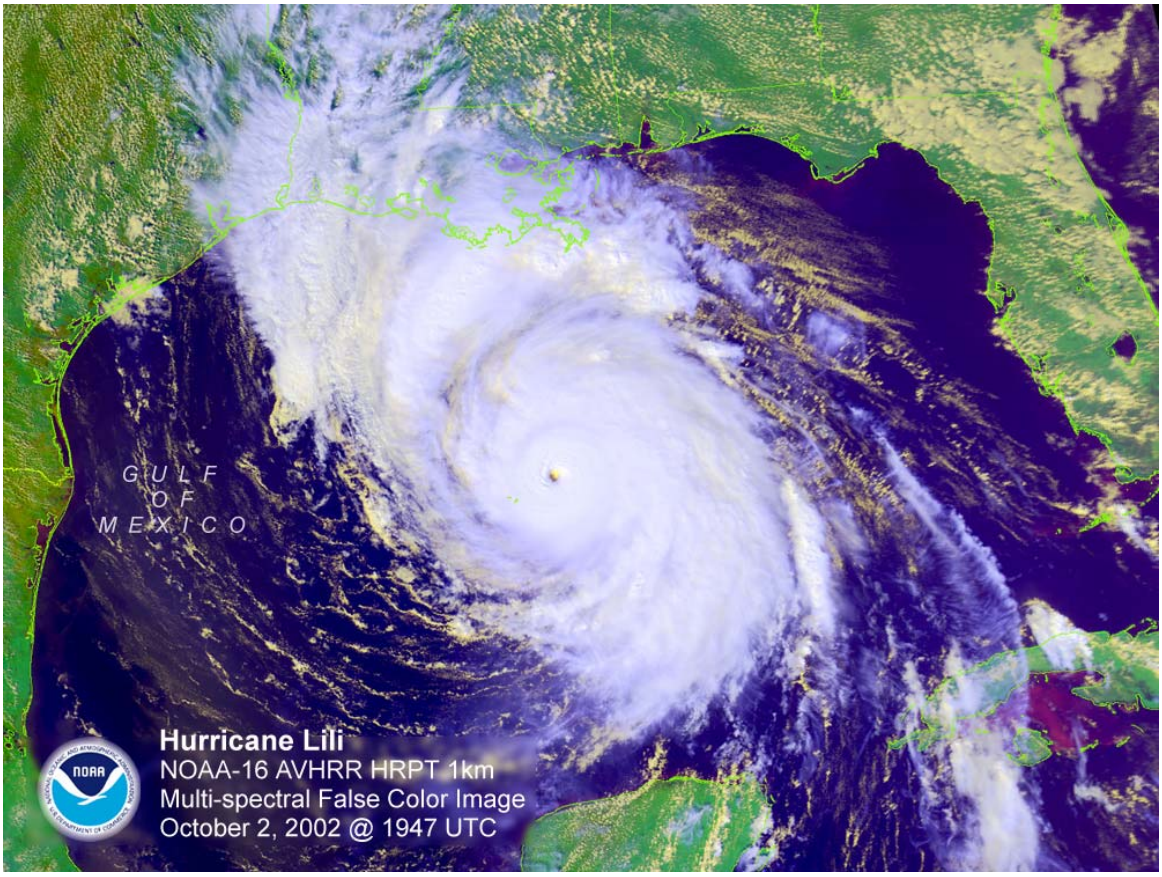
Florida Commission on Hurricane Loss Projection Methodology



Professional Team Audit Report
2002 Standards

Risk Management Solutions, Inc.

On-Site Review
May 15 & 16, 2003

On May 15 & 16, 2003, the Professional Team visited on-site at Risk Management Solutions, Inc. (RMS) in Newark, California. The following people participated in the review.

RMS

Richard R. Anderson, FCAS, MAAA, Chief Actuary
Auguste Boissonnade, Ph.D., Vice President Model Development
Michael Drayton, Ph.D., Principal Modeler
Uday K. Eyunni, Lead Software Engineer
Atul C. Khanduri, Ph.D., Program and Project Manager
Craig Miller, Ph.D., Research Engineer – Consultant
Gilbert L. Molas, Ph.D., Lead Engineer
Guy C. Morrow, S.E., Head of Science and Engineering
Brian F. Owens, MBA, MSc, Director, Technical Marketing
John Reiter, Vice President, RiskLink Software Development, Catastrophe Applications, RiskLink Product Development
Mohan P. Sharma, Ph.D., Lead Engineer
Pane Stojanovski, Ph.D., Vice President, Global Risk Modeling

Professional Team

Mark Johnson, Ph.D., Statistician, Team Leader
Marty Simons, ACAS, Actuary
Paul Fishwick, Ph.D., Computer Scientist
Fred Stolaski, P.E., Structural Engineer
Tom Schroeder, Ph.D., Meteorologist
Nari Balsara, P.E., Structural Engineer observer
Jenni Evans, Ph.D., Meteorologist observer
Donna Sirmons, Staff

The review began with introductions and an overview of the audit process. RMS gave a presentation highlighting the hurricane model components and outlining the model changes since the February 2002 submission and the associated effects on loss costs. Changes to the model components include:

- Basin-wide stochastic event set
  - Introduction of an importance-sampled event set
  - Adjustments to landfall frequencies
  - Changes in overland filling rates
  - Extra-tropical transition
- Wind field hazard model
  - High resolution database (NLCD March, 2000 based on data from the early to mid 90's) for defining surface roughness
  - High resolution grid for calculating wind speeds and losses
- Vulnerability, mitigation and calibration

- 28 construction classifications and functions
- Regional variability in building inventory upgraded to county level from state level
- Calibration of new insurance claims data (Georges)

Reviewed scatter plots and other graphical representations showing the impact on AAL and frequencies due to the changes listed above.

RMS provided a detailed explanation for how they calculate exposure and loss by cell in a variable resolution grid (VRG). Reviewed color-coded maps statewide, by county, and by ZIP Code level showing the surface roughness decay factor on the VRG grid.

Discussed the change in wind speed calculations for Hurricane Andrew and verified the reclassification had no impact on the model as there was no change to Central Pressure, Rmax, or Forward Speed for Hurricane Andrew.

Discussed and reviewed corrections to be made to the submission that will be provided to the Commission prior to the May 29 & 30, 2003 meetings.

- Standard 5.1.6 – conversion factors
- Standard 5.3.5 – range of mitigation credits
- Standard 5.4.12 – typographical correction
- Pages 82–89 – include additional personnel
- Page 117 – input/output forms used in producing output ranges

Verification of Standard 5.3.5 could not be made while on-site owing to the fact that RMS did not provide to the Commission the mitigation measures and their ranges of possible impacts on damage. The Professional Team expects that verification can be made subject to RMS providing the required information that was presented to the Professional Team while on-site. RMS has indicated the required information will be provided to the Commission prior to the May 29 & 30, 2003 meetings. Hence, verification is conditional on the aforementioned material being provided to the Commission on or before May 30, 2003.

Deficiencies from April 1, 2003 Meeting

1. Output Ranges – The Commission deemed the Output Ranges as provided in your submission test on pages 192-200 as a deficiency.

   RMS Response:

   ..Output Range for "Renters – Masonry" that were omitted from our original submission.

   Verified: Yes

   Professional Team Comments:

   Reviewed Output Ranges for Renters-Masonry originally omitted from the submission.

Risk Management Solutions, Inc. – Pre-Visit Letter

The main purpose of the on-site review performed by the Professional Team (Pro Team) of the Florida Commission on Hurricane Loss Projection Methodology (FCHLPM) is to verify that the written and electronic submission conforms to the model producing the output ranges included in the submission to the FCHLPM. It is particularly important to review in detail all information relating to the model, including any information that may be considered proprietary. It is the responsibility of the modeler to provide all information necessary for a complete review of the model. For each reference within the submission that cites "material to be shown to the professional team," it is important that the material is presented to the Pro Team during the on-site review. Material that the modeler intends to present to the FCHLPM should be presented to the Pro Team during the on-site review.

In the course of preparing for the on-site review, the Pro Team has identified some specific areas that it intends to cover while on-site. These items are provided below to assist the modeler in preparing for the on-site review. Some of this material may have been shown or available on a previous visit by the Pro Team.

The goal of the Pro Team is to provide the FCHLPM with a clear and thorough report of the model, subject to non-disclosure conditions. All modifications, adjustments, assumptions, or other criteria that were included in producing the information requested by the FCHLPM in the submission should be disclosed and will be reviewed.

It is important that all material prepared for presentation during the on-site review be presented using a medium that is readable by all members of the Pro Team. Access to critical articles or materials referenced in the submission or during the on-site review should be available on-site for the Pro Team. The Pro Team should be provided access to a phone line that can provide internet access through one of the Pro Team member computers for reference work that may be required while on-site.

For your information, the Pro Team will arrive in business casual attire.

1. General

1.1 Page 1, Standard 5.1.2 – Explain whether any employees are no longer involved in the model due to professional conduct.
1.2 Page 2, Standard 5.1.3 – Describe how Model Revision Policy was used for revisions from version 4.2SP1a to version 4.3a.
1.3 Page 3, Standard 5.1.6 – Provide conversion factors and explanation for not including the factors in the submission to the FCHLPM.

General items numbered 1.4 through 1.13 below refer to the output ranges.

1.4 Explain any differences in minimum and maximum loss costs for any county where the changes from last year's submission exceed 5%.
1.5 Provide a brief overview of any differences in minimum and maximum loss costs for any county regardless of the magnitude of the difference.
1.6 Explain any significant differences in the relativities between building and contents loss costs from those derived from last year's submission.
1.7 Explain any significant differences in the relativities between mobile homes and other construction types loss costs from those derived from last year's submission.

1.8 Explain any significant differences in the relativities among deductibles from those derived from last year's submission.
1.9 Explain any differences in the relativities between building and additional living expense loss costs from those derived from last year's submission.
1.10 Explain any differences in the relativities between building and appurtenant structure loss costs from those derived from last year's submission.
1.11 Explain the relationship between the loss cost for a $2,500 deductible Personal Residential/Renters/Frame and a 5% deductible Personal Residential/Renters/Frame loss cost.
1.12 Provide any internal comparisons performed since the prior submission regarding the following:
   a. Model output vs. insurance company data
   b. Model output prior to and after zip code updates
   c. Changes in loss costs brought about by model revisions
   d. Changes in loss costs brought about by other changes.
1.13 Explain the relationship among $0 Deductible Structure, $0 Deductible Contents, $0 Deductible Appurtenant Structure, and $0 Deductible Additional Living Expense.

2. Meteorology

2.1 Page 5, Standard 5.2.3 – Present and describe in detail the input file used in generating your stochastic storm set.
2.2 Pages 7-9, Standard 5.2.6 and cover letter – Discuss the impacts of "smoothed coastal activity rate" on Florida landfall rates. Demonstrate the quality of fit of simulated storms to historical records for appropriate coastal segments in Alabama, Georgia, and Mississippi.
2.3 Pages 10-12, Standard 5.2.8 – Discuss in detail your model's approach to treating surface roughness.
2.4 Page 13, Standard 5.2.10 – Present contour plots of wind fields (2-dimensional, instantaneous) as developed for Form F.
2.5 Page 48, Module 1, Section I, A #2 – Discuss your model's use of the pressure profile characteristic in equation 1. Discuss details of the calculation of V_s / V_g in step 2.
2.6 Page 49, Module 1, Section I, A #2 – Describe the roughness length used for each of the 10 land cover classes. For simulating specific storms, does the model sample local and upstream roughness or mimic the storm exactly?
2.7 Page 61, Module 1, Section I, A #9 – Discuss the considerations of extra-tropical transition.
2.8 Page 101, Module 3, Section I, #6 – Discuss the relationship between sea surface temperature and central pressure.
2.9 Discuss impacts of Hurricane Andrew reclassification on your model.

3. Vulnerability

3.1 Page 15, Standard 5.3.2 – Provide several examples of vulnerability function curves for each type required. Typical examples of regional variation shall be shown.
3.2 Page 15, Standard 5.3.3 – Show within the computer code where peak gust wind speed of 50 mph is used as the starting point of damage being considered.

3.3 Page 16, Standard 5.3.4 – Provide construction types and characteristics and include validation of the range of magnitude and direction (positive or negative) of the variations in damage.
3.4 Page 16, Standard 5.3.4 – Provide data and methods used to determine "Year Modifiers". Range of magnitude and direction of the variation in damage shall be included.
3.5 Page 16, Standard 5.3.4 – Discuss specifically the assumptions used for any changes due to the new Florida Building Code.
3.6 Page 16, Standard 5.3.5 – Provide examples of evaluation of the combined effect of multiple mitigation measures.
3.7 Page 17, Standard 5.3.5 – Was "Gable end bracing for roof shapes other than hip roof" and "Non-glazed openings such as garage doors" considered as secondary modifiers?
3.8 Page 18, Standard 5.3.6 – Verify ALE losses are considered for instances where no building or content losses occur.
3.9 Page 18, Standard 5.3.6 – Are abnormal working conditions considered in determining the time factors to repair/reconstruct the property?
3.10 Pages 56-59 & 63, Module 1 – Verify numbering and references to Tables.
3.11 Page 58, Module 1, Section I, A #7 – Provide the details of the two building vulnerability classes that were added. (Standard 5.3.1)
3.12 Page 58, Module 1, Section I, A #7 – Provide a basic description of the building classifications in "Construction Class." (Standard 5.3.1)
3.13 Page 63, Module 1, Section I, B #7 – Provide data and calculations to validate "State Average Impact" ranges. (Standard 5.3.5)
3.14 Page 63, Module 1, Section I, C #1.a – Discuss the omission of these effects. (Standard 5.3.1)
3.15 Page 72, Module 1, Section II, A #5 – Has any new insurance data been obtained? Have any new field investigations been made? Has any new building stock been added? Has any new data on mobile homes been obtained? (Standard 5.3.1)
3.16 Page 109, Module 3, Section III, #4 – Expand on this to include description of modifiers, range of modifications, direction of change, effect of multiple modifiers, etc. Describe how user input can affect the model output, how such user input is monitored for reasonableness, and how such user input is disclosed to the recipient of the model output. (Standard 5.3.1)
3.17 Page 109, Module 3, Section III, #5 – Provide list of fixtures and construction techniques designed for hazard mitigation that are considered and refer to discussions in the other Standards and Modules. Describe how user input can affect the model output, how such user input is monitored for reasonableness, and how such user input is disclosed to the recipient of the model output. (Standard 5.3.1)
3.18 Copies of any papers, reports, and studies used in the development of the vulnerability functions shall be available for review. Copies of all public record documents used may be requested for review.

4. Actuarial

4.1 Pages 18-19, Standard 5.4.1 – Describe in detail how inherent hazard mitigation and building code criteria are considered when utilizing insurance company data for creation or validation of model components. Explain how this process is expected to change as mitigation criteria apply to greater percentages of properties in Florida.
4.2 Page 19, Standard 5.4.1 – Have available during the on-site review the detailed summaries of the exposure and loss data sets, the description of the data review

process, and the use of the data in the development of vulnerability functions as referenced in your response to this standard.

4.3 Page 20, Standard 5.4.4 – Describe the methods used and the resulting expected impacts upon the loss costs of the revised default from state to county for unknown construction types.

4.4 Page 29, Standard 5.4.12 – Describe in detail the changes made in the smoothing techniques used relative to stochastic event generation as referenced in your response to this standard. Describe the changes in land fall rates and describe your analysis relative to the effects upon those rates brought about by the smoothing technique revisions.

4.5 Page 29, Standard 5.4.12 – Describe in detail each change made in the wind field, the computation of roughness factors and other relevant meteorological changes that may impact upon the output ranges. For each such change, describe the impact upon the output ranges.

4.6 Page 29, Standard 5.4.12 – Describe in detail each of the damage function revisions. Describe the impact of the vulnerability changes on the output ranges.

4.7 Page 117, Module 3, Section IV, #11 – Provide the input/output forms used in producing the Output Ranges.

4.8 In all cases where insurance company inputs are used to derive or to verify model output, be prepared to provide the following:

a. Identify insurance company
b. Provide initial insurance company submission for review
c. Provide correspondence between model and insurance company relative to data amendments
d. Provide example of model adjustments for invalid zip code information
e. Provide methods used to remove demand surge from Hurricane Andrew data, if such data is used for modeling or verification.

4.9 Be prepared to explain differences in average annual loss provided in Standard 5.4.11 between this submission and the previous submission.

4.10 Be prepared to describe the impact upon loss costs of any model revisions not specifically referenced above.

4.11 Describe any differences between this submission and the prior submission relative to results displayed on Forms A, B, and C.

4.12 Table 1 below summarizes the percentage changes in maximum wind speed for each of the coverage categories as reported in Form B (2002 relative to 2001) by city. Table 2 provides the same information by hurricane category. The average wind speed has increased by 9.8 mph, yet each loss category (by city and coverage) shows huge decreases across the board. Explain these decreases.

Table 1. Percentage Changes in Form B by City: 2002 Relative to 2001

City	Max WS	Total Loss	Cov A Loss	Cov C Loss	Cov D Loss
Ft. Myers	10.1	-43.3	-38.9	-62.1	-44.4
Ft. Pierce	9.1	-54.4	-51.0	-69.2	-56.0
Jacksonville	8.8	-42.8	-39.3	-59.9	-39.0
Miami	12.9	-21.7	-16.4	-46.0	-19.2
Panama City	10.8	-30.9	-26.1	-51.8	-34.3
Tampa	7.1	-43.5	-39.3	-61.7	-45.2
Average	9.8	-39.4	-35.2	-58.5	-39.7

Table 2. Percentage Changes in Form B by Category: 2002 Relative to 2001

Category	Max WS	Total Loss	Cov A Loss	Cov C Loss	Cov D Loss
1	3.7	-43.8	-39.2	-69.5	-50.6
2	4.5	-48.1	-43.3	-72.6	-49.7
3	8.7	-39.7	-34.5	-62.7	-38.3
4	13.7	-34.3	-30.4	-48.1	-29.3
5	18.4	-31.4	-28.6	-39.4	-30.5
Average	9.8	-39.4	-35.2	-58.5	-39.7

5. Computer

5.1 During the Computer Software audit, the Pro Team will expect all elements of the code base (i.e., actuarial, engineering, scientific, user interface, database) to be addressed. Please ensure that all personnel involved with designing, writing, and maintaining of this software are available.

5.2 During the overall audit process, the Pro Team may request "code spot checks" to assist in verifying a standard that is related to such code, either in terms of its structure (i.e., syntax) or its execution. During a spot check, it will be necessary to convene the coder or software engineer responsible for this aspect.

5.3 Page 34, Standard 5.5.1 – The Pro Team will verify that "All computer software (i.e., user interface, scientific, engineering, actuarial) relevant to the modeler's submission is consistently documented." It is expected that any and all software that is used in the model will be so documented.

5.4 Page 35, Standard 5.5.3 – Be prepared to identify the model component custodian as required in the standard.

6. Statistical

6.1 Page 38, Standard 5.6.4 – Describe the "other variables directly related to loss" that were used in the sensitivity analysis. Describe the analyses referenced to the Pro Team.

6.2 Page 39, Standard 5.6.5 – Describe the "other variables directly related to loss" that were used in the sensitivity analysis. Describe the analyses referenced to the Pro Team.

6.3 Page 39, Standard 5.6.6 – Present the stratified sampling approach and attendant analyses to the Pro Team.

6.4 Pages 42-43, Module 1, Section I, A #2 – Describe the "importance sampling" process referenced on these pages of the submission.

6.5 Page 76, Module 1, Section II, B #13 – Describe your definition of "inappropriate variability" cited on this page.

6.6 Page 149, Module 3, Section VII, Form F – Provide Pro Team with lost cost analysis.

6.7 In addition to the FCHLPM required analyses, be prepared to present any internal sensitivity and/or uncertainty analyses performed on your model by internal staff members or by outside consultants.

5.1 General Standards – *Mark Johnson, Leader*

5.1.1 Scope of the Computer Model and Its Implementation

The computer model shall project loss costs for personal lines residential property from hurricane events, excluding flood and storm surge, except as flood and storm surge apply to Additional Living Expense (ALE). References to the model throughout the Standards shall include its implementation.

If the modeler uses historical data that include losses from flood and storm surge, then the modeler shall disclose the techniques employed to exclude such losses, and those techniques shall be based on accepted scientific methods.

If the modeler uses engineering or other data that include losses from flood and storm surge, then the modeler shall disclose the techniques employed to exclude such losses, and those techniques shall be based on justifiable methods.

Reference: Module 1, Section I, C.1.d (storm surge and flood damage to the infrastructure) (page 64)

Audit: This standard concerns the scope of the computer model and its implementation that is expected to project loss costs for personal residential property due to hurricane events. ALE is mentioned explicitly since flood and storm surge can in fact impact ALE. The main intent of the audit is to determine the capabilities of the model and to assess its implementation for purposes of Florida estimated loss costs.

Is there a flood or storm surge component to the model? Is it in the "off" position for the production of Florida output ranges as well as other information supplied in the standards and modules (e.g., 5.4.11 and Form B)?

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Verified that flood and storm surge are not included when producing the loss costs in the Output Ranges as reflected in the input/output reports.

5.1.2 Qualifications of Modeler Personnel and Independent Experts

Model construction, testing, and evaluation shall be performed by modeler personnel or independent experts who possess the necessary skills, formal education, or experience to develop hurricane loss projection methodologies.

The model or any modifications to an accepted model shall be reviewed by modeler personnel or independent experts in the following professional disciplines, if relevant: structural/wind engineering (licensed Professional Engineer (PE)), statistics (advanced degree), actuarial science (Associate or Fellow of Casualty Actuarial Society or Member of the American Academy of Actuaries), meteorology (advanced degree), and computer science/engineering (advanced degree). These individuals shall abide by the standards of professional conduct adopted by their profession.

Reference: *Module 2 #2 (professional credentials),* (page 82)
#3 (multi-discipline team), (page 92)
#5 (independent expert review) (page 96)

Audit: The Professional Team would like to review the professional vitae of modeler personnel and independent experts responsible for the current model and information on their predecessors, if different than current personnel. For the actuarial personnel, professional status in the appropriate actuarial organization or organizations is usually apparent on the vitae. For other disciplines, the vitae ought to be sufficient to make a determination for this standard, with further commentary possible during the on-site interactions. Background information on individuals providing testimonial letters in the submission must be provided.

Do you have any new personnel (since last year) working on the model? If so, resumés should be available. Were any personnel dismissed for violations of the professional code of conduct? If so, what influence would it have on the model under review?

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Personnel involved in the model meet the standard. Verified no employees were removed from the Florida hurricane model project for professional misconduct.

5.1.3 Model Revision Policy

The modeler shall have developed and implemented a clearly written policy for model revision with respect to methodologies and data. The modeler shall clearly identify the model version under review. Any revision to any portion of the model that results in a change in any Florida residential hurricane loss cost must be accompanied by a new model version number.

Reference: *Module 1, Section I, A.1 (model version number),* (page 41)
A.9 (model revisions) (page 60)

Audit: The Professional Team would like to see the process for model revisions (both methodology and data, especially updates from year-to-year with new storms). What safeguards or controls are in place? How does the annual update take place? How is it identified? How are each of the changes mentioned in 5.4.12 consistent with this policy? Citing specific examples gives further strength to the Professional Team assessment (for 1996 storms, we did the following ... and now the updated storm set is in place....). The Professional Team computer expert could then review the current set up.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed RMS model revision policy and its implementation. Reviewed and discussed a decision tree schematic of the revision process.

Documentation reviewed:
- Product Delivery Overview

5.1.4 Independence of Model Components

The meteorology, vulnerability, and actuarial components of the model shall each be demonstrated to be theoretically sound without compensation for potential bias from the other two components. Relationships within the model among the meteorological, vulnerability, and actuarial components shall be demonstrated to be reasonable.

Reference: *Module 1, Section II, B.11 (independent functions or variables),* (page 75)
B.13 (model sensitivity), (page 76)
B.14 (sensitivity in output results), (page 76)
B.15 (SA & UA performed on model) (page 77)
Standard 5.5.3 (Model Architecture and Component Design) (page 35)
Standard 5.5.5 (Verification) (page 35)

Audit: This standard will be considered after the review of meteorology, vulnerability, and actuarial sections. The modeler needs to demonstrate to the Professional Team that their choices of model components adequately portray hurricane phenomena and effects (damage and loss costs). This can be accomplished indirectly via agreement with historical loss costs and attendant tests but also requires an assessment of the theoretical soundness of each component. A model would not be found to meet this standard, if an artificial calibration adjustment had been made to improve the match of historical and model results for a specific storm. What impact do changes in the model from the previous year potentially impact this standard? How can you demonstrate that in fact these changes do not impinge on this standard?

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Verified that each of the model components acts independently and the independence was seen with the changes made in meteorology this year having no impact on the vulnerability functions or the relativities among coverages, deductibles, mobile homes, and other construction types. The flow of information through the code further supports verification of the standard.

5.1.5 Risk Location

Zip codes used in the model shall be updated at least every 24 months using information originating from the United States Postal Service. The United States Postal Service issue date of the updated information shall be disclosed.

Zip code centroids, when used in the model, shall be based on population data and shall be visually demonstrated to be reasonable.

Zip code information purchased by the modeler shall be verified by the modeler for accuracy and appropriateness.

Reference: *Module 1, Section II, A.2 (primary databases)* (page 70)
Module 3, Section VI, #1 (handling of invalid zip codes) (page 138)
Module 3, Section VII, Form A (Zip Code Data Base) (page 141)

Audit: Aside from disclosure of updates, the Professional Team is likely to ask to view the location of centroids for specific zip codes. Interest in specific zip codes arises in the context of logical relationship to risk or in basic assessments of loss costs. What is the effective (official United States Post Office) date corresponding to the database of zip codes? What is the date at which the zip codes and their centroids were introduced into the model?

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Verified the ZIP Code centroids are population based. Discussed the QA procedures for validating the ZIP Code database purchased from a vendor and used in RiskLink. The database has been updated within the past 24 months.

5.1.6 Identification of Units of Measure and Conversion Factors

All units of measure for model inputs and outputs shall be clearly identified. All conversion factors used by the model shall be disclosed.

Reference: Module 1, Section I, C.2 (input variables) (page 64)

Audit: Are there any units of measure omitted or incorrectly stated?

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Reviewed a table of the conversion factors used in RiskLink 4.3a.

Documentation reviewed:

- American National Standard for Use of the International System of Units (SI): The Modern Metric System

5.1.7 Visual Presentation of Data

Visualizations shall be accompanied by legends and labels for all elements. Individual elements shall be clearly distinguishable, whether presented in original or copy form.

a. For data indexed by latitude and longitude, by county or by zip code, a color contour map and a continuous tone map with superimposed county and zip code boundaries shall be produced.

b. Florida Map Colors: Maps will use two colors, blue and red, along with shades of blue and red, with dark blue and dark red designating the lowest and highest quantities, respectively. The color legend and associated map shall be comprised of an appropriate number of intervals to provide readability.

Reference: Module 3, Section I, #10 (maps of maximum winds at zip code level) (page 103)
Module 3, Section V, #3 (maps of loss costs by zip code), (page 120)
#7 (maps of output ranges % change by county) (page 126)

Audit**:** The modeler will have key maps, charts, and graphs pre-prepared and will have the ability to quickly prepare such maps during an on-site review. All visualizations should be presented in a manner that enables simultaneous viewing by the entire Professional Team.

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Reviewed numerous color-coded maps, graphical representations, and plots. All visualizations shown to the Professional Team as well as those to be presented to the Commission were in compliance.

5.2 Meteorological Standards – *Tom Schroeder, Leader*

5.2.1 Units of Measure for Model Output

All model outputs of length, wind speed, and pressure shall be in units of statute miles, statute miles per hour, and millibars, respectively.

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Correct units of measure were verified throughout the course of the audit.

5.2.2 Damage Function Wind Inputs

Wind inputs to the damage function shall be in units consistent with currently used wind measurement units and/or shall be converted using standard meteorological/engineering conversion factors which are supported by literature and/or documented measurements available to the Commission.

Reference: Module 3, Section II, #2 (wind speed conversion) (page 108)
Standard 5.1.6 (Identification of Units of Measure and Conversion Factors) (page 3)

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Verified that appropriate units are used. Reviewed factors for converting among sustained ten-minute, one-minute, and gust winds.

5.2.3 Official Hurricane Set or Suitable Approved Alternatives

Modelers shall include in their base storm set all hurricanes, including by-passing hurricanes, which produce hurricane force winds in Florida. The storm set, derived from

the Tropical Prediction Center/National Hurricane Center (TPC/NHC) document *Tropical Cyclones of the North Atlantic Ocean, 1871-1998,* updated through the 2001 hurricane season and/or the HURDAT (HURricane DATa) data set, is found in the *Report of Activities as of November 1, 2002* under Section VII, Compliance With Standards and Related Information, #4 (Base Storm Set). All proposed alternatives to the characteristics of specific storms in the storm set shall be subject to the approval of the Commission.

Reference: *Module 1, Section II, A.1 (deviation from official hurricane set),* (page 68)
A.2 (primary databases), (page 70)
B.7 (parameters for hurricane frequency), (page 74)
B.8 (stochastic hurricane generation) (page 74)
Module 3, Section I (Hurricane Set) (page 99)

Audit: The input file used in generation of the stochastic storm set is useful evidence of compliance with this standard. The modeler should be prepared to show the storm set used.

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Reviewed RMS input file used in generating the stochastic storm set. Verified the base set includes all storms, landfalling or bypassing, through 2001 and is in agreement with the Commission base storm set.

5.2.4 Hurricane Characteristics

Methods for depicting all modeled hurricane characteristics including but not limited to wind speed, radial distributions of wind and pressure, minimum central pressure, radius of maximum winds, strike probabilities, and tracks shall be based on information documented by scientific literature or modeler information accepted by the Commission.

Reference: *Module 1, Section II, B.1 (wind speeds used for loss estimation),* (page 72)
B.2 (asymmetric nature of hurricanes), (page 72)
B.3 (filling rate function), (page 73)
B.4 (land friction), (page 73)
B.5 (characteristics used for wind speed estimation), (page 74)
B.6 (dependent wind speed variables), (page 74)
B.7 (parameters for hurricane frequency), (page 74)
B.8 (stochastic hurricane generation) (page 74)
Module 3, Section I (Hurricane Set) (page 99)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 149)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)

Audit: Prepare graphical depictions (e.g., histograms overlaid with fitted density functions) of storm characteristics as used in the model. The modeler should be prepared to describe the data set basis for the fitted distributions, to describe assessments of correlated characteristics (e.g., central pressure and radius of maximum winds), to describe the fitting methods used and any smoothing techniques employed, and to defend choices of parametric distributions used. The modeler should be prepared to present information on the spatial distribution of hurricane force winds (e.g., the radius of hurricane force winds) associated with both modeled and historical events. Throughout the review of this standard, an assessment of the goodness-of-fit of parametric distributions to historical should be provided, consistent with 5.6.2.

With respect to storm tracks, the stochastic storm set or its equivalent should depict realistic storm tracks. This can be demonstrated through Figure 3 in Module 3, Section 1, for example. Consistency between historical and modeled tracks means: (1) distributions of storm tracks should accurately depict actual storm tracks in Florida; and (2) comparisons are to be based on methods documented in accepted scientific literature or proposed by the modeler and accepted by the Commission.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed in detail extratropical transition considerations and their impact on hurricane wind fields. Reviewed an example of a transitioning storm – Hurricane Floyd in 1999. Discussed its development as tropical, the start of the transition as Floyd moved close to the coast line, and then near the end of transition as Floyd moved onshore at the coast of the Carolinas.

Reviewed color-coded maps showing the ratio of loss cost by county with and without transitioning. Discussed in detail where the greatest impact is observed.

Discussed the formulation of the pressure profile coefficient (Holland B parameter) and Vs/Vg parameters.

Reviewed the equations for calculating the gradient wind field and the Holland B parameters for the left-hand and right-hand side of the storms. Reviewed scatter plots showing the relationships among the pressure profile parameter, central pressure, and Rmax.

Discussed the changes in the model for surface winds and the gradient to surface wind relationship. Reviewed the formula used in calculating the surface wind fields.

Reviewed scatter plots of observed versus modeled wind speeds for various radius to maximum winds for the left-hand and right-hand side.

Reviewed scatter plots comparing the modeled 1-minute wind speed against those in other sources (Landsea, Kraft, and Extended Best Track 1988-2000).

Discussed the relationship between sea surface temperature and central pressure as determined by the random walk model. Reviewed color-coded map of Minimum Sustainable Pressure.

Documentation Reviewed:

- Third Review and Comments on Cyclone Simulation Model, G. J. Holland

5.2.5 Landfall Intensity

Models shall use maximum one-minute sustained 10-meter wind speed when defining hurricane landfall intensity. This applies both to the base storm set adopted in 5.2.3 used to develop landfall strike probabilities as a function of coastal location and to the modeled winds in each hurricane which causes damage. The associated maximum one-minute sustained 10-meter wind speed shall be within the range of wind speeds (in statute miles per hour) categorized by the Saffir-Simpson scale.

Saffir-Simpson Hurricane Scale (for displayed parameters):
A scale from 1 to 5 that measures hurricane intensity.

Category	Winds (mph)	Central Pressure (MB)	Damage
1	74 – 95	$\geq$ 980	Minimal
2	96 - 110	965 - 979	Moderate
3	111 - 130	945 - 964	Extensive
4	131 - 155	920 - 944	Extreme
5	Over 155	< 920	Catastrophic

Reference: *Module 3, Section I, #1 (definition of event),* (page 99)
#2 (upper limit of wind speeds produced), (page 99)
#3 (multiple landfalls), (page 100)
#11 (frequency and annual occurrence rates), (page 104)
#12 (number of events, relative frequency and annual occurrence rate by category) (page 105)
Module 3, Section VII, Form B (30 Hypothetical Events)

Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)
Standard 5.6.3 (Uncertainty Characterization) (page 38)

Audit: The modeler should be prepared to describe and to support category 3-5 storms with respect to intensity and wind speed. In particular, defend the goodness-of-fit of historical versus modeled frequencies (by intensity), providing confidence intervals where appropriate.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Verified no change in model definitions of intensity. RMS categorizes intensity for Florida by miles per hour.

5.2.6 Hurricane Probabilities

Modeled hurricane probabilities shall reasonably match the historical record through 2001 for category 1 to 5 hurricanes, shall be consistent with those observed for each geographical area of Florida, and shall be displayed in vertical bar graphs. "Consistent" means: (1) spatial distributions of modeled hurricane probabilities shall accurately depict vulnerable coastlines in Florida and the states of Alabama, Georgia, and Mississippi; and (2) probabilities are compared with observed hurricane frequency using methods documented in accepted scientific literature or proposed by the modeler and accepted by the Commission.

Reference: *Module 1, Section I, B.2 (handling of beach/coastal areas)* (page 61)
Module 1, Section II, A.1 (historical database for wind speeds and frequency), (page 68)
B.7 (parameters for hurricane frequency), (page 74)
B.8 (stochastic hurricane generation) (page 74)
Module 3, Section I (Hurricane Set) (page 99)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)
Standard 5.6.3 (Uncertainty Characterization) (page 38)

Audit: The modeler should be prepared to describe and to support the method of selecting stochastic storm tracks and angle of landfall. The modeler should be prepared to describe and to support the method of selecting storm track strike intervals. If strike locations are on a discrete set, show the landfall points for major metropolitan areas in Florida. Assess the goodness-of-fit of modeled to historical frequencies for the four sections of the state and overall. The modeler should be prepared to demonstrate that the quality of fit extends beyond the Florida border by showing results for appropriate coastal segments in Alabama, Georgia, and Mississippi. Explain any significant discrepancies.

In particular, defend the goodness-of-fit of historical versus modeled frequencies (by intensity), providing confidence intervals where appropriate.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

RMS uses new smoothing algorithm in computing landfall rates. Reviewed the impact of this algorithm on resulting landfall rates. Reviewed graphical comparisons of multiple landfall rates for Cat 1 – 5 storms showing the annual occurrence rate by landfall gate for historical storms and modeled storms. Reviewed comparisons for prior year's submission and current submission. Verified that RMS took into account the adjacent states of Alabama, Georgia, and Mississippi. Reviewed comparisons showing landfall rates by category for Alabama, Georgia, and Mississippi.

5.2.7 Hurricane Probability Distributions

Modeled probability distributions for hurricane intensity, eye diameter, forward speed, radii for maximum winds, and radii for hurricane force winds shall be consistent with historical hurricanes in the Atlantic basin as documented in accepted scientific literature available to the Commission.

Reference: *Module 1, Section I, A.2 (probability distributions)* (page 41)
Module 1, Section II, B.1 (wind speeds used for loss estimation), (page 72)
B.7 (parameters for hurricane frequency), (page 74)
B.8 (stochastic hurricane generation) (page 74)
Module 3, Section 1, #2 (upper limit of wind speeds produced), (page 99)
#5 (hurricane tracks), (page 100)
#9 (radius of hurricane force winds, Rmax and FFP by CP), (page 102)
#11 (frequency and annual occurrence rates), (page 104)
#12 (number of events, relative frequency and annual occurrence rate by category) (page 105)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 149)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)
Standard 5.6.3 (Uncertainty Characterization) (page 38)

Audit: The modeler should be prepared to disclose the goodness-of-fit of parametric distributions to historical hurricane characteristics.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed additional K-S tests, and scatter plots showing Rmax versus Central Pressure and Latitude for both the left-hand and right-hand side of the storms. Discussed the correlations between Central Pressure and Rmax and between Latitude and Rmax. (See also Standard 5.6.1)

5.2.8 Land Friction

Land friction shall be used in the model to reduce wind speeds over land, shall be based on scientific methods, and shall provide realistic wind speed transitions between adjacent zip codes, counties, and territories. The magnitude of friction coefficients shall be consistent with accepted scientific literature, consistent with geographic surface roughness, and shall be implemented with appropriate geographic information system data.

Reference: *Module 1, Section II, B.4 (land friction),* (page 73)
B.5 (characteristics used for wind speed estimation) (page 74)
Module 3, Section I (Hurricane Set) (page 99)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 149)

Audit: The modeler should be prepared to describe the handling of land friction. Maps by zip codes are required.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed in detail the changes to RMS' modeling approach for surface wind speeds, the methodology used in developing the surface roughness database, and the calculation of surface roughness effects on mean wind speed, turbulence intensity, and peak gust wind speed.

Reviewed the formula used in calculating the roughness length and the classification schema comparing RMS' surface roughness to ASCE 7-98, Cook (1985), Wieringa (1993), and updated Davenport (1992). Discussed the associations among the different roughness classes.

Reviewed the roughness length used for each of the RMS land cover classes. Discussed sampling of the surface roughness database and reviewed examples.

Discussed the modeling of peak gust wind speed and the effect of surface roughness. Reviewed graphical representation showing mean wind speed, peak

gust, and turbulence intensity changes in response to changes in the surface roughness factor.

Discussed the impact of upstream roughness changes and reviewed graphical representations showing the impact on mean wind speed and gust wind speed at 10 meters over land and over water and showing the wind speed variation by direction.

Reviewed color-coded maps at the state level, county level, and ZIP Code level showing the effect of the surface roughness factor. Discussed the calculation of exposures by variable resolution grid cell.

Reviewed scatter plots and color-coded maps showing the results of the surface roughness modeling effects on Florida as a whole. Reviewed graphical representations comparing the 2001 model to the 2002 model and showing the ratio of the friction factors from 2001 versus 2002.

Documentation reviewed:

- The Designer's Guide to Wind Loading of Building Structures: Part 1: Background, damage survey, wind data and structural classification, Building Research Establishment Report, N. J. Cook, 1985.

5.2.9 Hurricane Overland Weakening Rate

The hurricane overland weakening rate methodology used by the model shall be provided to the Commission and shall be shown to be (1) reasonable as observed in comparison to historical records, and (2) documented in accepted scientific literature or in modeler information accepted by the Commission.

Reference: *Module 1, Section II, B.3 (filling rate function)* (page 73)
Module 3, Section I (Hurricane Set) (page 99)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 149)

Audit: The modeler should be prepared to compare the model's weakening rates to historical Florida storms and to weakening rates documented in scientific literature.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed RMS adoption of the Kaplan-DeMaria formulation of filling rate (i.e., weakening rate). Discussed ranges of filling coefficient.

5.2.10 Temporal and Spatial Wind Field Characteristics

The time variant wind field, including the radial distribution of wind speeds, shall be demonstrated to be consistent with accepted scientific principles, such as:

1. The radius of maximum winds shall reflect specified hurricane characteristics.
2. The magnitude of the asymmetry shall increase as translational speed increases, all other factors held constant.
3. The wind speed shall decrease with increasing surface roughness (friction), all other factors held constant.

Reference: *Module 3, Section I, #6 (decay rates),* (page 101)
#9 (radius of hurricane force winds, Rmax and FFP by CP) (page 102)
Module 3, Section II (Hurricane Wind Field) (page 108)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 144)
Form F (Hypothetical Events for SA & UA) (page 149)

Audit: Forms B, C, and F provide the information used in auditing this standard. Contour plots of the wind field from Form F are desired. If prepared, they should be presented to the Professional Team on-site and be consistent with the sensitivity and uncertainty analyses for wind speed.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed contour plots of the maximum wind speed for Cat 1, Cat 3, and Cat 5 hurricanes over time at 0 hour, 1 hour, 2 hour, etc. for Central Pressure, Rmax, forward speed and the filling rate coefficient.

Reviewed RMS' asymmetry factor in wind speed through contour plots adapted from the Form F analysis and prepared while we were onsite. Verified that asymmetry increased as translational speed increased.

Verified that RMS model winds decrease with increasing surface roughness. Discussion included review of materials included under Standard 5.2.8.

5.3 Vulnerability Standards – *Fred Stolaski, Leader*

5.3.1 Derivation of Vulnerability Functions

Development of the vulnerability functions is to be based on one or more of the following: (1) historical data; (2) tests; (3) structural calculations; (4) expert opinion. Any development of the vulnerability functions based on structural calculations and/or expert opinion shall be supported by tests and historical data to the extent such data are available.

The derivation of the vulnerability functions shall be described and demonstrated to be theoretically sound.

Any modification factors/functions to the vulnerability functions or structural characteristics and their corresponding effects shall be disclosed and shall be clearly defined and their theoretical soundness demonstrated.

Reference: *Module 1, Section I, A.7 (categories of vulnerability functions),* (page 58)
A.8 (documents/research used in development of vulnerability functions),(59)
C.1.a (socio-economic effects) (page 63)
Module 1, Section II, A.5 (claims data used in development of vulnerability functions) (page 72)
Module 3, Section III (Vulnerability Functions-Damage Estimates)(page 109)
Module 3, Section IV, #3 (appurtenant structures vulnerability function),(112)
#4 (mobile home vulnerability function), (page 112)
#5 (contents vulnerability function), (page 112)
#6 (ALE vulnerability function) (page 113)
Standard 5.4.1 (Underwriting Assumptions) (page 19)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)

Audit: Historical data shall be available in the original form with explanations for any changes made and descriptions of how missing or incorrect data were handled. To the extent that historical data are used to develop vulnerability functions, be prepared to demonstrate the goodness-of-fit of the data to fitted models per 5.6.2. Complete reports detailing loading conditions and damage suffered are required for any test data used. Complete structural calculations shall be presented so that a variety of different building types and construction characteristics may be selected for review. The basis for expert opinion and original site inspection reports shall be available.

Copies of any papers, reports, and studies used in the development of the vulnerability functions shall be available for review. Copies of all public record documents used may be requested for review.

All modifications to the vulnerability functions shall be individually listed with the direction (either positive or negative) and the range of magnitude of the change indicated. Any variation in the change over the range of wind speeds shall be identified.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Verified RiskLink does not explicitly include the impact of demand surge. Demand surge is not built into the model itself, but rather is a post-processing component that can be applied to the model output externally. RMS excluded a percentage of the losses from Hurricane Andrew due to demand surge based on independent research for validation purposes.

Reviewed process for developing vulnerability functions from a reference curve based on a typical mix of features with damage determined by engineering calculation. Insurance data, field experience, and testing was used to verify and validate the development of additional vulnerability functions based on the reference curve for specific types of structures. Modifications to the base vulnerability function are listed in Standard 5.3.5.

Reviewed dataflow diagram of the vulnerability component model.

No new insurance data has been obtained on mobile homes. Insurance data for Hurricane Georges (1998) has been included.

Documentation reviewed:

- Performance of Roofing Systems in Hurricane Hugo, James R. McDonald and Thomas L. Smith, August 1990
- Building Performance: Hurricane Andrew in Florida, Observations, Recommendations, and Technical Guidance, FEMA, February 1993
- FEMA Building Performance Assessment Report: Hurricane Georges in the Gulf Coast, March 1999
- Hurricane Hugo One Year Later, Benjamin L. Sill and Peter R. Sparks

5.3.2 Required Vulnerability Functions

Vulnerability functions shall separately compute damages for building structures, mobile homes, appurtenant structures, contents, and additional living expense.

Reference: *Module 1, Section I, A.7 (categories of vulnerability functions),* (page 58)
Module 3, Section III (Vulnerability Functions-Damage Estimates) (page 109)
Module 3, Section IV, #3 (appurtenant structures vulnerability function),(112)

#4 (mobile home vulnerability function), (page 112)
#5 (contents vulnerability function), (page 112)
#6 (ALE vulnerability function) (page 113)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 118)
#4 (output ranges) (page 154)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 144)
Form D (Loss Costs),
Form F (Hypothetical Events for SA & UA) (page 149)

Audit: Multiple samples of vulnerability functions for building structures, mobile homes, appurtenant structures, contents, and additional living expense shall be available to the Professional Team. The magnitude of logical changes among these items for a given wind speed shall be explained and validation materials shall be available.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed examples of vulnerability function curves for various building types (residential frame, residential masonry, mobile homes with and without tie downs). Reviewed data files for building stock by county. Reviewed computer code where these data files were loaded.

5.3.3 Wind Speeds Causing Damage

Damage associated with a declared hurricane event shall include damage incurred for wind speeds above and below the hurricane threshold of 74 mph. The minimum wind speed that generates damage shall be specified.

Reference: *Module 1, Section II, B.1 (wind speeds used for loss estimation)* (page 72)
Module 3, Section III (Vulnerability Functions-Damage Estimates) (page 109)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 149)

Audit: The disclosed minimum wind speed shall be reasonable with validation material available. The computer code showing the inclusion of the minimum wind speed at which damage occurs shall be verified.

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Reviewed the data tables for wind speed and verified that the damage cut-off is 50 mph peak gust.

5.3.4 Construction Characteristics

In the derivation and application of vulnerability functions assumptions concerning construction type, construction characteristics, new building codes, and revisions to existing building codes shall be demonstrated to be reasonable and appropriate.

Reference: *Module 1, Section I, A.7 (categories of vulnerability functions),* (page 58)
B.7 (vulnerability modifications range of impacts on loss costs), (page 63)
C.1.b (building code and enforcement), (page 63)
C.1.c (construction characteristics) (page 64)
Module 1, Section II, A.3 (damageability assumptions) (page 71)
Module 3, Section III (Vulnerability Functions-Damage Estimates) (page 109)
Module 3, Section IV, #4 (mobile home vulnerability function), (page 112)
Module 3, Section VII, Form D (Loss Costs),
Form F (Hypothetical Events for SA & UA) (page 149)

Audit: Construction types and characteristics used shall be listed and include validation of the range of magnitude and direction of the variations in damage. Any variation in differences, such as less damage to obviously stronger structures (masonry verses frame), shall be fully explained.

All modifications to the vulnerability functions due to a new building code or revisions to the existing building code shall be documented and include the range of magnitude and direction of any changes. Any variation in the change over the range of wind speeds shall be identified.

These modifications shall fully comply with 5.3.1.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed RMS construction classifications by material, stories, and occupancy. Reviewed scatter plots showing the validation of the model for the classifications provided.

Discussed in detail the use of year modifiers and the methodology for their use. Discussed the assumptions relating to the new Florida Building Code.

Documentation reviewed:

- South Florida Mitigation Baseline Survey Report, Volume I and II, Walter Gillis Peacock, Betty Hearn Morrow, Hugh Gladwin, International Hurricane Center and Institute for Public Opinion Research, FIU, October 1998
- Phase III: Volume III, Item 6, Twenty Four Appendices Containing the Logic and Data to Generate Structural Damage Curves for the 24 ISO Building Classes
- Cost-Effectiveness of the New Building Code for Windstorm Resistant Construction Along the Texas Coast, Final Report, Stubbs, Perry, and Lombard, Texas Engineering Experiment Station, March 1995
- Florida Building Code 2001
- 1997 Standard Building Code
- ASCE 7-95
- ASCE 7-98

5.3.5 Mitigation Measures

Modeling of mitigation measures to improve a building's wind resistance and the corresponding effects on vulnerability shall be disclosed and demonstrated to be theoretically sound. These measures shall include, but not be limited to, fixtures or construction techniques that enhance:

- Roof strength
- Roof covering performance
- Roof-to-wall strength
- Wall-to-floor-to-foundation strength
- Opening protection
- Window, door, and skylight strength.

The percentage changes in the statewide, zero deductible personal residential non-mitigated loss costs that would be produced in the output ranges due to each mitigation measure shall be individually and specifically provided to the Commission, including ranges of possible impacts on damage for each mitigation measure listed.

Methods for estimating the effects of mitigation measures shall be shown to be reasonable both individually and in combination.

Reference: *Module 1, Section I, A.6 (mitigation factors)* (page 58)
Module 3, Section III, #5 (hazard mitigation) (page 110)

Audit: The comprehensive and detailed listings of items that are required or should be considered ensures consistency and completeness among all modelers in presenting the necessary disclosures and demonstrations of theoretical soundness.

Total effect on damage due to use of multiple mitigation measures shall be documented and shown to be reasonable.

Proprietary: **Yes**
Verified: **Conditional Verification**

Professional Team Comments:

RMS separates the modification factors into seven main categories which are further separated into multiple subdivisions based on detailed, individual properties. A base vulnerability function curve, as described in Standard 5.3.1, is modified for the effects of each modification factor. Reviewed table showing range of possible impacts of individual factors on damages. Discussed methodology used to combine factors without overlapping the effects of the individual features.

Documentation reviewed:

- The Effectiveness of Hurricane Shutters in Mitigating Storm Damage, Jose D. Mitrani, Wilson C. Barnes, Jerry Jarrell, FIU, 1995
- The Magnitude and Distribution of Wind-Induced Pressures on Hip and Gable Roofs, D. Meecham, D. Surry and A.G. Davenport
- Design Wind Pressure Coefficients for Monoslope Roofs: A Time Series Approach, T. Stathopoulos, K. Suresh Kumar, A.R. Mohammadian
- Variations of Wind Pressure on Hip Roofs with Roof Pitch, Y.L. Xu and G.F. Reardon
- Hurricane Shutter Design, Design 1, Shutters for Wood-Frame Buildings, APA
- Hurricane Shutter Design, Design 2, Shutters for Masonry Block Structures, APA
- Hurricane Shutter Design, Design 3, Shutters for Masonry Block Structures, APA
- Wood Construction Connectors, Simpson Strong-Tie Co., Inc., 2001
- Windstorm Mitigation Manual for Light Frame Construction, August 1997
- Evaluation of Roof Sheathing Fastening Schedules for High Wind Uplift Pressures, Thomas P. Cunningham Jr.
- Audel Complete Roofing Handbook, 2nd Edition, James E. Brumbaugh
- 1986 Low Rise Building Systems Manual

5.3.6 Additional Living Expenses (ALE)

In the estimation of Additional Living Expenses (ALE), the model shall consider hurricane damage including storm surge damage to the infrastructure.

The ALE vulnerability function shall consider the time it will take to repair/reconstruct the home.

Reference: *Module 1, Section I, C.1.d (storm surge and flood damage to the infrastructure)* (page 64)
Module 3, Section IV, #6 (ALE vulnerability function) (page 113)
Module 3, Section V, #4 (output ranges) (page 154)
Module 3, Section VII, Form B (30 Hypothetical Events), Form D (Loss Costs), Form F (Hypothetical Events for SA & UA) (page 149)
Standard 5.4.9 (ALE) (page 26)

Audit: The methodology and available validation for determining the extent of infrastructure damage and its effect on undamaged properties shall be made available to the Professional Team.

Documentation and calculations used to determine the time to repair/reconstruct the property shall be shown. Use of expert opinion or other modifications shall be explained.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Verified ALE losses can occur without damage to the structure.

5.4 Actuarial Standards – *Marty Simons, Leader*

5.4.1 Underwriting Assumptions

When used in the modeling process or for verification purposes, adjustments, edits, inclusions, or deletions to insurance company input data used by the modeler shall be based on accepted actuarial, underwriting, and statistical procedures. The methods used shall be documented in writing.

For damage estimates derived from or validated with historical insured hurricane losses, the assumptions in the derivations concerning (1) construction characteristics, (2) policy provisions, (3) claim payment practices, and (4) relevant underwriting practices underlying those losses shall be identified and demonstrated to be reasonable and appropriate.

Reference: *Module 1, Section I, B.4 (annual aggregate loss distributions)* (page 62)
Module 1, Section II, A.3 (damageability assumptions), (page 71)
A.4 (other assumptions), (page 71)
A.5 (claims data used in development of vulnerability functions) (page 72)
Module 3, Section IV (Insurance Functions-Company Loss Estimates) (111)

Standard 5.3.4 (Construction and Codes) (page 16)
Standard 5.6.1 (Use of Historical Data) (page 37)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)

Audit: Quality assurance procedures will include methods to assure accuracy of input insurance data prior to code execution. Compliance with this standard shall be readily demonstrated through rules and documented procedures.

Be prepared to disclose how the claim practices of insurance companies are accounted for when claims data for those insurance companies are used to develop or to verify model calculations. For example, the level of damage the insurer considers a loss to be a "total loss." Be prepared to disclose the methods used to delineate among the insurer claim practices in the use of historical claims data to verify model outputs.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed how RMS uses hazard mitigation and building code criteria with insurance loss data for validation of the vulnerability model. Reviewed new Hurricane Georges insurance exposure and loss data received and used for validation purposes. Reviewed correspondence between modeler and insurer regarding the handling of data anomalies. No new mobile home data has been obtained.

5.4.2 Actuarial Modifications

All actuarial modifications made to the model shall be disclosed to the Commission and based on accepted engineering and actuarial criteria.

Reference: Module 1, Section I, A.6 (actuarial functions modification factors), (page 58)
A.10 (modifications available for model user), (page 61)
B.7 (actuarial modifications range of impacts on loss costs), (page 63)
C.1.b (building code and enforcement), (page 63)
C.1.c (construction characteristics) (page 64)
Module 3, Section III, #3 (building code enforcement), (page 109)
#4 (quality of construction type, materials and workmanship), (page 109)
#5 (hazard mitigation) (page 110)
Module 3, Section V, #4 (output ranges) (page 154)
Module 3, Section VII, Form D (Loss Costs),
Form F (Hypothetical Events for SA & UA) (page 149)
Standard 5.3.4 (Construction and Codes) (page 16)

Audit: Be prepared to disclose adjustments made to account for future impacts on loss costs brought about by revisions due to building code changes or revised mold claim procedures. If loss costs are not adjusted following a revision in Florida building codes or for revised mold claim procedures, be prepared to provide the actuarial criteria indicating no adjustment is appropriate based on expected future insurance company claim payments.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Verified that RMS does not use modification factors in the actuarial functions beyond the building characteristic modifiers discussed in 5.3.5.

5.4.3 Loss Cost Projections

Loss cost projections produced by hurricane loss projection models shall not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin. Hurricane loss projection models shall not make a prospective provision for economic inflation.

Reference: *Module 1, Section I, B.4 (annual aggregate loss distributions),* (page 62)
C.1.a (socio-economic effects) (page 63)
Module 3, Section III, #2 (socio-economic effects) (page 109)
Module 3, Section V (Average Annual Loss Functions-Loss Costs) (page 118)
Module 3, Section VII (Baseline Tests) (page 139)

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Verified no change in the model. Additional insurance data reviewed. RMS uses insurance company claims data for validation tests. Model outputs do not include prohibited items.

5.4.4 Insurer Inputs

The modeler shall disclose any assumptions, fixed and/or variable, that relate to insurer input. Such assumptions shall be demonstrated to be actuarially sound. Assumptions that can vary by specific insurer shall be disclosed in a model output report. Fixed assumptions, that do not vary, need to be disclosed to the Commission.

Reference: *Module 1, Section I, A.10 (modifications available for model user),* (page 61)
B.4 (annual aggregate loss distributions) (page 62)
Module 1, Section II, A.3 (damageability assumptions), (page 71)
A.4 (other assumptions) (page 71)
Module 3, Section III, #2 (socio-economic effects), (page 109)
#3 (building code enforcement), (page 109)
#4 (quality of construction type, materials and workmanship), (page 109)
#5 (hazard mitigation) (page 110)
Module 3, Section IV (Insurance Functions-Company Loss Estimates) (111)
Module 3, Section V, #4 (output ranges), (page 154)
#9 (distribution of hurricanes by size) (page 123)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 144)
Form D (Loss Costs),
Form E (PML), (page 148)
Form F (Hypothetical Events for SA & UA) (page 149)
Standard 5.4.11 (Comparison of Estimated Hurricane Loss Costs) (page 28)
Standard 5.4.12 (Output Ranges) (page 29)

Audit: Potential areas for assumptions may include, but are not limited to, the following:

1. Insurance to Value. Hurricane loss projection models may make assumptions as to the relationship of the amount of insurance to the replacement cost, repair cost, or actual cash value of property. This relationship, called insurance to value, can vary by insurer and can further vary over time.
2. Demographic Assumptions. Hurricane loss projection models may also include assumptions made by insurers using the model. These may include the percentage of houses in a zip code having a particular roof type, cladding, or other structural characteristic. Other assumptions may be more subjective such as maintenance or state of repair.
3. Appurtenant Structures. The model should take into account the prevalence of appurtenant structures by geographic area. In many geographic areas there are relatively few appurtenant structures. Insurers, however, provide an amount of insurance for these structures anyway. Also, change in limits for appurtenant structures may not result in a commensurate change in expected losses because the existing limits may already exceed the value of these structures.
4. Contents. A change in contents limits may not result in a commensurate change in losses because the existing limits may already exceed the value of the contents.
5. Additional Living Expenses. A change in additional living expenses limits may not result in a commensurate change in losses because the existing limits may already exceed the largest likely loss.
6. Insurer Exposures By Zip Code. Some modelers rely on exposure data by zip code provided by insurers in preparation of a rate filing. In such cases,

the modeler will validate all zip code information received from insurance company clients to assure that valid zip codes are used.

All items included in the input and output forms submitted to the Commission shall be clearly labeled and clearly defined.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed the changes in the building inventory mix that was upgraded to a more detailed county level basis from the state level.

5.4.5 Demand Surge

Loss cost projections shall not explicitly include demand surge. Any adjustment to the model or historical data to remove implicit demand surge, shall be disclosed and demonstrated to be reasonable.

Reference:	*Module 1, Section I, C.1.a (socio-economic effects)*	(page 63)
	Module 1, Section II, A.3 (demand surge)	(page 71)
	Module 3, Section III, #2 (socio-economic effects)	(page 109)
	Module 3, Section V, #8 (Hurricane Andrew loss costs)	(page 126)
	Module 3, Section VII (Baseline Tests)	(page 139)

Audit: Demonstrate how the presence of demand surge has been incorporated in any analysis where Hurricane Andrew losses are used for development or verification of the model or its output. Demonstrate how demand surge is incorporated in any other data used in the development or verification of the model.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Verified demand surge was not included in producing the loss costs. RMS removes a percentage of total losses from Hurricane Andrew based on independent research when using Andrew data for validation.

5.4.6 Logical Relation to Risk

Loss costs shall not exhibit an illogical relation to risk, nor shall loss costs exhibit a significant change when the underlying risk does not change significantly.

1. Loss costs produced by the model shall be positive and non-zero for all zip codes.
2. Modelers shall produce color-coded maps for the purpose of comparing loss costs by five-digit zip code within each county and on a statewide basis.
3. Loss costs cannot increase as friction or roughness increase, all other factors held constant.
4. Loss costs cannot increase as the quality of construction type, materials and workmanship increases, all other factors held constant.
5. Loss costs cannot increase with the presence of fixtures or construction techniques designed for hazard mitigation, all other factors held constant.
6. Loss costs shall decrease as deductibles increase, all other factors held constant.
7. Loss costs cannot increase as the quality of building codes and enforcement increases, all other factors held constant.
8. The relationship of loss costs for individual coverages (A, B, C, D) shall be consistent with the coverages provided.

The above tests are intended to apply in general. There may be certain anomalies that are insignificant or are explainable by special circumstances. This standard applies separately to each coverage.

Reference: *Module 1, Section 1, A.6 (actuarial functions modification factors),* (page 58)
B.1 (consistent loss costs produced), (page 61)
B.3 (deductibles, policy limits, replacement costs, insurance-to-value) (page 62)
C.1.b (building code and enforcement), (page 63)
C.1.c (construction characteristics) (page 64)
Module 3, Section III, #3 (building code enforcement), (page 109)
#4 (quality of construction type, materials and workmanship), (page 109)
#5 (hazard mitigation) (page 110)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 118)
#4 (output ranges), (page 154)
#5 (explanation of differences in output ranges from prior year), (page 123)
#9 (distribution of hurricanes by size) (page 135)
Module 3, Section VII (Baseline Tests) (page 139)
Standard 5.1.7 (Visual Presentation of Data) (page 4)
Standard 5.2.8 (Land Friction) (page 10)
Standard 5.3.4 (Construction and Codes) (page 16)
Standard 5.3.5 (Mitigation Measures) (page 17)
Standard 5.4.7 (Deductibles and Policy Limits) (page 23)

Audit: A. Prepare graphic representation of loss costs by zip code. Provide statewide, by region, and major population centers.

B. For land friction, provide a color-coded map by zip code of friction for Florida and identify low, average, and high loss costs. Be prepared to call up loss costs for selected zip codes in Florida.

C. Form B will be used to assess coverage relationships.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Coverage relationships reviewed prior to and during on-site review. Reviewed color-coded maps by ZIP Code of the loss cost relationships for wood frame, masonry, and mobile home.

5.4.7 Deductibles and Policy Limits

The model shall provide a mathematical representation of the distribution of losses to reflect the effects of deductibles and policy limits, and the modeler shall demonstrate its actuarial soundness.

The relationship among the modeled deductible loss costs shall be shown to be reasonable. Differences in these relationships from those previously found acceptable, if applicable, shall be explained and shown to be reasonable. If applicable, changes in the methods used to reflect the effects of policy limits shall be disclosed.

Reference: *Module 1, Section I, B.3 (deductibles, policy limits, replacement costs, insurance-to-value)* (page 62)
Module 3, Section IV, #1 (variety of damage produced by a given wind speed), (page 111)
#2 (insurer loss calculation), (page 111)
#8 (property value and replacement cost calculations) (page 113)
Module 3, Section V, #3 (maps of loss costs by zip code), (page 120)
#4 (output ranges), (page 154)
#9 (distribution of hurricanes by size) (page 135)
Module 3, Section VII, Form D (Loss Costs)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)

Audit: The company actuary will be asked to attest to the actuarial soundness of the procedure. To the extent that historical data are used to develop mathematical depictions of contents functions, be prepared to demonstrate the goodness-of-fit of the data to fitted models as per 5.6.2. Be prepared to discuss and justify changes from the prior submission in the relativities among corresponding deductible amounts for the same coverage.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed the differences in relativities among deductibles. Reviewed scatter plots comparing the prior model to the new revised model on the changes in the deductible relativities for the different coverage types.

Discussed and reviewed the formulation and methodology accounting for deductibles and policy limits.

5.4.8 Contents

The model shall provide a separate mathematical representation of contents loss costs, and the modeler shall demonstrate its actuarial soundness.

The relationship between the modeled building and contents loss costs shall be shown to be reasonable. If applicable, differences and the reasons for those differences from prior submissions in the relativities between loss costs for the building and the corresponding loss costs for contents shall be explained and shown to be reasonable.

Reference: *Module 1, Section I, B.6 (distinction for different policy types)* (page 62)
Module 3, Section IV, #5 (contents vulnerability function), (page 112)
#7 (depreciation assumptions) (page 113)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 118)
#4 (output ranges) (page 154)
Module 3, Section VII, Form B (30 Hypothetical Events), Form C (One Hypothetical Event), Form D (Loss Costs) (page 144)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)

Audit: The company actuary will be asked to attest to the actuarial soundness of the procedure. To the extent that historical data are used to develop mathematical depictions of contents functions, be prepared to demonstrate the goodness-of-fit of the data to fitted models as per 5.6.2. Be prepared to discuss and justify changes from the prior submission in the relativities between loss costs for buildings and the corresponding loss costs for contents.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Relationship between building and contents loss costs were shown to be reasonable.

Discussed the differences in relativities between building and contents loss costs. Reviewed scatter plots showing a comparison of modeled versus observed losses and the relationship between the prior model and the new revised model for building and contents loss. RMS provided an explanation for the changes in the relationship between building and contents loss.

5.4.9 Additional Living Expenses (ALE)

The model shall provide a separate mathematical representation of Additional Living Expense (ALE) loss costs, and the modeler shall demonstrate its actuarial soundness.

The relationship between the modeled building and ALE loss costs shall be shown to be reasonable. If applicable, differences and the reasons for those differences from prior submissions in the relativities between loss costs for the building and the corresponding loss costs for ALE shall be explained and shown to be reasonable.

The modeler shall disclose the methods used in the model to incorporate ALE losses from damage to the infrastructure and the methods shall be shown to be reasonable.

Reference: *Module 1, Section 1, C.1.d (storm surge and flood damage to the infrastructure)* (page 64)
Module 3, Section IV, #6 (ALE vulnerability function) (page 113)
Module 3, Section V, #4 (output ranges) (page 154)
Module 3, Section VII, Form B (30 Hypothetical Events), Form C (One Hypothetical Event), Form D (Loss Costs) (page 144)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)

Audit: The company actuary will be asked to attest to the actuarial soundness of the procedure. Also, be prepared to document, discuss, and justify the following during the on-site review:

A. The method of derivation and data on which the ALE vulnerability function is based;
B. Validation data specifically applicable to ALE;
C. Assumptions regarding the coding of ALE losses by insurers;
D. For Hurricane Andrew, be prepared to quantify and discuss the effects of demand surge on ALE;
E. Assumptions regarding the variability of ALE by size of property;
F. Statewide application of ALE assumptions;

G. Assumptions regarding ALE for mobile homes, tenants, and condominium exposure;
H. Logical relation to contents, especially contents versus ALE for condominiums; and
I. ALE resulting from damage to the infrastructure.

To the extent that historical data are used to develop mathematical depictions of ALE functions, be prepared to demonstrate the goodness-of-fit of the data to fitted models as per 5.6.2.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed the differences in relativities between building and ALE loss costs. Verified the relativities remained basically the same. Relationships were shown to be reasonable.

5.4.10 Replication of Known Hurricane Losses

The model shall be shown to reasonably replicate incurred losses on a sufficient body of past hurricane events, including the most current data available to the modeler. This standard applies separately to personal residential and mobile homes to the extent data are available. Personal residential experience may be used to replicate building-only and contents-only losses. The modeler shall demonstrate that the replications were produced on an objective body of loss data by county or an appropriate level of geographic detail.

Reference: *Module 1, Section II, A.5 (claims data used in development of vulnerability functions),* (page 72)
C.3 (damage estimates validation tests) (page 78)
Module 3, Section IV, #9 (validation comparisons of actual exposures and loss to modeled exposures and loss) (page 114)
Module 3, Section V, #2 (loss costs relationships by type of coverage and type of construction), (page 118)
#8 (Hurricane Andrew loss costs) (page 126)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)
Standard 5.6.3 (Uncertainty Characterization) (page 38)

Audit: A. Provide the following for each insurer and hurricane:

1. The version of the model used to calculate modeled losses for each storm provided;
2. For each storm, a general description of the data and its source;

3. A disclosure of any material mismatch of exposure and loss data problems, or other material consideration. For each storm, the date of the exposures used for modeling and the date of the hurricane;
4. An explanation of differences in the actual and modeled storm parameters;
5. A listing of the departures, if any, in the wind field applied to a particular hurricane for the purpose of validation and the wind field used in the model under consideration;
6. The type of property used in each storm to address:
   a. Personal versus commercial
   b. Residential structures
   c. Mobile homes
   d. Condominiums
   e. Buildings only
   f. Contents only
7. For each example, the inclusion of demand surge, storm surge, loss adjustment expenses, or law and ordinance coverage in the actual losses, or the modeled losses.

B. Have the following documentation available for on-site review:

1. Provide a copy of the publicly available documentation that you plan to provide to the Commission;
2. A listing of all data sources excluded from validation and the reasons for excluding the data from review by the Commission (if any);
3. An analysis that identifies and explains anomalies observed in the validation data;
4. For Hurricane Andrew, be prepared to quantify and discuss the effects of demand surge; and
5. User input sheets for each insurer and hurricane detailing specific assumptions made with regard to exposed property.

C. Use confidence intervals per 5.6.3 to gauge the comparison between historical and modeled losses.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed comparisons of historical to modeled losses. Reviewed in detail information provided in the submission. Reviewed insurer claims data for comparison with model outputs including data analyzed since prior submission from Hurricane Georges.

5.4.11 Comparison of Estimated Hurricane Loss Costs

The model shall provide the annual average zero deductible statewide loss costs produced using the list of hurricanes in 5.2.3 historical hurricanes in Florida based on the 1998 Florida Hurricane Catastrophe Fund's (FHCF) aggregate personal residential exposure data, as of November 1, 1999. These will be compared to the statewide loss costs produced by the model on an average industry basis. The difference, due to uncertainty, between historical and modeled annual average statewide loss costs shall be demonstrated to be statistically reasonable.

Reference: *Module 1, Section II, C.2 (expected loss estimates validation tests),* (page 77)
C.3 (damage estimates validation tests) (page 78)
Module 3, Section I, #7 (decay rate compared to Kaplan-DeMaria), (page 102)
#11 (frequency and annual occurrence rates) (page 104)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 118)
#4 (output ranges), (page 154)
#5 (explanation of differences in output ranges from prior year), (page 123)
#9 (distribution of hurricanes by size) (page 135)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 37)
Standard 5.6.3 (Uncertainty Characterization) (page 38)

Audit: Be prepared to discuss and justify the following during the on-site review:

A. Meteorological parameters;
B. The effect of by-passing storms;
C. The effect of actual storms that have two landfalls impacting Florida;
D. The departures, if any, from the wind field, vulnerability functions, or insurance functions applied to the actual hurricanes for the purposes of this test and those used in the model under consideration;
E. Exposure assumptions;
F. Identify and explain any unusual results;
G. Use confidence intervals per 5.6.3 to gauge the comparison between historical and modeled losses;
H. The zero deductible statewide loss for each hurricane in the Official Storm Set; and
I. The zero deductible loss by zip code for Hurricane Andrew.

Proprietary: **No**
Verified: **Yes**

Professional Team Comments:

Reviewed analysis comparing historical and modeled annual average statewide loss costs. Differences were shown to be statistically insignificant. Reviewed in detail and discussed differences from the prior submission.

5.4.12 Output Ranges

Any model previously found acceptable by the Commission shall provide an explanation suitable to the Commission concerning the differences in the updated output ranges. Differences between the prior year submission and the current submission shall be explained in the submission including, but not limited to:

1. Differences and the reasons for those differences from the prior submission of greater than ten percent in the weighted average loss costs for any county shall be specifically listed and explained in the modeler's submission to the Commission. The submission shall include a specific listing of each affected county.
2. Differences and the reasons for those differences from the prior submission of ten percent or less in the weighted average loss costs for any county shall be explained in the aggregate in the modeler's submission to the Commission.

Reference: *Module 1, Section I, B.2 (resolution used for output ranges)* (page 61)
Module 3, Section V, #4 (output ranges), (page 154)
#5 (explanation of differences in output ranges from prior year), (page 123)
#6 (output ranges % change by county), (page 123)
#7 (maps of output ranges % change by county) (page 126)

Audit: Be prepared to discuss and justify the following during the on-site review:

1. Changes from the prior submission of greater than ten percent in weighted average loss costs for any county.
2. Changes from the prior submission of ten percent or less in weighted average loss costs for any county.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed the impact of the vulnerability function changes on the Output Ranges. Reviewed graphical representations of validations comparing modeled losses versus observed loss results between last year's and this year's model version.

Reviewed color-coded maps showing the changes in loss costs by county and the relative county risk from last year to this year. Discussed the contribution of vulnerability and hazard changes in the model to the changes in loss costs. Reviewed color-coded maps showing the impact of all changes made to the model components.

Reviewed the effect on loss costs of changes in the friction factors. Reviewed color-coded maps by ZIP Code centroid depicting the changes by county.

Discussed in detail the modeled AAL 19% increase from loss costs produced last year. All changes are attributable to the changes made in the meteorology and vulnerability components of the model.

The Professional Team informed RMS that the Commission will be updating the FHCF exposure database provided next year, and they will be required to run both the old and new exposure data sets.

5.5 Computer Standards – *Paul Fishwick, Leader*

5.5.1 Primary Document Binder

A primary document binder, in either electronic or physical form, shall be created, and shall contain fully documented sections for each subsequent Computer Standard. Development of each section shall be indicative of accepted software engineering practices. All computer software (i.e., user interface, scientific, engineering, actuarial) relevant to the modeler's submission must be consistently documented.

Reference: *Module 1, Section I (General Description of the Model)* (page 41)
Module 1, Section II (Specific Description of the Model) (page 68)

Audit: The Professional Team will audit all aspects of the submission. Modeler personnel, or their designated proxies, responsible for each aspect of the software (i.e. user interface, quality assurance, engineering, actuarial) shall be present at the break-out meeting when the computer standards are being audited.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed the primary document binder that contains:

- flowcharts of the overall hurricane model
- data flow diagrams of the model components
- class inheritance diagrams
- engineering specifications
- test plans and procedures
- control flow diagrams
- coding conventions which were expanded and updated
- details on the development process

- changes associated with the revised hazard and vulnerability data
- changes associated with the new variable resolution grid (VRG) data

5.5.2 Requirements

The modeler shall document all requirements specifications of the software, such as interface, human factors, functionality, documentation, data, human and material resources, security, and quality assurance.

Reference: *Module 1, Section I (General Description of the Model)* (page 41)
Module 1, Section II (Specific Description of the Model) (page 68)
Module 3, Section VI, #2 (computer code tampering) (page 138)

Audit: The Professional Team will ask modelers for the requirements specifications documentation and review onsite.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed in detail the process followed in development of the model, coding, testing, and implementation. Discussed who has authorization to change the source code, and the procedures for tracking and verifying those changes. Discussed the procedures for changes made to the data.

Documentation reviewed:

- RiskLink v4.3a Product Definition
- RiskLink Functional Specification
- RiskLink Technical Specification
- RiskLink System Administration Manual that lists resource, security, and database requirements
- Visual SourceSafe Introduction and Overview for security requirements
- RiskLink DLM User Guide that summarizes the interface and functionality requirements
- Coding Standards detailing technical requirements for user interface, human factors design, source code design and implementation, database design and coding, and component interface design

5.5.3 Model Architecture and Component Design

The modeler shall document detailed control and data flow diagrams, interface specifications, and a schema for all data files along with field type definitions. Each network diagram shall contain components (including referenced sub-component

diagrams), arcs, and labels. A model component custodian shall be identified and documented.

Reference: *Module 1, Section I (General Description of the Model)* (page 41)
Module 1, Section II (Specific Description of the Model) (page 68)

Audit: All codes will be designed in diagrams that depict the flow of data and control. Other synonyms for "component" are module, function, plug-in, or object. In all cases, a component has a clear input/output interface. The idea of interacting components with flows extending from one component to another came about in systems theory and engineering and was extended to software engineering. While the standards do not dictate programming paradigm, they require that the top-level design of the code is in an aggregate form that references common components such as STORMS, WIND FIELD, DAMAGE, and COST.

All model component custodians or their designated proxies must be available at the time of audit.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Component Custodian documentation included both primary and backup (secondary) custodians. Discussed in detail the methodology for changes made to the source code and the security system in place.

Documentation reviewed:

- Class Diagrams
- General Class Diagrams
- Component Diagrams
- Flow Charts
- Data Flow Diagrams and Data Dictionary
- Component Custodians at the primary and secondary levels
- Most Recent Change by Component

5.5.4 Implementation

The software shall be traceable from the flow diagrams and their components down to the code level. All documentation, including document binder identification, shall be indicated in the relevant component. The highest design level components shall incrementally be translated into a larger number of components until the code level is reached.

Reference: *Module 1, Section I (General Description of the Model)* (page 41)
Module 1, Section II (Specific Description of the Model) (page 68)

Audit: Each of the components in 5.5.3 is refined into subcomponents, and at the end of the component "tree" there are blocks of code. All documentation and binder identifications will be referenced within this tree. This creates a traceable design from aggregate components down to the code level.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Performed spot checks on the following:
1. Data files, and associated C++ code, for weighted averages of damage curves with inventory at the county and state levels.
2. Transition wind field track data files and code for verifying the method associated with the transition to an extratropical storm.
3. The method for initializing the profile shape parameter.

Documentation reviewed:
- Component Diagrams
- Data Flow Diagrams and Data Dictionary
- StormIND.US file containing storm rates for Florida

5.5.5 Verification

1. General

The modeler shall employ and document procedures employed, such as code inspections, reviews, calculation crosschecks, and walkthroughs, sufficient to demonstrate code correctness. The code shall contain sufficient logical assertions, exception-handling mechanisms, and flag-triggered output statements to test the correct values for key variables that might be subject to modification.

2. Testing

Tests shall be documented for each software component, independent of all other components, to ensure that each component provides the correct response to inputs. The test specifications, procedures, and results shall also be documented to establish that the integration of all components produces model behavior that functions correctly.

Reference: *Module 1, Section I (General Description of the Model)* (page 41)
Module 1, Section II (Specific Description of the Model) (page 68
Standard 5.1.4 (Independence of Model Components) (page 2)

Standard 5.6.4 (Sensitivity Analysis for Model Output) (page 38)
Standard 5.6.5 (Uncertainty Analysis for Model Output) (page 39)

Audit: Some compilers will contain the ability to declare logical assertions. For those compilers without this capability, one can create "if-statements" with the appropriate flag. Assertions as to "what should be true" at specific points in the code aids in producing correct code.

To test the whole, unit testing is required on each of the parts. When each part is verified as working on an independent basis, then the parts can be combined together to create the final program. Tests should be run by varying component inputs to ensure correct output. To the extent that component inputs are varied according to sensitivity and uncertainty analyses, provide this material to the Professional Team for review.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Documentation reviewed:

- Sample C++ Source Files
- RiskLink 4.3a Test Procedures – MR Input Test Suite
- RiskLink 4.3a Mapping Test Plan
- Product Delivery Overview that illustrates the role of the review and testing within the development process
- Documentation templates and functional specifications
- Technical Specification that illustrates unit testing done by software developers

5.5.6 Model Maintenance and Revision

The modeler shall specify all policies and procedures used to maintain the code, data, and documentation. For each component in the system decomposition, the modeler shall list the installation date under configuration control, the current version number, and the date of the most recent change(s). The modeler shall use tracking software to identify all errors, as well as modifications to the code, data, and documentation.

Reference: *Module 1, Section I (General Description of the Model)* (page 41)
Module 1, Section II (Specific Description of the Model) (page 68)

Audit: Software maintenance includes a written and implemented policy for backup procedures. There are numerous software applications that aid the programming in source revision and control. Even if there are very few programmers, such an approach is necessary to track changes and ensure a quality software engineering process.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Documentation reviewed:

- Product Delivery Overview
- Sample Visual Intercept Incident Report from RiskLink Visual Intercept Database
- Visual Intercept Quick Reference Guide
- File Versioning
- Client Response System

5.5.7 User Documentation

The modeler shall have complete user documentation including all recent updates.

Reference: *Module 1, Section I (General Description of the Model)* (page 41)
Module 1, Section II (Specific Description of the Model) (page 68)

Audit: The Professional Team will talk to users of the software, including those familiar with the code as well as those who use the code without any knowledge of its components or their internal interfaces.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Documentation reviewed:

- RiskLink DLM User Guide
- RiskLink DLM Reference Guide
- RiskLink DLM System Administration Guide
- RiskLink Version 4.3a Release Notes
- RiskLink Mapping User Guide
- RiskLink Reports User Guide
- RMS U.S. Hurricane Model Methodology

5.6 Statistical Standards – *Mark Johnson, Leader*

5.6.1 Use of Historical Data

The use of historical data in developing the model shall be demonstrated to be reasonable using rigorous methods published in the scientific literature.

Reference: *Module 1, Section II, B.12 (statistical techniques used for probability distribution estimates)* (page 76)
Module 3, Section I, #8 (source of historical data set) (page 102)

Audit: Although the chi-square goodness-of-fit test is a commonly used procedure, there are more powerful (rigorous) tests available. Either the Kolmogorov-Smirnov (with relevant adjustments for parameter estimation) or Cramer-von Mises tests should be applied using a reasonable significance level. The Commission does not consider the chi-square goodness-of-fit test to be a rigorous methodology for demonstrating the reasonableness of models of historical data.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed the fits of CP, Rmax, and Vt. Reviewed scatter plots showing the standard deviation of the residuals for Rmax versus CP and Latitude. Reviewed the use of smoothed historical data on landfall rates and historical data used in constructing vulnerability functions.

5.6.2 Comparison of Historical and Modeled Results

The modeler shall demonstrate the agreement between historical and modeled results using accepted scientific and statistical methods.

Reference: *Module 1, Section II, A.1 (deviation from official hurricane set),* (page 68)
B.7 (parameters for hurricane frequency), (page 74)
C.1 (wind speed validation tests), (page 77)
C.3 (damage estimates validation tests), (page 78)
C.5 (other validation tests), (page 79)
C.6 (validation tests documentation) (page 79)
Module 3, Section I, #12 (number of events, relative frequency and annual occurrence rate by category), (page 105)
#13 (probability of hurricanes by year) (page 107)
Module 3, Section III, #3 (building code enforcement), (page 109)
#4 (quality of construction type, materials and workmanship), (page 109)

#5 (hazard mitigation) (page 110)
Module 3, Section IV, #3 (appurtenant structures vulnerability function), (page 112)
#4 (mobile home vulnerability function), (page 112)
#5 (contents vulnerability function), (page 112)
#6 (ALE vulnerability function) (page 113)

Audit: Examples include hurricane frequencies, tracks, intensities and physical damage.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed several K-S tests comparing historical versus modeled results for central pressure, Rmax, and forward speed. Examined landfall rates and radius to hurricane force winds. Reviewed validation tests comparing modeled versus historical average annual loss.

5.6.3 Uncertainty Characterization

The modeler shall provide an assessment of uncertainty using confidence intervals or other accepted scientific characterizations of uncertainty.

Reference: Module 1, Section II, B.9 (confidence intervals produced) (page 74)

Audit: Note that confidence limits could be used for distribution parameter limits and prediction limits could be used for situations in which future values are envisaged.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed confidence intervals using boot strapping techniques for Rmax on both the left-hand and right-hand side of modeled storms compared to historical storms.

Reviewed vulnerability intervals for loss by ZIP Code on wood frame and masonry construction types. Uncertainties in CP, Vt, Rmax, vulnerability relationships, and AAL were characterized.

5.6.4 Sensitivity Analysis for Model Output

The modeler shall demonstrate that the model has been assessed with respect to sensitivity of temporal and spatial outputs to the simultaneous variation of input variables using accepted scientific and statistical methods. Statistical techniques used to perform sensitivity analysis shall be explicitly stated and the results of the analysis shall be presented in graphical format.

Reference: *Module 1, Section I, A.5 (critical variables determined from SA)* (page 56)
Module 1, Section II, B.13 (model sensitivity), (page 76)
B.14 (sensitivity in output results), (page 76)
B.15 (SA & UA performed on model) (page 77)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 149)
Standard 5.2.10 (Temporal and Spatial Wind Field Characteristics) (page 13)

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed in detail Form F results and analyses. These analyses included standardized regression coefficient (SRC) calculations and corresponding contour plots for wind, max wind, mean damage ratio, and loss costs. The analysis sheds further insight on the decay rate.

5.6.5 Uncertainty Analysis for Model Output

The modeler shall demonstrate that the temporal and spatial outputs of the model have been subjected to an uncertainty analysis using accepted scientific and statistical methods. The analysis shall identify and quantify the extent that input variables impact the uncertainty in model output as the input variables are simultaneously varied. Statistical techniques used to perform uncertainty analysis shall be explicitly stated and results of the analysis shall be presented in graphical format.

Reference: *Module 1, Section I, A.5 (assessment of uncertainty in loss costs produced by variables)* (page 56)
Module 1, Section II, B.9 (confidence intervals produced), (page 74)
B.13 (model sensitivity), (page 76)
B.14 (sensitivity in output results), (page 76)
B.15 (SA & UA performed on model) (page 77)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 149)
Standard 5.2.10 (Temporal and Spatial Wind Field Characteristics) (page 13)

Audit: Although some modelers may use parameters as synonyms for input variables, the latter terminology is preferred here.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Reviewed in detail Form F results and analyses. These analyses included expected percentage reduction (EPR) calculations and corresponding contour plots for wind, max wind, mean damage ratio, and loss costs. The analysis sheds further insight on the decay rate.

5.6.6 County Level Aggregation

At the county level of aggregation, the contribution to the error in loss costs estimates induced by the sampling process shall be demonstrated to be negligible using accepted scientific and statistical methods.

Reference: *Module 1, Section II, C.2 (expected loss estimates validation tests)* (page 77)
Module 3, Section V, #4 (output ranges), (page 154)
#5 (explanation of differences in output ranges from prior year), (page 123)
#6 (output ranges % change by county) (page 123)
#7 (maps of output ranges % change by county) (page 126)
Module 3, Section VII, Form D (Loss Costs)
Standard 5.6.3 (Uncertainty Characterization) (page 38)

Audit: Provide a graph assessing the accuracy associated with low impact areas such as Nassau County. Assess where appropriate, the contribution of simulation uncertainty via confidence intervals per 5.6.3.

Proprietary: **Yes**
Verified: **Yes**

Professional Team Comments:

Discussed in detail the phases involved in importance sampling for verification of AAL by county. Reviewed graphical representations of the ratio of the AAL convergence for each county in Florida of the reduced sample set compared to the Monte Carlo simulation. Reviewed scatter plot of county AAL ratios (reduced versus full) by county in Florida after an iterative procedure.

Reviewed K-S test results and graphical representations comparing historical storms to stochastic storms for Central Pressure, Forward Velocity on the full Monte Carlo set and the reduced sample set.

Modules Verification:

Module 1

A few items not already covered in the pre-visit letter or in the course of the audit were resolved.

Module 2

See Standard 5.1.2 on modeler personnel.

Module 3

A few items not already covered in the pre-visit letter or in the course of the audit were resolved.

Form A

Reviewed change in Form A results from last year.

Form B

Discussed differences in Form B results from the previous submission and verified the differences were attributable to the changes made in the model.

Form C

Discussed differences in Form C results from the previous submission and verified the differences are reflective of the vulnerability curve changes.

Form D

Discussed differences in Form D from the previous submission and verified the differences were attributable to the changes made in the model.

Form E

Discussed the definitions of the terms annual aggregate and occurrence and found Form E acceptable as submitted.

Form F

RMS presented their Uncertainty/Sensitivity Analysis results. Reviewed contour plots of various category hurricane wind speeds showing the standardized regression coefficients at times 0, 2, 5, and 7 for Central Pressure, Rmax, Forward Speed and RMS fill rate coefficient. Discussed the fourth variable distribution (fill rate coefficient), the formula for its calculation, and how the factor was used in the Form F analysis.

Reviewed RMS' analysis for loss cost including contour plots for Central Pressure, Rmax, Forward Speed, and the filling rate coefficient for various hurricane categories at times 0, 2, 5, and 7.