ASOP Resources Relative to AIR Catastrophe Models

Provided to AIR's Actuarial Clients

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AIR WORLDWIDE

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1 Introduction

Actuarial Standards of Practice (ASOPs), which apply to actuaries rather than models, allow the use of models only if the actuary carries out certain responsibilities intended to optimize professional judgment.

ASOP 38 Using Models Outside the Actuary's Area of Expertise, enumerates five basic responsibilities for the use of complex models outside of the actuary's own area of expertise:

- Determine appropriate reliance on experts
- Have a basic understanding of the model
- Evaluate whether the model is appropriate for the intended application
- Determine that appropriate validation has occurred
- Determine the appropriate use of the model and its results

ASOP 23 Data Quality, addresses the recommended practices for dealing with data in the following areas:

- Data selection: Select the data with due consideration of appropriateness, reasonableness, comprehensiveness, limitation and cost of feasibility of alternative data
- Use of imperfect data: Actuary should first decide on whether to use the data (Are the biases in the results of the study material?) and then document the bias as well as potential adjustment to the data
- Reliance on data supplied by others: Actuary should, when practicable, review the data for reasonableness and consistency

Other ASOP standards (ASOP 39, ASOP 41, etc.) may also be relevant to the actuary's use of catastrophe models. These dictums clearly imply that the actuary must do a fair amount of homework when relying on model results to support rate filings or for any other risk management decisions. Simply filing rates to regulators and the public solely with "the model said so" meets neither actuarial standards of practice nor regulatory rules in most states.

The purpose of this document is to provide a summary resource to assist actuaries in their use of our models—which may be outside their area of expertise—as well as identify relevant considerations for conforming to the ASOPs.

2 Model Overview

Catastrophe models consist of software applications embodying scientific relationships among physical events, the vulnerability of structures, and economic and insurance conditions. They use computing power to generate tens of thousands of simulated years of potential loss experience for any property data set presented to the models, essentially eliminating pure randomness caused by insufficient sample sizes. Beyond the "convergence" argument, there are other actuarial advantages to using modeled loss data:

- Current inventories of properties, replacement values, and policy conditions are inherently reflected in the model results to the extent they are reflected in the exposure data;
- The full statistical distribution of potential losses is returned by the model, not simply a "best estimate" based on a combination of historical data and selected adjustment factors;
- Sensitivity testing of the modeled losses to various assumptions about exposures, property attributes, and characteristics of the events is straightforward and transparent.

ASOP 38, Section 3.3.1, dictates that *"the actuary should be reasonably familiar with the basic components of the model and have a basic understanding of how such components interrelate within the model".* This chapter aims to provide the actuary with the background and resources necessary to become reasonably familiar with AIR catastrophe models.

2.1 AIR Model Framework

Figure 1 below illustrates the component parts of AIR catastrophe models.

Figure 1 Catastrophe Model Components

This first model component, event generation, addresses the hazard itself and answers the questions of where events are likely to occur, how large or severe they are likely to be, and how frequently they are likely to occur. AIR employs a large multi-disciplinary team of scientists, which includes meteorologists, climate scientists, seismologists, geophysicists, and statisticians, who combine their knowledge of the underlying physics of natural hazards with the historical data on past events.

At the end of the event generation process, a large catalog of tens of thousands of potential future events is created in accordance with their relative frequency of occurrence, not just events of average frequency but also the most extreme and rare events that make up the tail of the statistical distribution.

Once the model probabilistically generates a potential future event, it propagates the event across the affected area. For each location within the affected area, local intensity (e.g. wind speed, ground motion) is estimated. High resolution geophysical data and algorithms are employed to model the local effects of each simulated event at each affected site.

In the damage estimation component, the local intensities of each simulated event are superimposed onto a database of exposed properties which are input by the user. Mathematical relationships, called damage functions, describe the relationship between the intensity of the event, which varies by location, and the expected damage ratio to the exposed buildings and contents to produce estimates of the resulting monetary damage when applied to replacement cost estimates. AIR employs experienced structural engineers who develop damage functions for many different construction types and occupancies for building, contents, and time element loss.

In the last component of the model, insured losses are calculated by applying the specific policy conditions to the total damage estimates. Policy conditions may include deductibles by coverage, site- specific or blanket deductibles, coverage limits and sublimits, coinsurance, attachment points and limits for single or multiple location policies, and risk or policy specific reinsurance terms. Explicit modeling of uncertainty in both intensity and damage calculations enables a detailed probabilistic calculation of the effects of policy conditions.

Each component, or module, represents both the analytical work of the multi-disciplinary research team that is are responsible for its design and the complex computer programs that run the simulations. The ongoing research of the scientists and engineers ensures that AIR models reflect the latest advances in scientific understanding. The models undergo a continual process of review, refinement, enhancement, and validation.

2.2 Key Scientific Resources for Model Inputs

AIR's approach to catastrophe modeling is one of both scientific rigor and transparency. The most important job of our scientists and engineers is to keep abreast of the scientific literature, evaluate the latest research findings, and conduct original research of their own. In doing so, AIR's highly-credentialed research team ensures that our models incorporate the most current scientific knowledge in climate science, meteorology, hydrology, seismology, and wind and earthquake engineering. Data sources used in the course of model development are provided throughout the model documentation. In light of Solvency II, ASOP and other regulatory requirements, AIR provides a consolidated section on data sources, which is available in Section 1, "Facts-at-a-Glance", in the model description documents.

The data sources that are used to develop the industry exposure database can be found in the CATRADER section of the model description documents. They are also provided in the AIR Industry Exposure Database (IED) documents.

2.3 Reliance on Experts

Determining the appropriate level of reliance on experts is important for ASOP compliance. Per ASOP 38, Section 3.2, *"an actuary may rely on experts concerning those aspects of a model that are outside of the actuary's own area of expertise".* This section goes on to explain that actuaries who plan to rely on the use of catastrophe models should consider *"whether the individual or individuals upon whom the actuary is relying on are the experts in the applicable field"* and also *"the extent to which the model has been reviewed or opined on by experts in the applicable field".* Section 3.3.1 also discusses the actuary's responsibility to, *"identify which fields of expertise were used in developing or updating the model, and should make a reasonable effort to determine if the model is based on generally accepted practices within the applicable fields of expertise".*

AIR employs a large, full-time professional staff in actuarial science, computer science, insurance and reinsurance, geology, mathematics, meteorology, hydrology and other physical sciences, software engineering, statistics and structural engineering, among other disciplines. Most have advanced degrees and more than 80 hold Ph.Ds. AIR scientists and researchers apply general accepted practice in their specific discipline in model creation and validation. AIR's diverse team of experts continually strives to improve the accuracy and realism of catastrophe models. However, catastrophe modeling will always remain an inexact science and there are inherent uncertainties and assumptions throughout the model development process. AIR is committed to explaining all known sources of uncertainty and how they are treated within the models in our detailed technical documentation.

For particular areas of inquiry or less well-studied regions of the world that lack ample historical data, model development requires the use of expert scientific judgment. In some situations, AIR supplements in-house knowledge with external expertise using consultants or peer reviewers. For example, AIR has solicited external expertise on such topics as the impact of climate change on tropical cyclone activity, frequency estimates for assessing terrorism risk, and pandemic flu, among others.

For ongoing areas of research where there is no clear scientific consensus, AIR seeks to provide clients with guidance and modeling best practices in the form of white papers, briefs and, in some cases, alternate credible views of the risk.

A complete listing of individuals who have contributed significantly to the U.S. Hurricane Model development, enhancement, testing and/or validation can be found in the Florida Commission for Hurricane Loss Projection Methodology, Latest Submission Documentation (pg. 30):

https://www.sbafla.com/method/Portals/Methodology/ModelSubmissions/2015/AIR_2015_FCHLPM_final%20_submission_clean_copy.pdf

Credentials and background of teams who have contributed to the development of AIR models can be made available upon request.

2.4 Model Updates

Model updates are not undertaken frivolously at AIR and indeed a critical decision is when to incorporate a new scientific theory or new data. Rarely is a model update at AIR prompted by a single event or even multiple events. On the other hand, as events occur, AIR engineers have access to more—and more detailed—loss experience data. Analysis of that data is used for both validation and calibration of the AIR models, particularly of their damage functions. AIR also has the benefit of leveraging actual loss information from other subsidiaries across Verisk Analytics. Where available, modeled losses are extensively validated against loss estimates issued by ISO's Property Claims Services (PCS) and also from claims data received from AIR's sister company, Xactware.

Very generally, catastrophe models are updated for four primary reasons: 1) refinements to damage functions based on data from actual events, as noted above; 2) new scientific research; 2) enhanced and higher resolution geophysical databases, and; 3) the addition of sources of loss not previously modeled. Below are some examples of AIR models that were updated due to these reasons. This list is not exhaustive, but meant to convey how AIR determines when to significantly update a model or release a new one. For further discussion of the issues surrounding when catastrophe modelers incorporate new science, see the *AIR Current* Modeling Fundamentals: The Dynamic Nature of Science in Catastrophe Modeling.

For instance, in 2009, new findings by the wider scientific and engineering communities provided motivation for enhancements to the AIR Earthquake Model for the United States. The release featured comprehensive enhancements to virtually all model components, prompted in large part by the United States Geological Survey publication *Documentation for the 2008 Update of the United States National Seismic Hazard Maps*. The following year, AIR released the 2010 version of the AIR Hurricane Model for the United States, which featured the incorporation of a recently published wind field formulation that offers greater fidelity in modeling hurricane wind speeds. In 2013, AIR released a major update to the AIR Earthquake Model for Japan, which reflects the latest research on Japan's seismicity and the effects of the 2011 M9.0 earthquake in Tohoku, Japan.

The availability of better data at an ever higher resolution is a result, in some measure, of the almost exponential increase in computing power over recent years. In turn, increases in computing power have enabled catastrophe modelers to incorporate this data without sacrificing model runtimes. New algorithms for disaggregating exposure information to a high resolution grid level makes real sense only when the hazard can be modeled at a very high geophysical resolution (using, for example, high resolution soil, elevation, topographic data and the like). The 2014 update of the AIR Severe Thunderstorm Model for the United States features a high-resolution industry exposure database (along with the ability for clients to disaggregate their own exposure to high resolution) that takes full advantage of high-resolution hazard modeling. The additional level of detail enables better differentiation between risks, which in turn leads to better risk management practices and decisions that better align with strategic goals.

The explicit incorporation of previously unmodeled perils also motivates model updates. For example, as the influence of climate plays a more critical role in our clients' decision-making processes, AIR has proactively begun quantifying the implications of climate in its models. As a consequence of the highly active 2004 and 2005 hurricane seasons in the North Atlantic, for example, AIR introduced an alternative view of hurricane risk in the form of the AIR Warm Sea Surface Temperature (WSST) catalog to represent a long-term climatology of hurricane activity conditioned on those years since 1900 in which the Atlantic ocean has been warmer than average. For a general discussion of the issue of incorporating a changing climate in AIR models see the white papers: *Catastrophe Modeling in an Environment of Climate Change* and *Climate Change Impacts on Extreme Weather*. Another example is the ongoing research on tsunami risk. The data from the tsunami that was generated from the 2011 Tohoku earthquake is incorporated into the 2013 update to the AIR Earthquake Model for Japan, which features explicit modeling of tsunami generation and damage. This data was also a major contributor towards including explicit tsunami modeling in the update to the AIR Earthquake Model for Canada, which was released in 2014.

While AIR fully understands that model updates can be challenging, they can also present opportunities. Ultimately, AIR is confident that our clients benefit from a more robust and accurate view of risk provided by the model updates.

2.5 Model Validation

Actuaries that plan to rely on the use of catastrophe model output should ensure that the appropriate validation has been performed on the model. Section 3.3.1 of ASOP 38 states, *"the actuary should also be reasonably familiar with how the model was tested or validated and the level of independent expert review and testing".*

Each component of the AIR catastrophe models represents both the analytical work of the multi-disciplinary research team that is responsible for its design and the complex computer programs that run the simulations. The ongoing research of scientists and engineers at AIR ensures that the models reflect the latest advances in scientific understanding. The models undergo a continual process of review, refinement, enhancement, and validation.

AIR's validation process is not limited to the final model results. Throughout the model development process, every component is carefully verified against data from historical events. Of course, the goal of catastrophe models is not simply to replicate the historical record; rather, the model should reflect the full range of potential future catastrophe experience, including the most extreme events that may not have occurred historically. Therefore it is critical that the model be vetted and validated by the domain experts—both internal and external—for each model component to ensure reasonability.

It is important to point out that model validation is at its most robust for regions where the modeled peril is relatively frequent, and hence historical data is relatively abundant. For regions that experience catastrophes only rarely, the modeler is left to extrapolate from other regions where event frequency is higher and rely more heavily on expert judgment. In the case of the New Madrid Seismic Zone of the United States, for example, there has been only one event in the historical record of any significance from an insurance perspective (the series of three large earthquakes that occurred in the winter of 1811-1812). Seismicity in this intraplate region is still not well understood; however hundreds of seismologists in the U.S. Geological Survey and academic and other research institutions continue to study the region and publish their findings regarding its potential to produce future damaging earthquakes. This research is, of course, incorporated in the AIR model. Still, it must be acknowledged that there is considerable uncertainty surrounding estimates of modeled loss for this and similar regions of low seismicity.

Similarly, model validation is more robust in regions where there is an established and mature insurance market and thus abundant claims data with which to validate modeled losses and, in particular, detailed claims data. Validation of the modeled losses for the AIR Earthquake Model for Japan, for example, will be more robust than validation of modeled losses for the AIR Earthquake Model for China, despite the fact that earthquakes occur relatively frequently in China. This situation will undoubtedly change as China's insurance market grows and matures. In general, the claims data used by AIR for both model calibration and validation is most abundant in the United States, Europe, and Japan and is for wind (i.e., more frequent) perils. Claims data may also significantly increase after events of extreme significance, such as the 2011 M9.0 earthquake in Tohoku, Japan.

In regions for which claims data is not abundant, there is necessarily heavier reliance on published estimates of industry and economic losses. In addition, AIR engineers leverage the extensively validated damage functions from other, more mature insurance markets and then modify them to reflect local conditions, including the age of the building stock, local design and seismic codes, local construction practices, socio-economic circumstances, and claims adjustment practices.

Several sections in the AIR model documentation are devoted to a discussion of model validation. These include:

- Validating Stochastic Event Generation
- Validating Local Intensity
- Validating Damage Functions
- Validating Modeled Losses

For additional information on the model validation process, including examples from several AIR models, refer to the document *AIR Approach to Model Validation*. Note that documented examples represent only a fraction of the validation exercises undertaken in the course of model development.

2.6 Model Standards Certification

Relevant to ASOP 38, Section 3.2.c, the actuary should consider *"whether there are standards that apply to the model or to the testing or validation of the model, and whether the model has been certified as having met such standards".*

AIR has worked with insurance departments of various states in meeting their informational requirements. Rates based on the AIR models have been filed and approved in an increasing number of states. Documentation related to compliance with the standards of the following organizations is available upon request:

- Florida Commission for Hurricane Loss Projection Methodology
- Louisiana Department of Insurance
- Hawaii Department of Insurance
- Texas Department of Insurance
- Maryland Department of Insurance
- South Carolina Department of Insurance

2.7 Model Documentation

Starting in 2008, AIR undertook a major effort to significantly improve its model documentation. Enormous effort goes into the production of this documentation, which now accompanies all but two of AIR's models.[1] The enhanced documentation provides details on the science and engineering incorporated in the model, data sources used in the model's development, exhibits, and discussion surrounding model validation.

AIR's model documentation also includes details on the model's implementation in AIR software, including supported lines of business, coverages, construction and occupancy types, supported age and height bands where applicable, and lengthy tables providing the relative vulnerabilities of supported construction types. As part of an on-going effort to continue improving its model documentation, AIR has started providing these tables in separate Excel files, allowing clients to directly access the data as needed. These Excel files will be provided as model documents are updated, or new ones created, and will be accessible directly by means of a link in the Touchstone® section of the model description documents (described below).

2.8 Model Descriptions

AIR's model documents provide linked tables of contents and a bookmark panel for easy navigation. They are organized into sections that reflect the components of the model in a logical order allowing users to easily follow the development of the hazard and vulnerability aspects of the model. This organization is summarized below.

Section 1, "Facts at a Glance," provides an overview of the model, including modeled perils and subperils, a model abstract, data sources used for model development, summary statistics on the stochastic catalog, and modeled losses for key exceedance probabilities and significant historical events. Section 2 provides an overview of the modeled peril, with particular reference to the modeled country or region. It also provides summary information about significant historical events.

Section 3, "Event Generation," identifies the model parameters that "define" an event, and any explicitly modeled subperils, and details the generation of the simulated events that populate the stochastic catalog. Section 4, "Local Intensity Calculation" identifies the intensity parameters used in the model and describes how the intensity, of perils and explicitly modeled subperils, is modeled at each affected site.

Section 5, "Damage Estimation," discusses the model's damage functions for all the modeled peril and subperils. In some cases, there may be an additional section devoted to damage estimation, either for complex industrial facilities or other specialized lines of business; otherwise, Section 6, "Insured Loss Calculation," provides an overview of the model's financial module.

Sections 7 and 8 provide information on the implementation of the model in CATRADER and Touchstone, respectively. Finally, Section 9 offers selected references used in model development.

The following tables provide links to model description documents currently available on the AIR website.[2]

[1] *AIR Earthquake Model: Caribbean Region* and *AIR Earthquake Model for New Zealand* will be updated at a later date.

[2] All documents on the AIR website are available to logged-in clients by clicking Documentation and Downloads from the Client Portal or by entering all or part of the title in the search box.

Table 1 Links to Model Description Documents Available on AIR Website

CROP

MULTIPLE PERIL CROP INSURANCE (MPCI)	
China	*AIR Multiple Peril Crop Insurance (MPCI) Model for China*
United States (Contiguous U.S. *excluding* Connecticut, New Hampshire Maine, Rhode Island Massachusetts, Vermont)	*AIR Multiple Peril Crop Insurance (MPCI) Model for the United States*
CROP HAIL	
Canada	*AIR Crop Hail Model for Canada*
United States	*AIR Crop Hail Model for the United States*

CYBER

CYBER RISK	
	AIR Cyber Model

EARTHQUAKE

Asia-Pacific	
Australia	*AIR Earthquake Model for Australia*
Brunei, Hong Kong, Indonesia, Macau, Malaysia, Philippines, Singapore, Taiwan, Thailand, and Vietnam	*AIR Earthquake Model for Southeast Asia*
China	*AIR Earthquake Model for Mainland China*
India	*AIR Earthquake Model for India*
Japan	*AIR Earthquake Model for Japan*
New Zealand	*AIR Earthquake Model for New Zealand*

Caribbean		
Bahamas Barbados Cayman Islands Dominican Republic/Haiti Jamaica	Puerto Rico St. Maarten St. Martin Trinidad and Tobago U.S. Virgin Islands	*AIR Earthquake Model: Caribbean Region*

Central America			
Belize Costa Rica El Salvador	Guatemala Honduras	Nicaragua Panama	*AIR Earthquake Model for Central America*

Europe and the Middle East			
Austria Belgium Bulgaria Cyprus Czech Republic Denmark Estonia Finland France (including Monaco)	Germany Greece Hungary Ireland Israel Italy Latvia Lithuania Luxembourg Netherlands Norway	Poland Portugal Romania Slovakia Slovenia Sweden Switzerland Turkey United Kingdom	*AIR Earthquake Model for the Pan-European Region*

North America	
Alaska	*AIR Earthquake Model for Alaska*
Canada	*AIR Earthquake Model for Canada*
Hawaii	*AIR Earthquake Model for Hawaii*
Mexico	*AIR Earthquake Model for Mexico*
United States (—Contiguous U.S.)	*AIR Earthquake Model for the United States*

South America	
Chile	*AIR Earthquake Model for Chile*
Colombia	*AIR Earthquake Model for Colombia*
Peru	*AIR Earthquake Model for Peru*

Venezuela	*AIR Earthquake Model for Venezuela*
Ecuador	*AIR Earthquake Model for Ecuador*

EXTRATROPICAL CYCLONE (WINTER STORM)

Europe			
Austria **Belgium** **Czech Republic** **Denmark** **Estonia** **Finland**	**France** (including Monaco) **Germany** **Ireland** **Latvia** **Lithuania** **Luxembourg**	**Netherlands** **Norway** **Poland** **Sweden** **Switzerland** **United Kingdom**	*AIR Extratropical Cyclone Model for Europe*
North America			
Canada			*AIR Winter Storm Model for Canada*
United States (Contiguous U.S.)			*AIR Winter Storm Model for the United States*

FLOOD, COASTAL

Europe	
Great Britain (Southeast England)	*AIR Coastal Flood Model for Great Britain*

FLOOD, INLAND

Europe	
Germany	*AIR Inland Flood Model for Germany*
Great Britain (England, Scotland, Wales)	*AIR Inland Flood Model for Great Britain*
Austria, Czech Republic, Switzerland	*AIR Inland Flood Model for Austria, Czech Republic, Switzerland*
United States	*AIR Inland Flood Model for the United States*

PANDEMIC

Global		
Australia **Canada** **France** **Germany**	**Japan** **United Kingdom** **United States** (50 states and Washington, DC)	*AIR Pandemic Model*

The AIR Pandemic model includes excess morbidity and mortality from outbreaks caused by: influenza viruses, coronaviruses, filoviruses, Rift Valley fever virus, Crimean-Congo hemorrhagic fever virus, Lassa fever virus, Vibrio cholerae, Yersinia pestis (plague), and Neisseria meningitidis (meningococcal meningitis).

AIR has the added capability, on a consulting service basis, of analyzing pandemic risk in other countries. All supported countries are listed in Section 1.1 of the model description document.

SEVERE THUNDERSTORM (TORNADOES, HAIL, STRAIGHT-LINE WIND)

North America	
Australia	*AIR Severe Thunderstorm Model for Australia*
Canada	*AIR Severe Thunderstorm Model for Canada*
United States (Contiguous U.S.)	*AIR Severe Thunderstorm Model for the United States*

TERRORISM

North America	
United States (50 states and Washington, DC)	*AIR Terrorism Model*

The AIR Terrorism Model has a model domain for the deterministic terrorism module that includes 28 countries (Australia, Belgium, Brazil, Canada, China, Colombia, France, Germany, Greece, India, Indonesia, Ireland, Israel, Italy, Japan, Kenya, Lebanon, Mexico, Netherlands, Philippines, Russia, Singapore, South Africa, Spain, Thailand, Turkey, United Kingdom, and the United States).

AIR has the added capability, on a consulting service basis, of analyzing terrorism risk in any country.

TROPICAL CYCLONE (HURRICANE, TYPHOON)

Asia-Pacific	
Australia	*AIR Tropical Cyclone Model for Australia*
China	*AIR Typhoon Model for Mainland China*
Guam, Hong Kong, Macau, Philippines, Saipan, Taiwan, and Vietnam	*AIR Typhoon Model for Southeast Asia*
India	*AIR Tropical Cyclone Model for India*
Japan	*AIR Typhoon Model for Japan*
South Korea	*AIR Typhoon Model for South Korea*

Caribbean and Bermuda			
Anguilla Antigua and Barbuda Aruba Bahamas Barbados Bermuda British Virgin Islands Cayman Islands Cuba Dominica	Dominican Republic Granada Guadeloupe Haiti Jamaica Martinique Montserrat Netherlands Antilles Puerto Rico St. Barthélemy	St. Kitts and Nevis St. Lucia St. Maarten St. Martin St. Vincent and the Grenadines Trinidad and Tobago The Turks and Caicos Islands U.S. Virgin Islands	*AIR Tropical Cyclone Model for the Caribbean*

Central America			
Belize Costa Rica El Salvador	Guatemala Honduras	Nicaragua Panama	*AIR Tropical Cyclone Model for Central America*

North America	
Hawaii	*AIR Tropical Cyclone Model for Hawaii*
Mexico	*AIR Tropical Cyclone Model for Mexico*

United States Alabama Arkansas Connecticut Delaware Washington, DC Florida Georgia Illinois Indiana Kentucky Louisiana Maine Maryland Massachusetts Mississippi Missouri New Hampshire New Jersey New York North Carolina, Ohio Oklahoma Pennsylvania Rhode Island South Carolina Tennessee Texas Vermont Virginia West Virginia	*AIR Hurricane Model for the United States*
United States Offshore (Gulf of Mexico)	*AIR U.S. Hurricane Model for Offshore Assets*
Canada	*AIR Tropical Cyclone Model for Canada*

WILDFIRE

Asia-Pacific	
Australia	*AIR Bushfire Model for Australia*
North America	
United States (California**)**	*AIR Wildfire Model for California*

2.9 Other Topics of Interest to Aid Understanding of AIR Models

The sections below provide information on topics that our clients have identified as being of particularly interest in their relation to ASOPs.

Developing the AIR Industry Exposure Databases

AIR commits considerable resources to the development and maintenance of the AIR industry exposure databases (IEDs).

The task of compiling and analyzing diverse data sets—risk counts, building characteristics, and construction costs from a host of data sources, in a variety of languages and resolutions, and of different vintages—is both time- and labor-intensive. The IEDs are generally updated concurrent with a model update. Clients should take note of the model and IED updates each June. One good source for this information is the model release notes posted on the client portal.

All new model documentation provides the data sources and methodologies used to develop the AIR industry exposure database (IED) for that country or countries. A description and summary statistics of the IED, along with detailed breakdowns of the IED by construction type, occupancy class, and age and height bands (where they apply) for different countries can be found in the documents listed below.

Table 2 Industry Exposure Database Documentation

Australia			*AIR Industry Exposure Database for Australia*
Caribbean and Bermuda			
Anguilla Antigua and Barbuda Aruba Bahamas Barbados Bermuda British Virgin Islands Cayman Islands Cuba Dominica	Dominican Republic Granada Guadeloupe Haiti Jamaica Martinique Montserrat Netherlands Antilles Puerto Rico St. Barthélemy	St. Kitts and Nevis St. Lucia St. Maarten St. Martin St. Vincent and the Grenadines Trinidad and Tobago The Turks and Caicos Islands U.S. Virgin Islands	*AIR Industry Exposure Databases for the Caribbean Region*
Europe and the Middle East			
Austria Belgium Bulgaria Cyprus Czech Republic Denmark Estonia Finland France (including Monaco)	Germany Greece Hungary Ireland Israel Italy Latvia Lithuania Luxembourg Netherlands	Norway Poland Portugal Romania Slovakia Slovenia Sweden Switzerland Turkey United Kingdom	*AIR Industry Exposure Databases for the Pan-European Region*
India			*AIR Industry Exposure Database for India*
Japan			*AIR Industry Exposure Database for Japan*

United States (50 states and Washington, DC)	*AIR Industry Exposure Database for the United States*
Canada	*AIR Industry Exposure Database for Canada*
South America	*AIR Industry Exposure Database for South America*
South East Asia Guam, Hong Kong, Indonesia Macau, Philippines, Saipan Singapore, Taiwan, Vietnam	*AIR Industry Exposure Database for South East Asia*

Due to the update schedule, some IEDs do not reflect the most current industry exposures; this is particularly true for countries experiencing rapid economic growth. Many of our clients have therefore asked for factors, or indexes, that can be applied to total industry exposure and account for recent changes. This document provides such indexes for select countries indexed to more recent values spelled out in the following documents:

Table 3 Industry Exposure Index Documentation

Country Level Index Factors	*AIR Industry Exposure Indexes for Select Countries*
County Level indexed Factors	***AIR Industry Exposure Index Factors for the United States***

Damage Function Development

All model documentation provides information about the development of damage functions for that particular model. However, for an excellent discussion of the complexities involved in the development of damage functions—including engineering expertise, region-specific knowledge of building codes, insurance practices and demographics, abundant damage and claims data, and a little art—and what they are meant to capture, clients are encouraged to read the *AIR Current: Modeling Fundamentals—Anatomy of a Damage Function*.

Estimating Business Interruption Losses

With the release of Version 9.0 of the AIR software systems in 2007, AIR significantly enhanced the methodology by which business interruption losses are calculated with the AIR Hurricane Model for the United States. In addition to direct business interruption (BI) losses due to loss of business income during the period of restoration, the enhanced damage function now includes indirect business interruption losses stemming from actions taken by civil authorities, loss of business income from dependent properties, and utility service interruption.

Since 2007, the enhanced modeling of BI losses has been extended to other models and it will continue to be rolled out as models are updated or added, and as the availability of data for validation makes possible its inclusion. In the meantime, those models that support the estimation of BI losses but that do not yet incorporate the new methodology, estimate BI losses arising only from direct physical damage to the structure.

A discussion of the implementation of the enhanced BI calculations is available in Section 5 of the full model documentation.

Fire Following Earthquake

Currently, the following AIR models feature a separate Fire Following Earthquake (FFE) module that uses dynamic simulation techniques to estimate fire losses probabilistically:

- *AIR Earthquake Model for Japan*

  Fire ignition rates are based on a process similar to that presented in Scawthorn (2009) for events in California. Fire spread is simulated using a cellular automata model that incorporates characteristic city blocks for the country. See Section 5 of the full model documentation for detailed discussions of the methodology used for estimating FFE damage.

- *AIR Earthquake Model for the United States*

  Fire ignition rates are based on historical data. Fire spread is simulated using a cellular automata model that incorporates characteristic city blocks for the country. See Section 5 for detailed discussions of the methodology used for estimating FFE damage.

- *AIR Earthquake Model for Canada*

  Fire occurrences are modeled using a dynamic simulation of the fire in the local build environment. The behavior of a fire is simulated for its entire lifespan: from ignition and spread to burnout or suppression. Section 5 contains detailed discussions of the methodology used for estimating FFE damage.

Liquefaction

When an earthquake strikes an area that is saturated with groundwater, the shaking can cause the soil to lose its stiffness due to increased water pressure, and behave like a heavy liquid. When this happens, the soil loses its capability to support structures. The following AIR earthquake models include explicit modeling for liquefaction:

- *AIR Earthquake Model for the United States*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Japan*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Canada*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for India*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Southeast Asia*

  The AIR Earthquake Model for Southeast Asia includes a liquefaction component covering the countries/territories of Hong Kong, Indonesia, Macau, the Philippines, Singapore, Taiwan, and Vietnam. See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Australia*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for the Chile*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Colombia*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Ecuador*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Peru*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

- *AIR Earthquake Model for Venezuela*

  See Section 4 for detailed discussions of the methodology used to estimate liquefaction intensity. For the methodology used to estimate liquefaction damage, see Sections 5.

Landslide

The main objective of regional earthquake-triggered landslide hazard analysis is to evaluate the location of the areas where landslides can be triggered by future earthquakes. The susceptibility of an area to earthquake-triggered landslides can be assessed based on potential ground motion, and geological and topographical conditions. The following AIR earthquake model includes explicit modeling for landslides:

- *AIR Earthquake Model for the United States*

  See Section 4 for detailed discussions of the methodology used to estimate landslide intensity. For the methodology used to estimate landslide damage, see Sections 5.

- *AIR Earthquake Model for Canada*

  See Section 4 for detailed discussions of the methodology used to estimate landslide intensity. For the methodology used to estimate landslide damage, see Sections 5.

Tsunami

Currently, the following AIR models feature a separate tsunami module that uses dynamic simulation techniques to probabilistically estimate tsunami intensity and damage:

- *AIR Earthquake Model for the United States*

  See Section 4 for detailed discussions of the methodology used to estimate tsunami generation and intensity. For the methodology used to estimate tsunami damage, see Sections 5.

- *AIR Earthquake Model for Japan*

  See Section 4 for detailed discussions of the methodology used to estimate tsunami generation and intensity. For the methodology used to estimate tsunami damage, see Sections 5.

- *AIR Earthquake Model for Southeast Asia*

  The AIR Earthquake Model for Southeast Asia models tsunami risk to the countries and territories of Indonesia, the Philippines, and Taiwan. See Section 4 for detailed discussions of the methodology used to estimate tsunami generation and intensity. For the methodology used to estimate tsunami damage, see Sections 5.

- *AIR Earthquake Model for Canada*

  See Section 4 for detailed discussions of the methodology used to estimate tsunami generation and intensity. For the methodology used to estimate tsunami damage, see Sections 5.

- *AIR Earthquake Model for the Chile*

  See Section 4 for detailed discussions of the methodology used to estimate tsunami generation. For the methodology used to estimate tsunami damage, see Sections 5.

- *AIR Earthquake Model for Colombia*

  See Section 4 for detailed discussions of the methodology used to estimate tsunami generation. For the methodology used to estimate tsunami damage, see Sections 5.

- *AIR Earthquake Model for Ecuador*

  See Section 4 for detailed discussions of the methodology used to estimate tsunami generation. For the methodology used to estimate tsunami damage, see Sections 5.

- *AIR Earthquake Model for Peru*

  See Section 4 for detailed discussions of the methodology used to estimate tsunami generation. For the methodology used to estimate tsunami damage, see Sections 5.

Storm Surge

Currently, storm surge is explicitly modeled within the AIR Hurricane Model for the United States and the AIR Tropical Cyclone Model for Australia, while it is a free-standing peril for Great Britain. Model documentation can be found at the following links:

- *AIR Hurricane Model for the United States*

  The storm surge module is a fully probabilistic component of the AIR Hurricane Model for the United States. Descriptions of methodology used for storm surge generation are provided in Section 3, local intensity estimation in Section 4, and damage estimation in Section 5.

- *AIR Typhoon Model for Japan*

  Storm surge is modeled dynamically with inland extent and inundation depth, and incorporates tidal phase, amplitude and temporal variability. Descriptions of methodology used for storm surge generation are provided in Section 3, local intensity estimation in Section 4, and damage estimation in Section 5.

- *AIR Typhoon Model for Southeast Asia*

  The storm surge module is a fully probabilistic component of the AIR Typhoon Model for Southeast Asia for the countries of the Philippines, Taiwan, and Hong Kong. Descriptions of methodology used for storm surge generation are provided in Section 3, local intensity estimation in Section 4, and damage estimation in Section 5.

- *AIR Tropical Cyclone Model for Australia*

  Storm surge is modeled dynamically with inland extent and inundation depth, and incorporates tidal phase, amplitude and temporal variability. Descriptions of the methodology are provided in Section 4, while damage estimation is provided in Section 5.

- *AIR Coastal Flood Model for Great Britain*

  Storm surge is modeled separately and described in the full model documentation for Great Britain, which covers storm surge in southeastern England.

  For other tropical and extratropical cyclone models, storm surge losses are captured implicitly to the extent that modeled losses have been calibrated to and validated against loss experience data that include losses from storm surge.

Demand Surge

Documentation on the AIR demand surge function and its validation is described in the AIR document *AIR Demand Surge Function.*

Note that the current default AIR demand surge function was developed using economic principles and validated based on U.S. loss levels and component cost analyses, as described in this document. Because demand surge is a phenomenon seen only with especially large catastrophes, there are relatively few events with which to validate demand surge functions outside of the U.S. This scarcity of data is further complicated by the relative paucity of cost indexes and detailed data. Nevertheless, development of country/region demand surge functions is currently underway at AIR. These will depend on, among other things, the size of local and national labor markets and thus their ability to accommodate excess demand, and augmented by other labor, material, and construction indexes as available. The functions will reflect the interaction between supply and demand of rebuilding resources, and will be scalable to suit local economies.

In the meantime, for countries other than the U.S., clients may choose to apply the U.S. demand surge function or a user-defined demand surge function, at their discretion. Clients are also encouraged to perform sensitivity testing to better understand the scale of impact and uncertainty inherent in applying demand surge to non-U.S. models and perils.

2.10 Other Resources to Aid Understanding of AIR Models

AIR is committed to ensuring that our clients derive maximum value from the models and software they license. To that end, AIR offers a multi-tier approach to technical support that includes on- and off-site training and telephone support. AIR also offers the *AIR Institute Catastrophe Modeling Certification Program*—an intensive course designed to meet the industry's growing need for skilled catastrophe risk modelers and managers.

AIR also sponsors various Client Conferences which are great opportunities for our clients to learn about models for different perils, latest model updates and best practices of using AIR software. Throughout the year, AIR sponsors webinars to introduce new models, explain model updates, and discuss other relevant topics, all of which will benefit the users.

Extensive software documentation is available, including Touchstone and CATRADER User Guides, and guides for input data preparation. In addition, AIR has recently introduced a new genre of documentation for regions with complex policy conditions or cat pools. These "Using the Model" guides explain in detail how to use the AIR models in Touchstone and CATRADER, including any special instructions on importing data and running an analysis. Currently available are:

- *Using the AIR Earthquake Model for Japan*
- *Using the AIR Earthquake Model for the Pan-European Region*
- *Using the AIR Inland Flood Model for Great Britain*
- *Using the AIR Inland Flood Model for the United States in Touchstone*

- *Using the AIR Multiple Crop Insurance (MPCI) Model for China (V19)*
- *Using the AIR Multiple Crop Insurance (MPCI) Model for the United States (V.17.0)*
- *Using AIR's US Crop Hail Model in Catrader*
- *Using the AIR Typhoon Model for Japan*
- *Using the AIR Hurricane Model for the United States in Touchstone*
- *Using the AIR U.S. Hurricane Model for Offshore Assets*

More information on AIR's approach to training and technical support can be found on the Support Overview page of the AIR website. Support contact information can be found on the Client Portal.

Information about the AIR Institute Catastrophe Modeling Certification Program can be found at the AIR Institute page.

3 Model Uncertainty and Model Limitations

Actuaries using complex models, such as catastrophe models, should determine the appropriateness of the model for the intended application. ASOP 38, Section 3.4, indicates that the actuary *"should evaluate whether the model is appropriate for the particular actuarial analysis, and consider limitations of the model, modifications to the model, and the assumptions needed in order to apply the model output".*

Catastrophe models have become increasingly sophisticated since they were first introduced in the late 1980s. The models operate at ever higher resolutions (made possible by almost exponential increases in computing power); the scientific understanding of the physical phenomena of natural hazards continues to evolve and become more refined; and the availability of data used for both model development and model validation continues to increase. Nevertheless, translating model results into informed decision making requires a balanced understanding of uncertainty in model assumptions and parameters, and a judicious awareness of the limitations of modeling.

Several of these limitations are briefly discussed in the following sections.

3.1 Model Uncertainty

Catastrophe models are developed based on assumptions about complex physical phenomena of which there is imperfect understanding, and the observed data for model calibration is limited, particularly in regions of very low frequency of catastrophic events. There are multiple sources of uncertainty in catastrophe models and these can typically be grouped into two main classes; aleatory and epistemic.[3]

Aleatory uncertainty represents the inherent uncertainty due to the random nature of a physical or financial process. It should be expected that even as our knowledge of the process increases over time, aleatory uncertainty will never decrease, but we may acquire better tools for its measurement. The second source of uncertainty is epistemic, which results from lack of knowledge. This is

[3] See the *AIR Current* Understanding Uncertainty for a discussion of key concepts in understanding uncertainty in catastrophe loss estimation, including its various sources.

commonly manifested by uncertainty in the choice of the form of the model, known as model uncertainty, and in the estimation of parameters, known as parametric uncertainty.

Model uncertainty can be illustrated by the choice of whether the recurrence of earthquakes on faults is treated as time dependent or time independent, or by whether the current climate is considered to be stationary. Parametric uncertainty relates often to scarcity of data in the estimation of model parameters, particularly in non-active regions.

For additional information, please refer to the published document, *AIR Interim Guidance on Solvency II Compliance: Model Assumptions and Limitations.* This document consolidates general assumptions that apply across all AIR models and on specific key assumptions incorporated in the following AIR models:

- AIR Hurricane Model for the United States
- AIR Earthquake Model for the United States
- AIR Inland Flood Model for the United Sates
- AIR Severe Thunderstorm Model for the United States
- AIR Winter Storm Model for the United States
- AIR Extratropical Cyclone Model for Europe
- AIR Earthquake Model for Japan
- AIR Typhoon Model for Japan
- AIR Earthquake Model for Canada
- AIR Tropical Cyclone Model for the Caribbean
- AIR Tropical Cyclone Model for Hawaii

3.2 Modeled and Non-modeled Perils

Misunderstandings can occur when there is a lack of clarity about what the loss estimates produced by catastrophe models include or do not include. In some cases, associated perils that are not explicitly modeled may be captured—at least in some degree—implicitly, to the extent that modeled losses have been validated against actual claims data that may include these sources of loss. It should be noted, however, that even for some explicitly modeled perils, such as fire-following earthquake losses, the relative scarcity of detailed claims data necessarily leads to greater uncertainty in the loss estimates. These issues are discussed in greater detail the *AIR Solvency II Reference Guide.*

AIR also contributed to the good practice guide published by the Association of British Insurers, *Non-Modelled Risks—A guide to more complete risk assessment for (re)insurers.* A key part of AIR's contribution to the paper included techniques that can be used in risk quantification, for example the geospatial capabilities available in AIR's open platform Touchstone. These techniques are of particular interest for the assessment and management of non-modeled aspects of global catastrophe risks.

In all of the AIR's new model documentation, clients can find out what perils and sub-perils are explicitly modeled and what related perils and sub-perils are not modeled in Section 1, "Facts at a Glance" of the full model documentation, under "Modeled Perils." For example, the AIR Earthquake Model for Japan includes losses arising from ground shaking, liquefaction, fire following, and tsunami. Landslides associated with earthquakes are not explicitly modeled in the AIR Earthquake Model for Japan; however, as modeled losses have been calibrated to and validated against actual reported losses, the impact of landslides on modeled losses is captured implicitly. The 2014 release of the AIR Earthquake Model for Canada features explicit modeling of earthquake-induced landslides. It is advisable for actuaries and risk managers to create a list of non-modeled perils that are material to your business. A truly exhaustive list may be impractical as some non-modeled sources will be very local in their nature and difficult to identify.

3.3 Other Non-modeled Sources of Loss

In addition to secondary perils associated with the primary modeled peril, there may be other non-modeled sources of loss. AIR modeled losses, for example, do not explicitly include losses arising from the following sources:

- Loss Adjustment Expense
- Hazardous Waste Cleanup
- CAT Pool Assessments

In this context, AIR clients should be aware that AIR's demand surge function reflects economic inflation only. It does not account for other factors that may increase insured losses in the aftermath of a catastrophe, such as those above or insurance-to-value issues. These factors may cause higher losses than expected, but do not constitute demand surge. In addition, it is not correct to use a single factor to adjust for insurance-to-value or hazardous waste clean-up, as the correct adjustment for these issues is heavily dependent on the type of business a company writes. If further adjustments to loss estimates are required due to such issues, AIR clients have the option to manually modify the demand surge function, as well as the application of other loss adjustment factors. To resolve insurance-to-value issues, clients also have the option of using various AIR and ISO solutions to obtain more accurate replacement values for insured residential and commercial properties.

3.4 Limitations with Respect to Lines of Business, Occupancy Classes and Coverage

All of AIR's new model documentation includes detailed information about supported lines of business, coverage, construction types and occupancy classes. Information about supported lines of business can be found in Facts at a Glance in Section 1 of the model documentation. For information about modeled coverage, construction types, and occupancy classes, clients are referred to the sections in the full model documentation devoted to the model's implementation in CATRADER and Touchstone. In most cases, these are Sections 7 and 8 of the model document. (Note that AIR's capabilities for estimating losses to workers' compensation, personal accident and life policies are not offered by way of separate models; rather these are supported lines of business in some earthquake models and in the U.S. terrorism model.)

Modeled loss estimates for some occupancy classes and lines of business are characterized by more uncertainty than others—uncertainty that is primarily a function of the relative scarcity of available detailed damage and loss data for the development and validation of damage functions. Railways, dams, and life-lines, for example, fall into this category.

AIR has recently introduced sophisticated capabilities for estimating losses to highly complex industrial facilities in the U.S. for the earthquake and hurricane perils (see Section 6 in the model documentation for those perils). These models feature more than 400 unique damage functions for industrial components ranging from pipe racks, to flares, to tanks—distinguishing between anchored and unanchored components, and full or partially full tanks, for example. While these damage functions have been developed using site-specific risk assessments, advanced engineering studies, materials tests, and post-disaster field survey data, there remains a higher level of uncertainty in the loss estimates for these occupancies relative to residential and small commercial properties for which claims data is relatively abundant. (For more information on modeling industrial facilities, see the ***AIR***

Current A More Rigorous Approach to Assessing Catastrophe Risk for Industrial Facilities or the *Modeling Industrial Facilities* software documentation.)

Similarly, AIR has introduced capabilities in the earthquake and typhoon models for Japan for the estimation of losses to a variety of specialized risks such as railway systems, marine cargo, marine hull (including marine hull under construction), aviation, transit warehouses, and personal accident. Many of AIR's models, including the earthquake and hurricane models for the United States, the earthquake model for China, and the all of the typhoon models for the Northwest Pacific Basin (Japan, China, South Korea, and Southeast Asia) support loss estimation for buildings currently under construction. Actual observations of damage from past catastrophes as well as published research are used to develop damage functions for these exposures and, where appropriate, their contents. However, due to the complexity of the underlying risks, a scarcity of detailed claims data and, equally important, an inadequate degree of detail in the underlying exposure data available as input to the model, there is higher degree of uncertainty surrounding the loss estimates for these risks.

Detailed business interruption (BI) policy conditions and property characteristics are often not available to the user for input into a catastrophe model. For example, information on whether a policy includes coverage for dependent building(s) damage, their locations, and the degree of dependency between locations is generally not available. In addition, detailed BI and contingent BI (CBI) claims data is relatively scarce. AIR's methodology for modeling BI and CBI coverage employs network models that construct a simulation of the interconnections between the principal business, supply chains and lifelines, as well as logical assumptions about occupancy and the characteristics of "typical" BI policies to model total BI losses for any given occupancy and the variation in BI losses across different occupancies (see Section 5 of the relevant model's documentation). Nevertheless, companies should recognize the additional uncertainty with respect to modeled loss estimates for the BI and CBI coverage.

4 Data Input

Evaluating the quality and availability of user input data to be used in catastrophe models is an important requirement for ASOP compliance. ASOP 38, Section 3.3.2, explains, *"The actuary should understand the user input that is required to produce the model output. This understanding includes the level of detail required in the user input to produce the results that are consistent with the intended use of the model."*

ASOP 38 also refers actuaries to ASOP 23, *Data Quality*, for further guidance on quality and availability of the model user input data. High quality data is the key to any actuarial analysis. The standard requires actuaries to check data for consistency and reasonableness as well as accuracy and comprehensiveness. As stated in ASOP 23, Section 3.5(b), *"the actuary should review the data used directly in the actuary's analysis for the purpose of identifying data values that are materially questionable or relationships that are materially inconsistent."* Section 3.7 of ASOP 23 goes on to say that actuaries should use their professional judgment to determine: "*if the data are of sufficient quality to perform the analysis"* and/ or if "*the data requires enhancements before the analysis can be performed".*

4.1 Exposure Data Elements

Exposure data quality remains a key issue in catastrophe risk management. Accurate model output is highly dependent on the correct coding of risks. For example, significant underestimation of catastrophe losses can occur when limits are input in lieu of the replacement values, or when necessary coding for coverage of storm surge damage is missing. AIR models will assume that the correct replacement value of a structure is known and that the proper policy terms are used as input.

AIR's industry-level loss estimates rely on accurate replacement values, risk counts, and take-up rates, about which there is considerable uncertainty in many regions of the world. Depending on when the industry exposure database (IED) was last updated for each country, companies who use AIR industry loss estimates for decision making may wish to adjust those losses to reflect economic growth, construction booms, and changes in the insurance landscape.

Exposure data contains all the information which describes the physical and financial characteristics of the property under consideration.

There are three primary types of exposure data:

- **Location information** includes latitude, longitude, street address, ZIP Code, city, county, and state.

- **<u>Replacement Value</u>** is the cost to replace a risk should it be damaged or destroyed. This includes damage to a building (Coverage A and Coverage B) and its contents (Coverage C) as well as any cost due to loss of use (Coverage D). Note true replacement value is different from the coverage limits of a policy and also is different from market value.

- **<u>Primary Risk Characteristics</u>** of a building include the construction type and occupancy class of a building. It also includes other risk characteristics such as year built, number of stories, and special building modifiers to help protect against perils such as earthquake, hurricane, and severe thunderstorm damage. Vulnerability functions have been developed by AIR to account for many building characteristics in the calculation of damage.

Exposure data elements available for all modeled perils can be found in the associated model documentation. In the models, damage is calculated based on physical characteristics of structure. Construction and occupancy classifications form the basis of the damage functions in the model. When primary risk characteristic information is not available, you should make reasonable assumptions based on your understanding of the exposure data.

Damage functions are also developed to account for additional secondary risk characteristics. The AIR Individual Risk Module is used to modify damage functions of basic structural characteristics to account for the contribution of secondary risk characteristics on overall building performance. Secondary risk characteristics include features such as roof covering, roof shape, the presence or absence of storm shutters, foundation, and soft stories. Information about available secondary risk characteristics for modeled perils can be found in the associated model documentation.

4.2 Importing Exposure Data into AIR Software

Touchstone supports import of real and personal property exposure data as well as workers' compensation data. Using the AIR ImportExpress™ tool in Touchstone, users can import contract and exposure data from external sources into AIR Touchstone CEDE 2.0 databases, regardless of the format of the source. To learn more about mapping exposure data columns for importing in to Touchstone using AIR ImportExpress, please refer to the *<u>Column Heading Automapping for CSV Import</u>* section of the *<u>Touchstone Online Help</u>*.

AIR ImportExpress supports the following data formats:

- Almost any custom, client-specific data format saved as a text file
- AIR's open-source data formats, UNICEDE®/ (PX/FX)
- RMS's EDM exposure databases
- Standardized industry exposure data formats (ACORD Binding Authority); Touchstone does not support ACORD reports of Workers' Compensation fields
- CEDE 1.0 databases created for use with AIR's CLASIC/2 software

CEDE 2.0 databases are the optimal format for importing exposure data into Touchstone for loss analysis. AIR has openly published this non-proprietary schema design to ease the process of transferring catastrophe exposure data between users and companies, ensuring that everyone who needs access to your data will also be able to easily understand it. To learn more about the Touchstone database schema, including information about how Touchstone databases compare to its CLASIC/2 counterpart (CEDE 1.0), please refer to the *<u>Touchstone Database Overview</u>* online helptext.

UNICEDE/(PX/FX), or UPX, files also contain all of the exposure data necessary for performing analyses using Touchstone, CLASIC/2 or CATStation analyses. The UNICEDE/(PX/FX) Preparer's Guide contains itemized and detailed explanation of all the potential components of a UPX file, to help you prepare, revise or read these files. Please note that a searchable, online help version of the Preparer's Guide is available at www.unicede.com.

Other ways of importing the data include Location Spreadsheet Import and manual entry.

4.3 Understanding Data Uncertainties and Performing Data Quality Checks

Data uncertainties stem from missing, unknown and imperfect exposure data. Some common areas of uncertainties include geographic location, replacement values and the categorization of the risks with regard to vulnerability.

Model results are sensitive to the accuracy of geographic data. Catastrophe models compute the intensity of hazard at a given location (e.g. wind speed or ground motion intensity) depending on the latitude/longitude of the exposure. The modeled loss is more accurate when more detailed location-specific address information is provided. Users should always aim to have the highest resolution geographic data to ensure the most accurate results. When you import and geocode your exposure data in Touchstone, the import log will show the number of records that were imported and geocoded correctly. Users are encouraged to use online resources to complement their exposure data gaps or correct any mistakes that may exist in the address information. Furthermore, modeled loss estimates for any single location is very sensitive to geocoding precision, however, if your book is well-distributed across ZIP Codes, the resulting loss estimate may not be greatly affected by postal code centroid geocode precision for the whole portfolio.

The replacement value is an estimate of the cost to repair or replace a building damaged or destroyed. The estimate can be derived in a variety of ways, ranging from a professional building inspection to replacement cost estimators. Replacement values are important because estimated ground-up losses are calculated directly from the replacement value. There are a lot of uncertainties around the replacement value, for example if books do not keep pace with construction cost changes or limits are reported in place of replacement values. Users of the model are encouraged to perform data audits and do reasonability checks to eliminate those areas of uncertainties.

In the context of inputs to catastrophe models, a risk's vulnerability to damage is captured primarily in the input fields which characterize a risk's physical features. In the models, damage is calculated based on the physical characteristics of the structure. Construction and occupancy classifications form the basis of the damage functions in the model. Damage functions are also developed to account for additional characteristics, including year built, height, and secondary risk characteristics. Users are encouraged to perform sensitivity tests on these characteristics to get a good sense of the loss estimate volatility based on these characteristics.

Due to the uncertainties discussed above, we encourage users of our model to do reasonability checks before any data import. Prior to running a loss analysis, model users should always create (and review) a data quality summary report for the exposures being analyzed. This will enhance the model users' understanding of the exposure data structure, and help to identify any weaknesses in the exposure data, such as the number of risks coded with unknown characteristics. The Exposure Summary Dashboard in AIR's Touchstone software platform also provides a graphical report that enables model users to quickly assess the strengths and weaknesses of exposure data. Some examples of statistics to include in an exposure data quality summary report are:

- Compare the total replacement value (by coverage) and the number of risks against what is expected in the exposure data
  Create an overview of the exposure's key characteristics, such as proportion of replacement value by construction, occupancy, number of stories, and year built

- Summarize the totals related to policy conditions, such as total number of layers, reinsurance contracts, and total sum of limits and deductibles
- Compare the split of replacement value by geocode match (e.g. exact address or postcode centroid).

4.4 Dealing with Gaps in Data and Augmenting Data Quality

Touchstone's Data Quality diagnostic tools enable users to determine the strengths and weaknesses of the exposure data that has been imported for portfolio-level catastrophe loss analysis. If any data elements are missing or weak, the Data Quality tools are available to assist in supplementing the exposure data. To learn more about improving the quality of exposure data using Touchstone's Data Quality diagnostic tools, please refer to the document *Using Data Quality Analysis in Touchstone* or the *Data Quality Analysis* section of the *Touchstone Online Help*.

5 Model Output

ASOP 38 mandates that actuaries should ensure model output is applicable for its intended use. Further, it is the responsibility of the actuary to ensure the model output has been validated for reasonability, given the intent of its application. Section 3.3.3 states, *“the actuary should determine that the model output is consistent with the actuary’s use of the model”.* Later in ASOP 38, Section 3.5.2, states that, “*in view of the intended use of the model, the actuary should examine the model output for reasonableness”*. It goes on to say the actuary should consider factors like, “*the consistency and reasonableness of relationships among various output results”.* AIR models provide a range of outputs that can be utilized in different areas. The user should examine the model output for reasonableness and also relative to its intended use.

5.1 List of Common Model Output

The Probability Distribution of Losses (EP curve)

The EP curve is a ranking of simulated event losses and is used to quantify a complete risk profile. In general:

Exceedance probability of the nth highest loss = n/ [years in simulation]

Loss Exceedance probabilities are provided on both an annual aggregate and annual occurrence basis. An annual aggregate loss is the sum of the losses caused by all simulated events in a given single year. The probability distribution of annual aggregate losses displays the probability of experiencing aggregate losses of specified amounts resulting from all events in a given single year. These distributions provide the most comprehensive view of risk, and can be used in pricing, underwriting, portfolio management, and aggregate risk transfer decisions. An annual occurrence loss is the largest loss caused by a single simulated event in a given year. The probability distribution of annual occurrence losses displays the probability of experiencing losses of specified amounts resulting from a single event in a given single year. These distributions can be used in making decisions regarding individual occurrence limits and retentions for catastrophe reinsurance.

One important clarification to make is the concept of a return period. For example, the annual probability of exceeding a hurricane Katrina sized loss (approximately USD 48 billion) in the U.S. is roughly 5%, which translates to a return period of one in twenty years (1/.05). This does not imply that a Katrina sized hurricane is expected to occur in the U.S. once every twenty years. Instead, this indicates that there is a 5% probability that the U.S. will incur *at least* USD 48 billion of hurricane related insured losses *in any given year*.

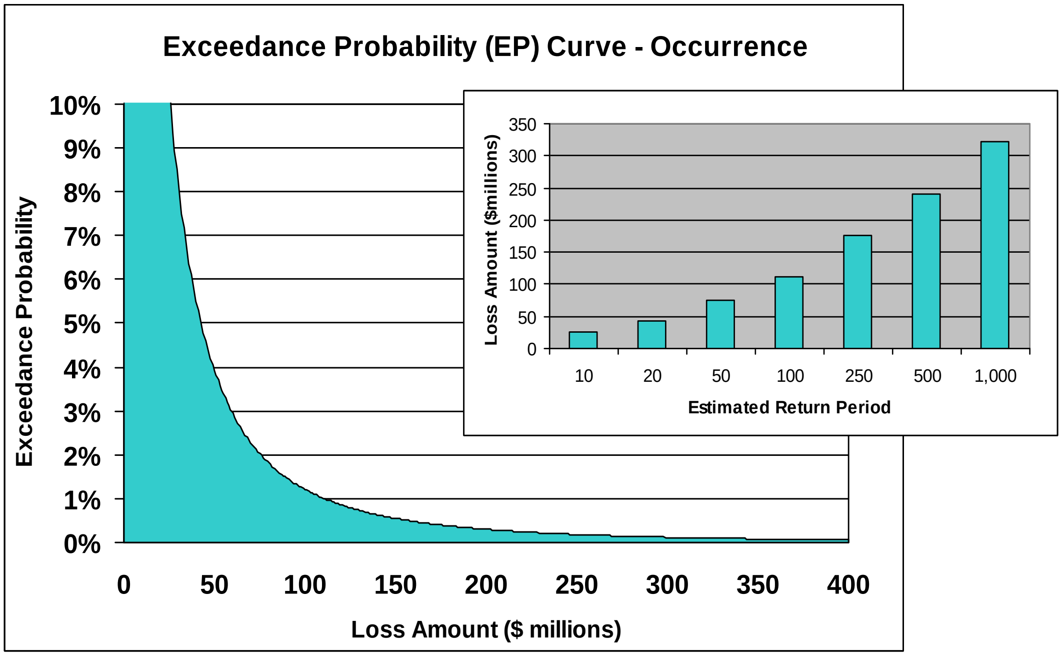

Figure 2 Exceedance Probability Curve

Event Loss Summary Detail Table

This table in the Touchstone user interface (or export) displays more detailed information about each of the events generated by the standard (probabilistic) loss analysis. This information allows users to assess the impact of large loss scenarios on a portfolio and also to dig into what type of event causes that size of losses to a portfolio. By default, the table displays stochastic events; however, you can also view historical and world scenario event losses by selecting them in the Events Detail section of the ribbon.

Table 4 below contains Event Loss Summary Table detailed information:

Table 4 Touchstone Event Loss Summary Table Detailed Information

Item	Description
Year	The year for the event based on the number of years simulated. It is a simulation year only and does not represent an actual date.
Event ID	The event identification number for the simulated event

Peril	The peril type for the simulated event
Ground-Up Mean Loss	The ground-up loss generated by the simulated event
Retained Mean Loss	The retained loss generated by the simulated event
Pre-Layer Gross Mean Loss	The pre-layer gross loss generated by the simulated event
Gross Mean Loss	The gross loss generated by the simulated event
Net of Pre-Cat Mean Loss	The net of pre-Cat loss generated by the simulated event
Post-Cat Net Mean Loss	The post-Cat Net loss generated by the simulated event
Event information	The intensity, magnitude, or other information about the event, along with the associated industry loss

Average Annual Loss

Average annual losses (AAL) by line of business, by coverage, by geographical area or by user defined category. “Average loss” is the long-term average loss, on either an aggregate or occurrence basis. It is calculated by using either the aggregate total losses or maximum occurrence losses for all the simulated years and then dividing by the number of years in the simulation. This information is usually used for ratemaking purposes. Users can use this to determine a catastrophe load by defined category or for studies to determine the best areas for expansion or retraction from a catastrophic point of view.

Event Footprints

For each individual event, our software provides detailed graphical and other key information about the event. For a hurricane event, this includes track information, landfall, and magnitude, radius of maximum winds, central pressure, and maximum wind speed. For an earthquake event, this includes magnitude, location, type of the fault, depth and source area. The figure below shows an example of a hurricane track map for Hurricane Katrina. By examining this map, we can compare the tracks of events of certain losses against the exposure data.

Figure 3 Sample Touchstone Hurricane Event Map

Estimates of Uncertainty

The EP Curve with Secondary Uncertainty' analysis feature in Touchstone allows users to display additional uncertainty. However, the user should be aware that the financial module always accounts for secondary uncertainty in loss calculations. The difference is that the EP Curve with secondary uncertainty is constructed using the secondary uncertainty around each event, whereas the Standard EP Curve uses the mean of each event distribution.

The uncertainties estimated by different model components are referred to as Primary (parameter/process) and Secondary (parameter) uncertainty (see Figure 4 below). Primary uncertainty refers to uncertainty in the modeling and estimation of the natural peril physical parameters that are included in an event catalog. Secondary uncertainty is the uncertainty in structural damage estimation, which is also referred to as the uncertainty in losses given an event has occurred.

Consider putting in section about location level intensities?

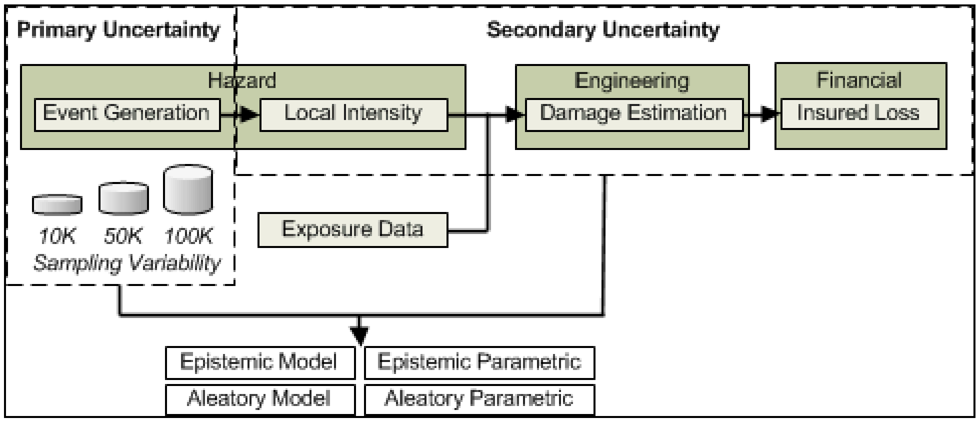

Figure 4 Primary and Secondary Uncertainty in the Model Architecture

To understand more about technical aspects related to the Touchstone Financial Module, including modeling uncertainty, please refer to the document: *Touchstone Financial Module.*

5.2 Independent Tests on Data Output

As noted above, users should understand the uncertainty in model assumptions and parameters, and be cognizant of the limitations of modeling. This section lists a few tests users of the model can do to understand the impact of assumptions inherent in an analysis as well as the uncertainties with the model results.

5.2.1 Testing Sensitivity to Alternative Catalogs

AIR has provided alternative catalogs that clients use to test the sensitivity to their loss result.

For the hurricane peril, for example, companies can choose to run AIR's standard or warm sea-surface temperature (WSST) conditioned catalog. While both represent views of long-term risk, the WSST catalog is developed based on only those years since 1900 in which sea-surface temperatures were warmer than average. Not surprisingly—since hurricanes are fueled by warm ocean waters—the WSST catalog incorporates higher rates of tropical cyclone activity. However, the relative impact of these two catalogs varies by region.

In the case of earthquake risk, clients can choose to run their exposure through the time-independent or the time-dependent catalog. In time-dependent models of earthquake occurrence, the probability that an earthquake will occur on a particular fault increases with the length of time elapsed since the previous event on that fault, while in time-independent models the probability of an earthquake is independent of when the last event occurred.

5.2.2 Validation of Company Claim Information Using Historical Events Set

AIR encourages all levels of model validation by clients and is readily available to guide the process. Clients can use historical catalogs provided in the software to test their book/locations and validate their own company loss experience claim data. If historical company claims data is used, this data must be trended or adjusted to current level accounting for both exposure growth and inflation.

Note, however, that there are several factors that impact the actual losses in an event, some of which are accounted for in the model and some of which cannot be accounted for given the nature of the input data and the limitations of any model. Additionally, there are limitations to the conclusions that can be drawn about the differences between actual and modeled losses due to the limited amount of exposure and loss data being contemplated. As a result, it is expected that losses output by a catastrophe model will differ, in many cases significantly, from actual losses for a client's book. However, if the output is consistently higher or lower than the model output, clients are encouraged to research causes of the difference. For example, clients should take care to identify sources of loss not covered by the modeled event, such as contingent business interruption, loss adjustment expense, hazardous waste cleanup, offshore assets, among others. Significant differences between actual and modeled losses can also result from exposure data quality issues. Additionally, clients should have an understanding of how robust the modeled parameters are for the given event. As an example, Hurricane Andrew was upgraded from a Category 4 to Category 5 storm ten years after the event occurred due to limited wind speed measurements observed at the time of the event. AIR research staff and consultants are available to work with clients to understand the limitations and uncertainty inherent in modeled event parameters and how your book of business may be impacted.

5.2.3 Reasonability Test Using Industry Exposure

Industry exposures are incorporated in CATRADER. Clients can input their exposure data into CATRADER as sums insured, and CATRADER will use the information to calculate the company's share of estimated industry losses. A comparison can be made against the users detailed loss estimates from Touchstone for reasonability/benchmark checking. (See the example results graphs below). However, some differences to note are:

- Differences in underlying exposure databases (Company versus market share)
- Deductibles and limits (Market share average versus policy specific)
- Embedded sub-perils (i.e. storm surge, tsunami, etc.)

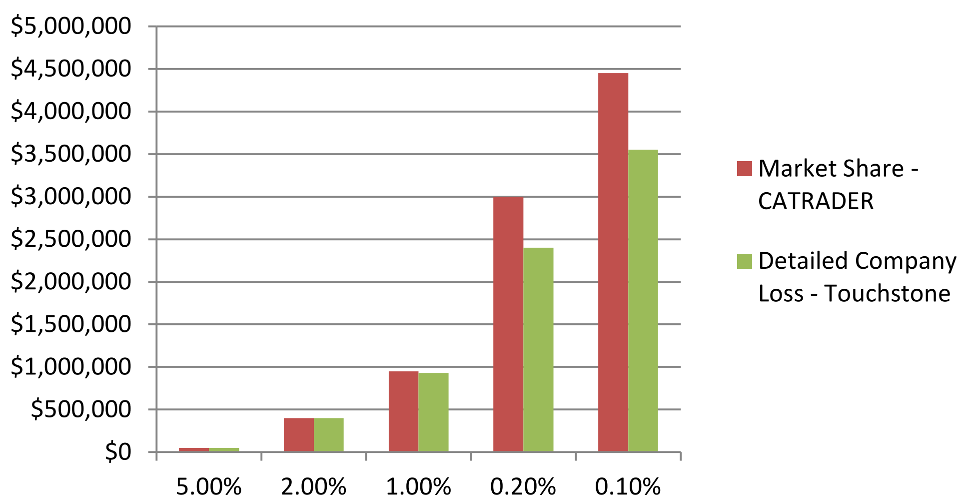

Figure 5 Reasonability Test Using Industry Exposure

From the above comparison, we can tell the company's data aligns with industry results very well. There are some differences at the tail. Further comparison down to the county level (see Figure 6 below) shows a large difference between the market share results produced by CATRADER and the detailed company loss result produced by Touchstone for Barnstable County. For this county, the modeled company losses are much lower than the market share losses, indicating the company may have been conservative in their business underwriting. If this analysis result is in line with the company underwriting strategy, then the user can be more confident in the cat loss analysis results.

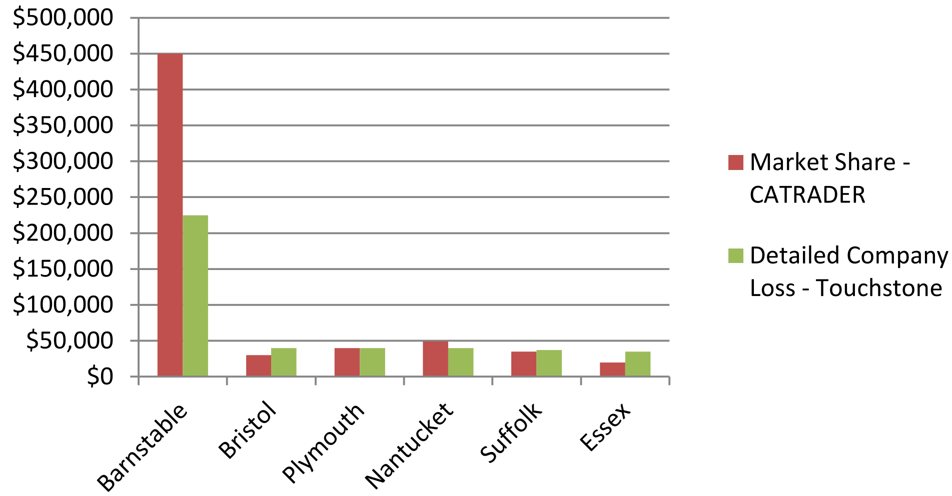

Figure 6 County Level Reasonability Test

5.2.4 Common Sensitivity Tests

Companies should always strive to understand the sensitivity of modeled loss results to changes in key assumptions. AIR encourages companies to perform their own sensitivity testing both within and external to the AIR software.

A list of some common sensitivity tests are:

- **Building Characteristics**: The sensitivity of loss results can be tested in a variety of ways based on differing primary and secondary risk characteristics. As an example, companies can create notional portfolio of a single construction type and then vary other parameters incrementally. Clients can also perform other cost-benefit analyses such as examining loss sensitivity when exposures are bulk coded or left as unknown. Testing the impact by altering secondary risk characteristics can also promote a better understanding of their complex interaction on modeled losses.

- **Storm Surge for Hurricane Peril**: The default storm surge factor for residential book is 10%. The increase in losses due to storm surge for specific book and exposure may seem linear; however, AIR's storm surge footprint is independent of the wind field and takes into account all the physical parameters of surge.

- **Demand Surge:** Demand surge is a check box on the analysis options screen. Users can use the AIR provided default demand surge curve or change it to incorporate different views from the management team to test on specific exposures. Customized demand surge functions can be added via Touchstone's administrative console.

- **Correlation:** There are two options for correlation testing on your specific book. Inter-policy correlation and intra-policy correlation. The inter-policy correlation refers to the correlation that exists between policies and would be used when dealing with a number of single location policies. The intra-policy correlation refers to the correlation between individual locations within a policy.

5.2.5 Additional Tests

- **Secondary Risk Characteristics**: Primary building characteristics include attributes as occupancy, construction, height, and year built , while secondary building characteristics include more detailed features, such as roof-covering, glazing type and roof to wall connection. Exploring the impact of secondary risk characteristics—and their complex interaction—is a particularly worthy exercise in light of the increasing number of states adopting mitigation credits. Indeed, users may want to run cost-benefit analyses to determine the benefit of collecting additional data on mitigation features. Many of these features can have a significant impact on estimating losses despite the secondary labeling.

- **Policy conditions test**: Determining the sensitivity of varying policy conditions is an important underwriting tool. Companies may quickly vary the attachment and exhaustion points, participation,deductibles, limits and even region of application within CATRADER as they explore risk transfer options.

- **Convergence tests:** AIR catalogs include 10K, 50K and 100K years of events. Touchstone uses advanced computing power to generate tens of thousands of simulated years of loss experience for any property data set presented to the models, essentially eliminating pure randomness caused by insufficient sample sizes. When users are to choose from different catalogs, it depends on the purpose of the project as well as the peril under study. Smaller portfolios or regions may require larger catalogs for sufficient convergence. For rate filing purposes for the U.S. hurricane peril, the 50,000 year catalog or higher is recommended.

- **Logical Relationship to Risk:** Anyone using the results from a catastrophe model is encouraged to confirm the model loss costs exhibit logical relationships among variables such deductible, construction type, policy form, coverage, territory, and regions.

6 Appropriate Use of Model Output

6.1 Common Uses of Model Output

Catastrophe models provide a wide range of outputs which have been presented in the previous section. These model outputs can be integrated into different areas of the insurance business including Enterprise Risk Management (ERM), Reinsurance Structuring, Portfolio Optimization, Actuarial/Pricing, Underwriting, and Claims Management. Catastrophe modeling can be imbedded in the regular workflow of the whole insurance business:

- **Enterprise Risk Management/ORSA**

  The EP curve is a core input into management's enterprise risk. In looking at the EP curve for their portfolio, a CRO or CFO can determine the probability of catastrophic losses that could trigger a rating downgrade to a company. At the same time, rating agencies now require that insurance companies employ comprehensive and integrated catastrophe risk management practices to earn secure ratings. Rating agencies want not only a more robust stress analysis based on modern risk metrics like Tail Value at Risk (TVaR), but a sense that catastrophe models are embedded into the workflow for underwriting, rating and financial management decision in the company. Companies can use the model output to communicate with different rating agencies or plug the model output in their capital requirement formulas.

- **Risk Transfer Decisions**

  Users can decide coverage for extreme events based on the occurrence EP curve and also use the aggregate EP curve for aggregate coverage, reinstatements or drop down provisions. It is important to note that the model output on which your reinsurance decision is based must include all risk exposure to your book of business. If you are buying reinsurance to cover a certain region or peril, ensure that the model output is applicable to that region or peril.

- **Portfolio Optimization**

  The output from catastrophe models can be leveraged for complex decision-making frameworks through the usage of optimization techniques. The optimization processes developed at AIR allow shaping a portfolio in such a way that several performance objectives can be optimized simultaneously while keeping track of multiple constraints. These types of processes give portfolio managers the ability to consider multiple decision criteria in a single framework that takes into account risk modeling results and other corporate objectives. Advanced analytics techniques are employed to sift through millions of possible alternatives to achieve best performing solutions. As an example, situations in which these techniques have been used include the management of residual risk pools, the design of growth strategies, and de-risking of a portfolio to reduce reinsurance costs while maximizing premiums. AIR has a dedicated group for consulting service in this area.

- **Pricing/ Ratemaking**

  Model output AAL (average annual losses) and Standard Deviation are used in actuarial pricing formulas and rate-filings. Adjustments to include non-modeled loss are needed to account for the absolute risk to your portfolio. The output can be adjusted to serve as a cat load directly in the pricing formula. Additionally, rating factors such as construction type, occupancy type, territory, and deductible are all part of the exposure as input.

- **Underwriting**

  Underwriters can use catastrophe model software at the point of sale in automated underwriting rules engines to make “go” or “no go” underwriting decisions. For example, they can check the exposure map to see if the exposure concentrations for the current and potential book. Our software also shows the relative riskiness of new potential risk. Location level EP curves can help the underwriters to price the policy as well as to derive coverage terms. Using catastrophic modeling in the underwriting process can help companies to manage their catastrophic risk at the “front end” before the policies get on their book.

- **Claim Management**

  AIR provides ALERT posting on imminent catastrophic events around the globe. ALERT stands for AIR Loss Estimate in Real Time. We provide online updated event information as well as industry loss estimate for big events. We also provide thousands of event scenarios based on most updated event parameters as well the potential future development for these parameters. Similar events in our catalogs are also identified. Clients can use this information to run against their exposures portfolio to get the earliest estimate for the potential losses to their company. Before each hurricane season, we encourage our clients to run their portfolio against the stochastic catalogs for advanced planning. During a hurricane event, our clients can download these real time events to get the earliest estimate for claim staff deployment, cash flow management, “live” cat protection purchase or communication to the interested party. Even after the event, our clients can still use our software to manage cash flow and decide whether to suspend or continue writing business in certain area. Please refer to the *ALERT website* for up-to-date event information.

6.2 Best Practices for Decision Making Using Model Output

Actuaries use output from catastrophe models to make many important decisions about risk management, reinsurance purchase, and pricing. The model output can be used in various ways to support these decisions, and the following are several examples of best practices.

- **Tail Value at Risk**

  TVaR is a quantification of the shape of your EP distribution beyond a certain threshold. It is an average of all simulated losses beyond a specified threshold. This is also a direct output from our model. TVaR can be used to compare the relative risk between two exposure portfolios. In general, a portfolio with a bigger TVaR value is riskier. Further, the TVaR value can be used as a basis for portfolio optimization. Mitigating the TVaR value by eliminating certain contracts or policies that contribute disproportionally to your total TVaR value can help to lower your TVaR as well as the AAL for the entire portfolio.

- **Consider Annual Aggregate EP Curves**

  The occurrence EP curve provides loss distribution for the largest potential loss in any given year while the aggregate EP curve provides loss distribution for the combined potential loss in any given year. Before the 2004-2005 hurricane seasons, many companies were adequately prepared for any one event occurrence, but they were not adequately prepared for a season with multiple U.S. hurricane landfalls. To prepare for the combination of multiple events in a season, the annual aggregate EP curve should be used.

- **Understand Loss Driving Events**

  Users of the model should look into event details to find out what kind of events is driving the losses for the company portfolio. The reinsurance coverage scheme should be different for one company whose losses are driven by a few large hurricane events versus another company whose losses are driven by a large amount of smaller severe thunderstorm events. Additional analyses to understand model output and extreme events beyond the cut off points are strongly encouraged.

- **Multi-year Horizon Analysis**

  Enterprise risk managers are usually focusing on a longer term period rather than just one year. A multi-year horizon analysis is helpful in this case. Users of the model can either combine the model results by randomly picking loss events from a one-year perspective analysis, or by using the multi-year catalog from CATRADER to come up with the EP curve for a multi-year risk analysis.

7 Documentation

ASOP 41 deals with the actuary's communications and includes guidance on documentation and disclosure. The standard requires that the appropriate records worksheets and other documentation of the actuary's work should be maintained by the actuary and retained for a reasonable period of time.

Process documentation is an integral part of natural catastrophe modeling. It guarantees consistency throughout the entire workflow and is essential for the validation process. Additionally, standardized process documentation facilitates the reproducibility of the modeled losses. Apart from the advantages for the company itself, a number of supervisory regimes (PRA, IAIS, Lloyd's of London, BaFin, U.S. Actuarial Standards Board) have increased the requirements with respect to detailed documentation of company's modeling and analysis approach as part of the supervisory guidelines and due diligence processes.

Documentation in catastrophe modeling could include the following steps:

1. Pre Analysis Phase and Log File Review
    - Document the raw data file as well as any changes that were made to the raw data file to get it ready for the analysis
    - Create a summary file that summarizes the exposure for review
    - Document the assumptions that are made for any data changes
    - Save and review the log files for data input and geocoding results
    - Decide on the analysis options that coincide with the output requirement and save the screenshot of the analysis option page

2. Analysis Phase:
    - Document the version of the software being used
    - Document the log file for the analysis.
    - Document the steps that are used to pull the results from the software
    - Document any assumptions and results for the sensitivity testing on model results
    - Document any loss adjustment factors as well as the derivation on the loss adjustment factors

In addition to the above, the actuary could also document steps performed to become reasonably familiar with the basic model components and the relationship between such. Details regarding the background and expertise of those the actuary has relied on could also be disclosed. The documentation process could also include any independent review of the actuary's use of the model and whether this use is appropriate for the given application, in accordance with the generally accepted practices.

For best practices on additional documentation process, please refer to our "*Best Practice for Using Catastrophe Models*" document.

About AIR Worldwide

AIR Worldwide (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 90 countries. More than 400 insurance, reinsurance, financial, corporate, and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, detailed site-specific wind and seismic engineering analyses, and agricultural risk management. AIR, a Verisk Analytics (Nasdaq:VRSK) business, is headquartered in Boston with additional offices in North America, Europe, and Asia.