26,451	26,451
5	41245 45211 44718	31,244 64,845 2,315	**64,845**
6		0	0
7	33514	9,954	9,954
8	43299	64,887	**64,887**

- The OEP is defined as the probability that the single largest event loss in a year (*Max* L_i) will exceed a loss threshold (*L*).
  - The OEP curve is a collection of loss thresholds, each one of them with the corresponding OEP
- In a simulated (YLT) framework, the maximum event loss for each year is determined and its year is counted if it exceeds that given threshold. The count of years is divided by the total number of simulated years to determine the probability.

$$OEP(L) = \frac{Count\ (years\ with\ Max\ L_i > L)}{Total\ Number\ of\ Years}$$

$$OEP(30{,}000) = \frac{4}{8} = 0.5$$

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Now let's move on the exceedance probability curves, starting with the OEP.

The OEP is defined as the probability that the single largest event loss in a year will exceed a given loss threshold. The OEP curve is generated by calculating the exceedance probabilities associated with a series of these loss thresholds. The calculation of the OEP with ELTs requires the financial model to consider every event and its potential for exceeding these thresholds – a large number of beta distribution calculations for every point on the curve.

In the YLT framework, calculating the probability is a process of counting and dividing. For a given loss threshold, you first identify the maximum loss in a year and then count the year if it exceeds the threshold. This is repeated for all years in the simulation. The exceedance probability is simply the number of years with a loss above the threshold divided by the total number of years.

In our example, we want to calculate the OEP for $30,000. Within the YLT, the maximum loss is identified for each simulated year. Four years exceed the threshold.

The probability is thus 4 / 8, or 0.5 – a 1-in-2 year event. Note that in year 5 there were two events that exceeded 30,000, but we only counted it once. We are interested in the number of years in which the threshold was exceeded, not the number of events.

AEP: COUNTING & DIVIDING

Year	Event	Loss	Agg Loss
1	46512 35468	64,128 21,548	**85,676**
2	48512	84,521	**84,521**
3		0	0
4	37546 31458	6,489 26,451	**32,940**
5	41245 45211 44718	31,244 64,845 2,315	**98,404**
6		0	0
7	33514	9,954	9,954
8	43299	64,887	**64,887**

- The AEP is defined as the probability that the aggregate loss in a year (*Agg* L_i) will exceed a loss threshold (L).
  - The AEP curve is a collection of loss thresholds, each one of them with the corresponding AEP
- In a simulated (YLT) framework, the event losses for each year are summed and the year is counted if the sum exceeds the given threshold. The count of years is divided by the total number of simulated years to determine the probability.

$$AEP(L) = \frac{Count\ (years\ with\ Agg\ L_i > L)}{Total\ Number\ of\ Years}$$

$$OEP(30{,}000) = \frac{5}{8} = 0.625$$

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The process for calculating the AEP is very similar.

Recall that the AEP is defined as the probability that the aggregate losses in a year exceed a given threshold. For the AEP it doesn't matter whether this is from a single large event or multiple smaller ones, only that the total loss for a year is over the threshold. This is a mathematically complex calculation in the ELT framework, requiring the use of a Fast Fourier Transform to consider the probabilities of multiple events occurring over thousands of potential combinations.

In the YLT framework, the calculation is the same as for OEP except that years are counted on the basis of the total losses.

In our example, the additional column now shows the aggregate loss for each year. If we are interested in the AEP for 30,000 loss, we count five years with an aggregate loss in excess of this amount.

The outcome is that the AEP for 30,000 is thus 5/8, or 0.625.

[SIDE NOTE: In case anyone asks, TCE is calculated the same way as AAL, but only years with losses exceeding the OEP or AEP threshold are summed and included in the count.]

SIMULATION UNCERTAINTY: SAMPLE SIZE & CONVERGENCE

- Greater number of samples in a simulation provided greater confidence in the estimate
- Sampling error captures the deviation between sample-based results and “actual” results

$$\textit{Sampling Error} = \frac{\textit{Approximate} - \textit{“Actual”}}{\textit{“Actual”}}$$

- Standard error ratio is used to quantify the confidence in an estimate based on sample data (it is a normalized view of the standard error).

$$\textit{Std. Error Ratio} = \frac{\textit{Analysis CV}}{\textit{SqrRt (Number of Samples)}}$$

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A final aspect of simulation is to acknowledge that the process does introduce an additional layer of uncertainty. Take the example of flipping a coin. Assuming the coin is fair, we can analytically expect that the coin will come up heads 50% of the time. If we test this by actually flipping the coin, however, it may take many coin flips to converge on the 50% -- especially if we want to be within 0.1%. Taking more samples increases the confidence in the estimate, but at the cost of longer processing.

We refer to this uncertainty as sampling error, or the deviation between the sampled approximation and the actual value.

In our coin-flipping example, if heads had come up 6 times in 10 flips, our sampled rate of heads is 0.6, giving a sampling error of (0.6 – 0.5)/0.5 = 0.2, or 20%.

We don’t always know the “actual” value, however, so we can instead use a mathematical relationship to make an estimate. The standard error ratio is a normalized view of the standard error that can be estimated from the analysis output. It is defined as the analysis CV divided by the square root of the number of samples. In simple terms, it is an estimate of how far the sample mean is likely to be from the population mean. What should be clear from this is that the higher the variability in the results, the more samples that will be required to reduce the error.

SAMPLE SIZE & CONVERGENCE EXAMPLE

- A portfolio analysis generates the following statistics:
  - AAL = 303
  - Std.Dev. = 3,906
  - Coefficient of Variation = 12.9

Simulated Years	Standard Error Ratio
800,000	12.9 / SQRT(800,000) = 1.4%
400,000	12.9 / SQRT(400,000) = 2.0%
200,000	12.9 / SQRT(200,000) = 2.9%
100,000	12.9 / SQRT(100,000) = 4.1%
50,000	12.9 / SQRT(50,000) = 5.8%
25,000	12.9 / SQRT(25,000) = 8.2%
12,500	12.9 / SQRT(12,500) = 11.5%
6,250	12.9 / SQRT(6,250) = 16.3%

Let’s look at a real example instead of coin flips. After running a portfolio, we get the following AAL and standard deviation, which yield a coefficient of variation of 12.9. What does this mean for our simulated years?

This table provides a summary of the standard error ratio for a range of simulated years. As the number of years increases, the error decreases. Given the significant uncertainties that can be associated with other components of a catastrophe model, these errors may be considered small. Sampling uncertainty is a component of the analysis, however, and it is important for users to recognize its contribution.

HOW MANY SAMPLES SHOULD WE TAKE?

…THERE IS NO “CORRECT” ANSWER

Peril

- Higher frequency perils converge faster.
- Number of events is more important than number of years.

Exposure

- Treaty covering a small geographic area requires more samples.
- Portfolio with higher CV requires more samples.

Business Context

- Interested in 25-year, 500-year, 5,000-year return period loss?
- Treaty in force for only six months?

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So the next question is undoubtedly, “How many samples should we take in the analysis?” Unfortunately, there is not a clear-cut answer this dilemma beyond “It depends.”

The characteristics of the peril will have an effect on the simulated results. High-frequency perils will converge faster because there are more occurrences from which to sample severity. This is a theme that will be repeated as we explore AAL metrics – higher event rates push down the coefficient of variation, which we saw is on the numerator of the standard error calculation.

The exposure characteristics contribute as well. If a portfolio is geographically concentrated, it will be affected by fewer events than one that is widely dispersed. Just as with the peril, anything that reduces the number of events will increase the CV and the potential sampling error. Exposure characteristics also include the contract type – an E&S book comprising mostly high attachment point policies will likely have a higher CV than an equivalent number of homeowners’ policies.

Finally, there is the business context – which probability levels are of interest? The sampling uncertainty is much higher for the 1-in-5,000 loss than 1-in-50, so the former will require more simulated years to converge. The example of a treaty that only is in force for part of a year is another case that might require a greater number of simulated years, as this further trims down the number of instances when the treaty will be affected relative to a full year term.

All of these examples repeat a theme: any characteristic of an analysis that reduces the likelihood of a “qualifying” sample, be it the peril, exposure, probability, or time window, increases the number of simulated years needed to reach a set threshold of simulation error. Quantifying this, understanding modeler recommendations, and developing guidelines related to model application are part of best practices for an organization.

UNIT 7 SUMMARY

- Year Loss Tables (YLTs) are a set of simulated years for which event frequency and severity have been sampled.
  - Can accurately model a variety of aggregate, seasonal, and multi-event financial terms.
  - YLTs reflect the same underlying model content as ELTs, but we must look across many simulated years to reproduce event frequency and severity distributions.
- Calculation of OEP and AEP losses with YLTs is mathematically simpler than the analytical ELT approach, consisting mostly of adding, counting, and dividing.
- Because the simulation process introduces samples errors into the generation of YLTs, the number of samples used should consider the goals and characteristics of the analysis.

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Please review these summary points for Unit 7. If any of this information is unclear, we encourage you to go back to that unit to review the details before concluding your study of this unit.

ADDITIONAL INFORMATION

- Documents available in RMS Owl, https://support.rms.com
  - Understanding the Financial Model
  - Introduction to Coding Financial Structures presentation
  - Financial Model Overview presentation
  - Reinsurance Methodology white paper
  - Secondary Uncertainty Methodology white paper
  - Exceedance Probability Methodology white paper
  - Financial Modeling and Results FAQ
  - Financial Loss Perspectives and EP Curve Modeling presentation
  - HD Model Methodology
  - Simulation Methodology in the Simulation Platform
  - Risk Modeler Simulation Methodology

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For a further understanding of the financial model, uncertainty calculations, or reinsurance applications, please refer to the documents shown here, which can be found in the documentation library in RMS Owl, support.rms.com.

EXERCISE 4

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Complete Exercise 4 and review the associated answers.