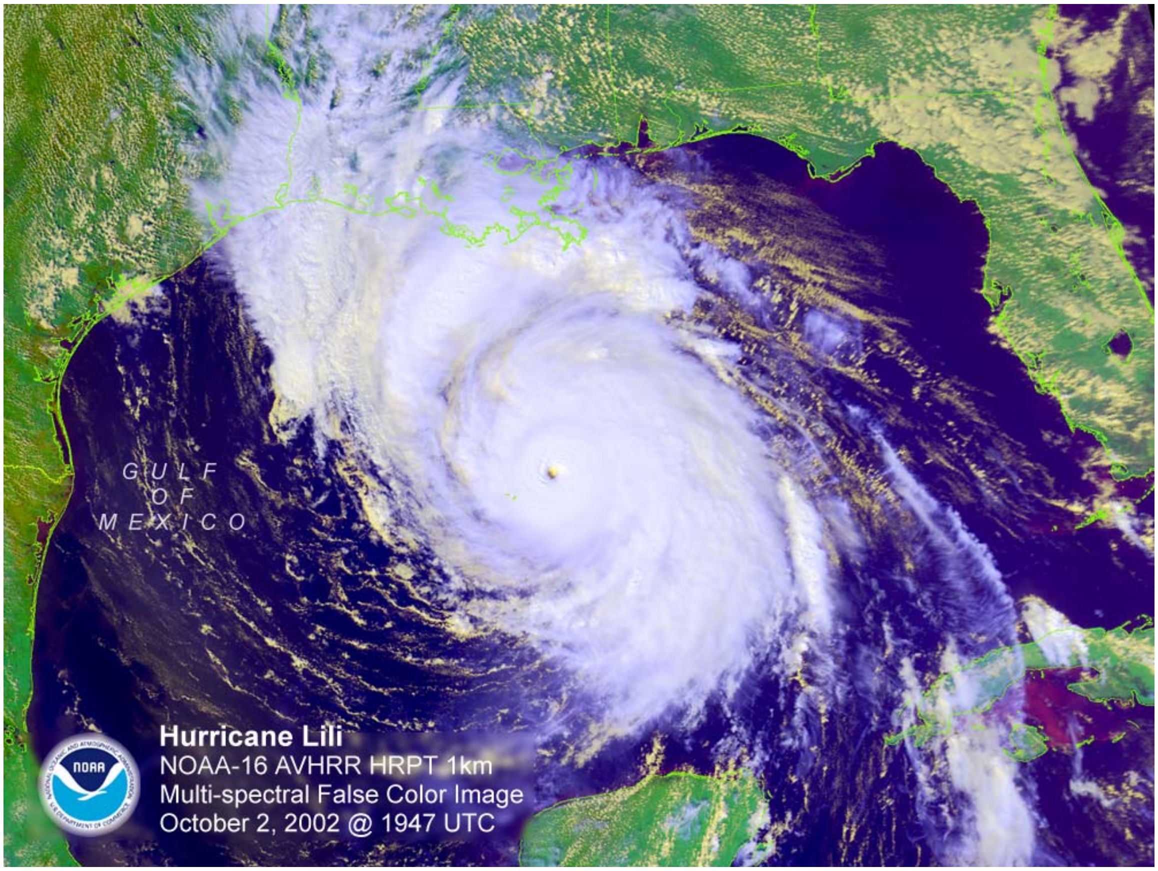
Florida Commission on Hurricane Loss Projection Methodology



Professional Team Audit Report
2002 Standards

AIR Worldwide Corporation

On-Site Review
April 29 & 30, 2003

On April 29 & 30, 2003, the Professional Team visited on-site at AIR Worldwide Corporation in Boston, Massachusetts. The following people participated in the review.

AIR

William Bernens, Services and Analytics, Manager
Bhaskar Chattaraj, Manager, Software Quality Assurance
Peter S. Dailey, Ph.D., Manager Atmospheric Science
Boris Davidson, Principal Software Architect
Michele Fischer, Research Scientist/Meteorologist
Paul Gauss, Technical Documentation Writer
Jayanta Guin, Ph.D., Vice President, Research and Modeling
David Lalonde, FCAS, FCIA, MAAA, Senior Vice President
S. Ming Lee, Senior Vice President
Greta M. Ljung, Ph.D., Senior Research Statistician
Shangyao Nong, Ph.D., Senior Research Scientist, Meteorology
Mohit Pande, Research Engineer
Miriam E. Perkins, ACAS, MAAA, Actuarial Analyst
Jorge Porto, Manager of Software Development
John Rowe, Manager, Exposures Group
Enis Simsek, Software Engineer

Professional Team

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

The review began with introductions and an overview of the audit process. AIR began with a discussion of the changes to the model from the previous year which include:

- ZIP Code database update – re-estimated physical properties at new ZIP code centroids and inclusion of the 2000 census data
- Historical catalog updated through 2001
- New approach for simulating radius of maximum winds
- Higher resolution data set for land use/land cover
- Increased time resolution of windfield computation

AIR explained the statewide impact on the weighted average loss cost due to the changes in the model listed above. Counties that had a change greater than 10% were attributed to significant ZIP Code population centroid movement and the change to a higher resolution Land Use Land

Cover database. AIR provided examples of changes in the weighted average loss cost from the previous submission.

There were no changes made to the vulnerability functions and no significant change in the relationships among coverages, deductibles, mobile homes, and other construction types.

We discussed the change in wind speed calculations for Hurricane Andrew. AIR made the appropriate changes to their model.

We discussed AIR's change in time resolution and the methodology incorporated for selecting the time resolution for different wind speeds. We reviewed AIR's reason for the change and where the impact is felt.

Deficiencies from April 1, 2003 Meeting

1. Table 4 (page 40 in your submission) – provide an explanation for the weighted average figure given for "Secondary Water Resistance" under "Roof Attached Structures."

   AIR Response:

   The weighted average figure given for "Secondary Water Resistance" under "Roof Attached Structures" was mistakenly displayed as 3.1%. The correct figure is –3.1%. This error was due to a number being mistyped when entering a revised figure. We are resubmitting 25 copies of the corrected pages 39/40 and 105/106 (the table also appears in page 105 of the submission).

   Verified: Yes

   Professional Team Comments:

   Discussed AIR's process for computing the weighted averages provided in Table 4, Individual Risk Characteristics and Range of Wind Mitigation Credits.

2. Output Ranges (pages 16-20 in your submission) – provide an explanation of the relationship between the loss costs for a $2,500 deductible for a personal residential renters frame and a 5% deductible for a personal residential renters frame.

   AIR Response:

   This relationship existed for personal residential Renters Frame and Renters Masonry due to the use of the wrong deductible type. The appropriate deductible type for Renters is CA for dollar deductibles and CP for percent deductibles. Please note this causes additional changes to the other deductibles on these pages. We are resubmitting 25 copies of the full set of Output Ranges.

   Verified: YES

   Professional Team Comments:

   Discussed and reviewed the corrections made with the appropriate deductible type.

3. Output Ranges (pages 6-35 in your submission) – provide an explanation for the name of model and version number given in the footnote.

   AIR Response:

   The update to the 2003 model and version number on the pages noted was inadvertently not made. The remaining pages do reflect the current model. This error was also corrected in our resubmission of the Output Ranges.

   Verified: YES

   Professional Team Comments:

   Reviewed correction to the footnotes in the Output Ranges.

AIR Worldwide Corporation – 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 5.1.2 – Provide John Kam and Mohit Pande resumes for review.

General items numbered 1.3 through 1.12 below refer to the output ranges.

1.3 Explain any differences in minimum and maximum loss costs for any county where the changes from last year's submission exceed 5%.

1.4 Provide a brief overview of any differences in minimum and maximum loss costs for any county regardless of the magnitude of the difference.

1.5 Explain any significant differences in the relativities between building and contents loss costs from those derived from last year's submission.

1.6 Explain any significant differences in the relativities between mobile homes and other construction types loss costs from those derived from last year's submission.

1.7 Explain any significant differences in the relativities among deductibles from those derived from last year's submission.
1.8 Explain any differences in the relativities between building and additional living expense loss costs from those derived from last year's submission.
1.9 Explain any differences in the relativities between building and appurtenant structure loss costs from those derived from last year's submission.
1.10 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.
1.11 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.
1.12 Explain the relationship among <u>$0 Deductible Structure</u>, $0 Deductible Contents, <u>$0 Deductible Appurtenant Structure</u>, and $0 Deductible Additional Living Expense.

2. Meteorology

2.1 Page 8, Standard 5.2.3 – Present and describe in detail the input file used in generating your stochastic storm set.
2.2 Page 10, Standard 5.2.4 – Present details of Rmax calculation.
2.3 Page 10, Standard 5.2.4 – Provide details on the regression function *f* and details on the fit. Is the normal distribution assumption viable based on consideration of residuals? By subsequent storms do you mean all Atlantic storms through 2001? If not, please define.
2.4 Pages 14-17, Standard 5.2.6 – Demonstrate the quality of fit of simulated storms to historical records for appropriate coastal segments in Alabama, Georgia, and Mississippi.
2.5 Page 20, Standard 5.2.8 and cover letter – Discuss impacts of the use of high-resolution land use/land cover data set wind speeds.
2.6 Page 23, Standard 5.2.10 – Present contour plots of wind fields (2-dimensional, instantaneous) as developed for Form F.
2.7 Page 154, Module 3, Section I, #9 – Do you have an updated plot of Table 26 indicating the potential correlation structure?
2.8 Page 201, Module 3, Section VII, Form F – Describe in detail the variation of the reduction factor referenced in the second highlighted paragraph on page 201.
2.9 Discuss impacts of Hurricane Andrew reclassification on your model.
2.10 Discuss your methodology for converting gradient-level winds to surface winds.

3. Vulnerability

3.1 Page 27, Standard 5.3.1 – All new claims data should be available for review.

3.2 Pages 27-29, Standard 5.3.1 – Provide additional information for Figures 13-18 such as company and storm name.

3.3 Page 29, Standard 5.3.2 – Provide several examples of vulnerability function curves for each type required. Typical examples of regional variation shall be shown.

3.4 Page 30, Standard 5.3.3 - Show, in computer code, where peak gust wind speed of 40 mph is used as the starting point of damage being considered.

3.5 Page 34, Standard 5.3.5 – Provide mitigation module features such as input of various building features, combination of building features, and examples of engineering principles and building performance observations on which the vulnerability function modifications are based.

3.6 Page 35, Standard 5.3.5 – Verify table referenced in second paragraph.

3.7 Page 35, Standard 5.3.5 – Provide examples of evaluation of the combined effect of multiple mitigation measures.

3.8 Page 35, Standard 5.3.6 – Verify ALE losses are considered for instances where no building or content losses occur.

3.9 Page 35, Standard 5.3.6 – Are abnormal working conditions considered in determining the time factor to repair/reconstruct the property?

3.10 Page 101, Module 1, Section I, B #7 – Discuss in detail modifications to vulnerability functions due to building code effectiveness with emphasis on effects due to the new Florida Building Code, division of state into regions, and insight into engineering judgment used to determine the ranges of building losses. (Standard 5.3.1)

3.11 Page 102, Module 1, Section I, B #7 – Provide data for reduced risk due to mansards in “Roof Geometry” category in Table 19. (Standard 5.3.5)

3.12 Page 106, Module 1, Section I, C #1.b – Describe six building categories based on construction under new Florida Building Code. Does quality of construction vary with region, and on what is this decision based? (Standard 5.3.4)

3.13 Page 111, 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)

3.14 Page 165, Module 3, Section IV, #5 – Is there a threshold of damage percent at which damage to contents is assumed to occur? (Standard 5.3.1)

3.15 Page 165, Module 3, Section IV, #6 – Verify that direct and indirect losses are considered. Is there a threshold of damage percent at which ALE expenses are assumed to occur? (Standard 5.3.1)

3.16 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 Page 36, 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 37, Standard 5.4.2 – Discuss the underlying data and criteria used to develop each of the values in Table 4 on this and subsequent pages. Be prepared to describe the methods used and the resulting impact when multiple mitigation credits are appropriate.

4.3 Page 46, Standard 5.4.7 – Provide the numerical values on the axes in Figure 19. What is the proportion of the distribution with discrete mass at 0 and 1?

4.4 Page 55, Standard 5.4.12 – Present details of the impacts of the change in the zip code data base and the inclusion of the 2000 census data as referenced in your response to this standard.

4.5 Page 55, Standard 5.4.12 – Describe in detail the new approach for correlating the radius of maximum winds with central pressure as cited in your response to this standard.

4.6 Page 55, Standard 5.4.12 – Describe in detail the "higher resolution data set" referenced in your response to this standard. Include a description of the "significant changes" referred to in this response.

4.7 Page 55, Standard 5.4.12 – Describe in detail the changes made in the time resolution of the windfield as referenced in this response.

4.8 Page 55, Standard 5.4.12 – Describe in detail the enhancements made to the building vulnerability model as referenced in your response to this standard.

4.9 Page 56, Standard 5.4.12 – Provide AIR's analysis of each of the counties referenced on page 56, including the change in loss cost for each county and the rationale for AIR's conclusions relative to the reasons for the change.

4.10 Page 145, Module 2, 4.B – Disclose any model verification comparisons or analyses performed using data from AIR's new "primary insurance companies".

4.11 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.

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

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

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

4.15 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 9.5 mph, yet each coverage category shows a decrease in the loss. Coverage D losses for Categories 1 and 2 are typically small and therefore subject to big percentage changes based on small changes in loss. However, Total Loss is not as subject to such wide percentage fluctuations. Please explain why Ft. Myers and Ft. Pierce, for example, can have double digit increases in maximum wind speed, but have decreases in loss.

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	13.2	-7.6	-7.0	-10.2	-25.2
Ft. Pierce	14.6	-4.8	-4.8	-5.1	-12.3
Jacksonville	3.2	-1.1	-1.0	-1.5	-1.4
Miami	11.9	3.8	3.1	5.7	12.9
Panama City	4.8	0.6	0.2	1.5	-6.7
Tampa	9.1	-0.4	-0.5	0.0	-0.7
Average	9.5	-1.6	-1.7	-1.6	-5.6

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	8.2	-2.8	-2.8	-2.7	-15.0
2	8.6	-2.5	-2.4	-2.8	-10.7
3	8.8	-2.0	-1.9	-2.7	-4.1
4	9.6	-0.6	-0.9	-0.4	1.3
5	12.1	0.0	-0.3	0.6	0.8
Average	9.5	-1.6	-1.7	-1.6	-5.6

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 57, 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 59, Standard 5.5.4 – The Pro Team will verify that the "software shall be traceable from the flow diagrams and their components to the code level." Be prepared to expand upon the AIR response to this standard.

6. Statistical

6.1 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 107)

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

Professional Team Comments:

Verified the storm surge component of the model is in the "off" position when producing the loss costs in the Output Ranges and that the data used does not include losses from flood and storm surge.

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 135)
#3 (multi-discipline team), (page 143)
#5 (independent expert review) (page 146)

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:

Reviewed resumes of new modeler personnel and outside consultants:

- Mohit Pande, M.E.Sc. Civil Engineering, Specialization in Wind Engineering, Boundary Layer Wind Tunnel Laboratory, University of Western Ontario
- John Kam, Ph.D., Princeton University, Software design and development – outside consultant that performed a peer review of the model software.

Discussed reasons behind personnel who have left company since last visit.

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 69)
A.9 (model revisions) (page 96)

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:

Reviewed AIR's policy for model revision and release. Discussed the process of incorporating changes to the model and how they follow policy procedure.

Documentation Reviewed:
Policy on North Atlantic Hurricane Model Revisions, AIR Worldwide Corporation

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 120)
B.13 (model sensitivity), (page123)
B.14 (sensitivity in output results), (page 123)
B.15 (SA & UA performed on model) (page 124)
Standard 5.5.3 (Model Architecture and Component Design) (page 58)
Standard 5.5.5 (Verification) (page 60)

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:

The independence of the meteorology, vulnerability, and actuarial components of the model were verified and clearly 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.

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 109)
Module 3, Section VI, #1 (handling of invalid zip codes) (page 187)
Module 3, Section VII, Form A (Zip Code Data Base) (page 190)

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

Professional Team Comments:

Reviewed maps of population weighted ZIP Code centroids highlighting the changes from updating the ZIP Code database and the resulting effect on the loss costs.

John Rowe provided a presentation on the changes in AIR's methodology from 2001 to 2002 including how the ZIP Code centroids are generated, ZIP Code centroids are population weighted, and the impact the ZIP Code centroids have on the model.

Reviewed summary of centroid movements between years by county.

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 107)

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

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

Professional Team Comments:

Appropriate units of measure were verified through the review and all visual presentations shown were labeled correctly.

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 154)
Module 3, Section V, #3 (maps of loss costs by zip code), (Attachment I)
#7 (maps of output ranges % change by county) (Attachment H)

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: **Yes**
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 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 159)

Standard 5.1.6 (Identification of Units of Measure and Conversion Factors) (page 6)

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

Professional Team Comments:

Verified there was no change to the model from the previous year. Reviewed the standard and data used provided in the wind engineering literature. Reference was provided in support of specific conversions.

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 108)
A.2 (primary databases), (page 109)
B.7 (parameters for hurricane frequency), (page 115)
B.8 (stochastic hurricane generation) (page 118)
Module 3, Section I (Hurricane Set) (page 149)

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

Professional Team Comments:

Greta Ljung provided an overview of the input files used in generating the stochastic storm set including the steps involved in generating the catalog, the probability distributions for key model variables, and the input file for landfall locations.

Verified AIR updated the stochastic storm set for 2001.

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 112)
B.2 (asymmetric nature of hurricanes), (page 112)
B.3 (filling rate function), (page 113)
B.4 (land friction), (page114)
B.5 (characteristics used for wind speed estimation), (page114)
B.6 (dependent wind speed variables), (page 115)
B.7 (parameters for hurricane frequency), (page 115)
B.8 (stochastic hurricane generation) (page 118)
Module 3, Section I (Hurricane Set) (page 149)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA)(page 197)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)

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:

Greta Ljung and Shangyao Nong provided a presentation on AIR's new approach for simulating Radius of Maximum Winds. Discussed AIR's Rmax equation in the model and the process they went through in developing the equation. Reviewed graphical representations of the correlations between Rmax and Central Pressure and Rmax and Latitude. AIR explained the validation checks performed for the new Rmax approach. Reviewed graphical results of historical versus simulated Radius of Maximum Winds.

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	≥ 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 149)
#2 (upper limit of wind speeds produced), (page 149)
#3 (multiple landfalls), (page 150)
#11 (frequency and annual occurrence rates), (page 155)
#12 (number of events, relative frequency and annual occurrence rate by category) (page 156)
Module 3, Section VII, Form B (30 Hypothetical Events)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)
Standard 5.6.3 (Uncertainty Characterization) (page 65)

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

Professional Team Comments:

Verified no change from previous year in the model.

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 98)
Module 1, Section II, A.1 (historical database for wind speeds and frequency), (page 108)
B.7 (parameters for hurricane frequency), (page 115)
B.8 (stochastic hurricane generation) (page 118)
Module 3, Section I (Hurricane Set) (page 149)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)
Standard 5.6.3 (Uncertainty Characterization) (page 65)

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 for competitive reasons.**
Verified: **Yes**

Professional Team Comments:

AIR provided a goodness-of-fit summary of the Weibull distribution fitted to Central Pressure. The distributions were provided for various segments. Reviewed results of Kolmogorov-Smirnov goodness-of-fit tests and discussed the P-values.

Reviewed Shapiro-Wilk goodness-of-fit tests for Forward Speed including lognormal distributions fitted to Forward Speed distributions for different segments.

Verified AIR took into account the adjacent states of Alabama, Georgia, and Mississippi and the inclusion of a new year with no storms.

Reviewed validation tests on simulated storms versus historical storms segment by segment.

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 69)
Module 1, Section II, B.1 (wind speeds used for loss estimation), (page 112)
B.7 (parameters for hurricane frequency), (page 115)
B.8 (stochastic hurricane generation) (page 118)
Module 3, Section 1, #2 (upper limit of wind speeds produced), (page 149)
#5 (hurricane tracks), (page 150)
#9 (radius of hurricane force winds, Rmax and FFP by CP), (page 153)
#11 (frequency and annual occurrence rates), (page 155)
#12 (number of events, relative frequency and annual occurrence rate by category) (page 156)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 197)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)
Standard 5.6.3 (Uncertainty Characterization) (page 65)

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 numerous fits on the parametric distributions.

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 114)
B.5 (characteristics used for wind speed estimation) (page 114)
Module 3, Section I (Hurricane Set) (page 149)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA)(page 197)

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:

Shangyao Nong presented AIR's introduction of new Land Use Land Cover data (LULC). Discussed and reviewed in detail the changes in the data, the mapping of the new data, and the methodology used to apply the surface roughness to the LULC categories provided and the values assigned. Reviewed comparisons by county showing the differences in ZIP Code centroids that the change in the LULC brought about. Reviewed the impact on the model of introducing the new high resolution LULC data into the model. Discussed the benefits provided by the higher resolution LULC data and how it improved the model and the loss costs produced.

Reviewed in greater detail the smooth and line contours provided on pages 20 & 21 of the submission.

Note to Commission: No change was made in this standard in 2002; however, the modeler did make a change in the model. The Professional Team recommends this standard should be voted on separately rather than grouping with the standards with no change.

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 113)
Module 3, Section I (Hurricane Set) (page 149)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 197)

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:

Verified no change from last year.

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 151)
#9 (radius of hurricane force winds, Rmax and FFP by CP) (page 153)
Module 3, Section II (Hurricane Wind Field) (page 159)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 192)
Form F (Hypothetical Events for SA & UA) (page 197)

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

Professional Team Comments:

Reviewed contour plots of wind fields, graphical representations of the average wind speed profile for Cat 1, Cat 3, and Cat 5 hurricanes over time at 1 hour, 2 hour, etc.

Reviewed AIR's 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.

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 91)
A.8 (documents/research used in development of vulnerability functions), (94)
C.1.a (socio-economic effects) (page 105)
Module 1, Section II, A.5 (claims data used in development of vulnerability functions) (page 111)
Module 3, Section III (Vulnerability Functions-Damage Estimates) (page 160)
Module 3, Section IV, #3 (appurtenant structures vulnerability function), (164)
#4 (mobile home vulnerability function), (page 164)
#5 (contents vulnerability function), (page 165)
#6 (ALE vulnerability function) (page 166)
Standard 5.4.1 (Underwriting Assumptions) (page 36)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)

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 no change in the model. Reviewed new references to the Florida Building Code:

- ASCE 7-98, "Minimum Design Loads for Buildings and Other Structures"
- 2001 Florida Building Code
- 1999 Revisions to South Florida Building Code
- "Simulation of Hurricane Risk in the U.S. Using Empirical Track Model", P.J. Vickery, P.F. Skerlj, and L. A. Twisdale (2000)

Additional documentation reviewed:

- Additional validation data
- Vulnerability Function validation for 2003 US Hurricane Model
- Services and Analytics – Client Data Processing Procedures

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 91)
Module 3, Section III (Vulnerability Functions-Damage Estimates) (page 160)
Module 3, Section IV, #3 (appurtenant structures vulnerability function),(164)
#4 (mobile home vulnerability function), (page 164)
#5 (contents vulnerability function), (page 165)

#6 (ALE vulnerability function) (page 166)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 172)
#4 (output ranges) (page 209)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 192)
Form D (Loss Costs),
Form F (Hypothetical Events for SA & UA) (page 197)

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:

Verified there were no changes made to the vulnerability functions. Mohit Pande gave a presentation on AIR's vulnerability functions for buildings, ALE, etc. Reviewed examples of regional variation of wind vulnerability in Florida and discussed the factors applied to the vulnerability functions.

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 112)
Module 3, Section III (Vulnerability Functions-Damage Estimates) (page 160)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA) (page 197)

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 computer code and verified the damage cut-off sustained wind speed is 40 mph. No change was made in the model.

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 91)
B.7 (vulnerability modifications range of impacts on loss costs), (page 101)
C.1.b (building code and enforcement), (page 106)
C.1.c (construction characteristics) (page 106)
Module 1, Section II, A.3 (damageability assumptions) (page 109)
Module 3, Section III (Vulnerability Functions-Damage Estimates)(page 160)
Module 3, Section IV, #4 (mobile home vulnerability function), (page 164)
Module 3, Section VII, Form D (Loss Costs),
Form F (Hypothetical Events for SA & UA) (page 197)

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 new vulnerability functions developed to address the new Florida Building Code (FBC). Discussed the major changes in the FBC – new design wind speed map, revision of terrain exposure categories, wind-borne debris regions, high velocity hurricane zone (HVHZ), and wind resistant roof coverings.

Reviewed geographical representations of the Florida's wind-borne debris regions and high velocity hurricane zones. Discussed the requirements for enhanced roof strength and opening protections. Reviewed AIR's six regions, their definition of regions as per the FBC, and the methodology used in developing the six regions.

Reviewed pre-selected risk characteristics for residential masonry and graphical representations of the damage functions for the six FBC regions. Reviewed a comparison of the 2001 FBC and existing construction and the loss reductions associated with the change.

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 90)
Module 3, Section III, #5 (hazard mitigation) (page 161)

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: **Yes**

Professional Team Comments:

Reviewed various combinations of mitigation factors and discussed in detail the effect of multiple factors. Reviewed schematic of individual risk methodology and the differences in the wind resistance for building components. Discussed AIR's individual risk methodology. Reviewed framework for individual risk modules.

Reviewed AIR's data on damage functions for different building features and various mitigation features. Reviewed validation test results for opening protections and roof geometry.

Reviewed comparisons of other mitigation studies on the maximum percent reduction in damage based on various mitigation features (roof covering, roof sheathing, opening protection).

Reviewed study published by Texas Tech:
"Building Wind Damage Prediction and Mitigation Using Damage Bands", Christian O. Unanwa and James R. McDonald

Reviewed all of the ranges of wind mitigation listed for the individual risk characteristics in Table 18 in Module 1, Section I.B.7 (pages 102-105 of AIR submission). Verified calculations for values listed for individual items such as shutters, shingles, truss straps, and mansard type roof shape.

Reviewed following documentation:
- "The Effectiveness of Hurricane Shutters in Mitigating Storm Damage", Mitrani, Barnes, Jurrell (1995). This report was used to validate values that are based on expert opinion for the shutter ranges.
- Hurricane Individual Risk Methodology – Internal AIR document
- Individual Risk Methodology Flow Chart – Internal AIR document

The above documents were used to assemble a typical residential structure in Dade County with multiple combined risk characteristics and then determine the total effect on damage due to these mitigation measures.

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 107)

Module 3, Section IV, #6 (ALE vulnerability function) (page 166)
Module 3, Section V, #4 (output ranges) (page 209)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form D (Loss Costs),
Form F (Hypothetical Events for SA & UA) (page 197)
Standard 5.4.9 (ALE) (page 48)

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 no change in the model. Discussed AIR's handling of damage to the infrastructure.

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 99)
Module 1, Section II, A.3 (damageability assumptions), (page 109)
A.4 (other assumptions), (page 111)
A.5 (claims data used in development of vulnerability functions) (page 111)
Module 3, Section IV (Insurance Functions-Company Loss Estimates) (163)
Standard 5.3.4 (Construction and Codes) (page 31)

Standard 5.6.1 (Use of Historical Data) (page 62)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)

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:

Reviewed AIRs verification of wind mitigation credit table and analysis results. Discussed in detail the underlying data and criteria used to develop each of the values provided in Table 4, Individual Risk Characteristics and Range of Wind Mitigation Credits in Florida.

Reviewed feature code maps to mitigation feature options. Discussed in detail the methods used and the impact of multiple mitigation credits.

Reviewed results of analysis on relativity calculation of AAL with feature present to AAL for composite damage function.

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 90)
A.10 (modifications available for model user), (page 98)
B.7 (actuarial modifications range of impacts on loss costs), (page 101)
C.1.b (building code and enforcement), (page 106)
C.1.c (construction characteristics) (page 106)
Module 3, Section III, #3 (building code enforcement), (page 160)
#4 (quality of construction type, materials and workmanship), (page 161)
#5 (hazard mitigation) (page 161)
Module 3, Section V, #4 (output ranges) (page 209)
Module 3, Section VII, Form D (Loss Costs),

Form F (Hypothetical Events for SA & UA) (page 197)
Standard 5.3.4 (Construction and Codes) (page 31)

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

Professional Team Comments:

Verified AIR does not use modification factors to the actuarial functions. Reviewed weighted average of individual and multiple risk characteristics and the range of wind mitigation credits in Florida.

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 99)
C.1.a (socio-economic effects) (page 105)
Module 3, Section III, #2 (socio-economic effects) (page 160)
Module 3, Section V (Average Annual Loss Functions-Loss Costs)(page 172)
Module 3, Section VII (Baseline Tests) (page 188)

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

Professional Team Comments:

Verified no change in model. AIR 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),*(page98)
B.4 (annual aggregate loss distributions) (page 99)
Module 1, Section II, A.3 (damageability assumptions), (page 109)
A.4 (other assumptions) (page 111)
Module 3, Section III, #2 (socio-economic effects), (page 160)
#3 (building code enforcement), (page 160)
#4 (quality of construction type, materials and workmanship), (page 161)
#5 (hazard mitigation) (page 161)
Module 3, Section IV (Insurance Functions-Company Loss Estimates)(163)
Module 3, Section V, #4 (output ranges), (page 209)
#9 (distribution of hurricanes by size) (page 181)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 192)
Form D (Loss Costs),
Form E (PML), (page 196)
Form F (Hypothetical Events for SA & UA) (page 197)
Standard 5.4.11 (Comparison of Estimated Hurricane Loss Costs)(page 54)
Standard 5.4.12 (Output Ranges) (page 55)

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:

Verified no change in the model. Reviewed the Preparer's Guide and User's Guide that describe the format used to transfer exposure data to the CLASIC/2 software. Discussed AIR process for remapping client data to the UNICEDE/px format if necessary.

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 105)
	Module 1, Section II, A.3 (demand surge)	(page 109)
	Module 3, Section III, #2 (socio-economic effects)	(page 160)
	Module 3, Section V, #8 (Hurricane Andrew loss costs)	(page 179)
	Module 3, Section VII (Baseline Tests)	(page 188)

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. AIR does not remove demand surge from Hurricane Andrew; however, AIR does not rely on Andrew data for validation. Comparison of model output with Andrew results produces reasonable results in consideration of Andrew demand surge.

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 90)
B.1 (consistent loss costs produced), (page 98)
B.3 (deductibles, policy limits, replacement costs, insurance-to-value)(page 98)
C.1.b (building code and enforcement), (page 106)
C.1.c (construction characteristics) (page 106)
Module 3, Section III, #3 (building code enforcement), (page 160)
#4 (quality of construction type, materials and workmanship), (page 161)
#5 (hazard mitigation) (page 161)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 172)
#4 (output ranges), (page 209)
#5 (explanation of differences in output ranges from prior year), (page 176)
#9 (distribution of hurricanes by size) (page 181)
Module 3, Section VII (Baseline Tests) (page 188)

Standard 5.1.7 (Visual Presentation of Data) (page 6)
Standard 5.2.8 (Land Friction) (page 19)
Standard 5.3.4 (Construction and Codes) (page 31)
Standard 5.3.5 (Mitigation Measures) (page 34)
Standard 5.4.7 (Deductibles and Policy Limits) (page 46)

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

Professional Team Comments:

Reviewed graphical representations of the relationship between modeled and actual losses. Verified all Standard 5.4.6 relationships to risk are logical.

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 98)
Module 3, Section IV, #1 (variety of damage produced by a given wind speed), (page 163)
#2 (insurer loss calculation), (page 164)
#8 (property value and replacement cost calculations) (page 167)
Module 3, Section V, #3 (maps of loss costs by zip code), (Attachment I)
#4 (output ranges), (page 209)
#9 (distribution of hurricanes by size) (page 181)
Module 3, Section VII, Form D (Loss Costs)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)

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:

Reviewed probability distributions around the mean damage ratio and verified no change in the model with regards to deductibles and policy limits. Reviewed relationships among deductibles for reasonableness.

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 100)
Module 3, Section IV, #5 (contents vulnerability function), (page 165)
#7 (depreciation assumptions) (page 166)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 172)
#4 (output ranges) (page 209)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 192)
Form D (Loss Costs)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)

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:

Verified no change in the model. Reviewed relationship between building and contents loss costs for reasonableness.

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 107)
Module 3, Section IV, #6 (ALE vulnerability function) (page 166)
Module 3, Section V, #4 (output ranges) (page 209)
Module 3, Section VII, Form B (30 Hypothetical Events),
Form C (One Hypothetical Event), (page 192)
Form D (Loss Costs)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)

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:

Reviewed details on development of ALE loss functions and verified no change in the model. Reviewed relationship between building and ALE loss costs for reasonableness.

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 111)
C.3 (damage estimates validation tests) (page 128)
Module 3, Section IV, #9 (validation comparisons of actual exposures and loss to modeled exposures and loss) (page 168)
Module 3, Section V, #2 (loss costs relationships by type of coverage and type of construction), (page 172)
#8 (Hurricane Andrew loss costs) (page 179)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)
Standard 5.6.3 (Uncertainty Characterization) (page 65)

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: No
Verified: Yes

Professional Team Comments:

Reviewed and discussed differences between actual and modeled losses. Reviewed in detail information provided in the submission. Reviewed several individual insurer claims data for comparison with model outputs.

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 127)
C.3 (damage estimates validation tests) (page 128)
Module 3, Section I, #7 (decay rate compared to Kaplan-DeMaria), (page 151)
#11 (frequency and annual occurrence rates) (page 155)
Module 3, Section V, #2 (loss cost relationships by type of coverage and type of construction), (page 172)
#4 (output ranges), (page 209)
#5 (explanation of differences in output ranges from prior year), (page 176)
#9 (distribution of hurricanes by size) (page 181)
Standard 5.6.2 (Comparison of Historical and Modeled Results) (page 63)
Standard 5.6.3 (Uncertainty Characterization) (page 65)

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 and discussed differences between current and 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 98)
Module 3, Section V, #4 (output ranges), (page 209)
#5 (explanation of differences in output ranges from prior year), (page 176)
#6 (output ranges % change by county), (page177)
#7 (maps of output ranges % change by county) (Attachment H)

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 and reviewed in detail the changes in loss costs provided in the output ranges. Several counties were selected by the Professional Team for further investigation. Verified that all changes were attributable to the model changes made this year.

The Professional Team informed AIR 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.

AIR expressed the need to have the new FHCF exposure data early in the summer due to concerns with ALE being including in the data for the first time and the time factor involved with producing two sets of output ranges.

5.5 Computer Standards – *Paul Fishwick, Leader*

Reviewed the following changes in the model from last year:

Tropical Cyclone Model (2003):
- Binary data files' format enhancements
- Updated catalog (annual landfall frequency, maximum wind speed radius calculations)

- Updated physical properties and building codes data
- Increased time resolution for wind speed calculations

<u>Analytical Engine</u>:

- Bug fixes
- Performance tuning (across-the-board algorithmic and memory management enhancements)
- Updated individual risk modification function in support of Florida Building Codes
- Enhanced model management

<u>User Interface</u>:

- Bug fixes
- Analysis: Contract Submission Status-based filtering
- Analysis: Global Overrides
- Meta Filters: Support for layered contracts, Severe Thunderstorm
- CLF generation enhancements
- CLASVIEW: Loss, Exposure Exhibits by ZIP, As of Date, Submit Status
- Internationalization (currency, geocoding, geo-political validation, mapping, etc.)

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 69)
Module 1, Section II (Specific Description of the Model) (page 108)

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 AIR's primary document binder which contained fully documented sections for each computer standard and consistent documentation for all computer software relevant to the submission.

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 69)
Module 1, Section II (Specific Description of the Model) (page 108)
Module 3, Section VI, #2 (computer code tampering) (page 187)

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

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

Professional Team Comments:

Reviewed the following documentation:

- AIR Tropical Cyclone Model
- Software Requirements Specification (SRS)

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 69)
Module 1, Section II (Specific Description of the Model) (page 108)

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:

Reviewed the following documentation:
- CLASIC/2™ System Architecture
- Model Framework Documentation
- Model Flow Chart
- Component Custodian table and hierarchy
- Program flow charts for event generation and class diagrams for other portions of the model

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 69)
Module 1, Section II (Specific Description of the Model) (page 108)

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:

Reviewed the following documentation:
- Model Classes Documentation
- Model Datafiles Documentation

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 69)
Module 1, Section II (Specific Description of the Model) (page 108)
Standard 5.1.4 (Independence of Model Components) (page 3)
Standard 5.6.4 (Sensitivity Analysis for Model Output) (page 66)
Standard 5.6.5 (Uncertainty Analysis for Model Output) (page 67)

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:

Reviewed verification procedures and examples of calculation cross checks, unit tests, and exception handling mechanisms.

Reviewed following documentation:
- Model Testing Summary – US Hurricane – 2003
- Unit Testing of Model 21 in CLASIC/2
- Software Design Specifications (SDS) – Screenshots

- CLASIC/2 Testware Library
- GUI – Testing Guidelines
- Unit Test sample documentation

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 69)
Module 1, Section II (Specific Description of the Model) (page 108)

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:

Reviewed the following documentation:
- Microsoft Sourcesafe online documentation
- Policy Statement
- AIR Data Control Process
- AIR Software Documentation Process
- AIR Task application to maintain code, data, and documentation

Current Versions:
- Hurricane Model: Atlantic Tropical Cyclone Model 5.0.211
- Comprehensive Software: CLASIC/2 5.5

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 69)
Module 1, Section II (Specific Description of the Model) (page 108)

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:

Reviewed the following documentation:

- CLASIC/2 User's Guide
- CLASIC/2 Reference Manual
- CLASIC/2 – Version 5.5 Release Notes
- UNICEDE/px and UNICEDE/fx Preparer's Guides
- UNICEDE/px Optimization Instructions
- UNICEDE/px Distribute

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 120)
Module 3, Section I, #8 (source of historical data set) (page 153)

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 probability distributions for individual input variables including negative binomial for annual landfall frequency, Weibull for central pressure, and lognormal for forward speed. The goodness-of-fit was demonstrated through results of Kolmogorov-Smirnov and Shapiro-Wilk tests. Reviewed graphical comparisons confirming the agreement between the historical data and fitted probability distributions.

Reviewed the AIR Hurricane Model Responses to Statistical Standards for Florida Commission on Hurricane Loss Projection Methodology including an update of the segments outside Florida.

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 108)
	B.7 (parameters for hurricane frequency),	(page 115)
	C.1 (wind speed validation tests),	(page 126)
	C.3 (damage estimates validation tests),	(page 128)
	C.5 (other validation tests),	(page 130)
	C.6 (validation tests documentation)	(page 131)
	Module 3, Section I, #12 (number of events, relative frequency and annual occurrence rate by category),	(page 156)
	#13 (probability of hurricanes by year)	(page 158)
	Module 3, Section III, #3 (building code enforcement),	(page 160)
	#4 (quality of construction type, materials and workmanship),	(page 161)
	#5 (hazard mitigation)	(page 161)
	Module 3, Section IV, #3 (appurtenant structures vulnerability function),	(page 164)
	#4 (mobile home vulnerability function),	(page 164)
	#5 (contents vulnerability function),	(page 165)
	#6 (ALE vulnerability function)	(page 166)

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

Proprietary: Yes
Verified: Yes

Professional Team Comments:

Documentation reviewed:

- Vulnerability Function Validation for 2003 US Hurricane Model
- "Classification of Structural Models for Wind Damage Predictions in Florida", Jean-Paul Pinelli, Liang Zhang, Chelakara Subramanian, Anne Cope, Kurt Gurley, Sneh Gulati, and Shahid Hamid
- "Development of Loss Relativities for Wind Resistive Features of Residential Structures", Florida DCA study

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 118)

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 calculations, data values, and comparisons of empirical cdfs of historical loss and simulated loss.

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 79)
Module 1, Section II, B.13 (model sensitivity), (page 123)
B.14 (sensitivity in output results), (page 123)
B.15 (SA & UA performed on model) (page 124)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA)(page 197)
Standard 5.2.10 (Temporal and Spatial Wind Field Characteristics)(page 23)

Proprietary: Yes
Verified: Yes

Professional Team Comments:

Reviewed details on the sensitivity studies conducted on the Form F data as well as other internal sensitivity studies conducted by AIR. The results of the sensitivity studies included one-parameter at-a-time as well as multi-parameter studies. AIR's results matched those prepared by the Professional Team.

Reviewed a summary of the Sensitivity Analysis for Form F's loss cost and the standardized regression coefficients for loss cost by category for each input variable.

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 79)
Module 1, Section II, B.9 (confidence intervals produced), (page 118)
B.13 (model sensitivity), (page 123)
B.14 (sensitivity in output results), (page 123)
B.15 (SA & UA performed on model) (page 124)
Module 3, Section VII, Form F (Hypothetical Events for SA & UA)(page 197)
Standard 5.2.10 (Temporal and Spatial Wind Field Characteristics)(page 23)

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 AIR's uncertainty analyses of Form F which agreed with the results prepared by the Professional Team. Reviewed the loss costs analysis including contour plots showing the average loss cost for Cat 1, Cat 3, and Cat 5 hurricanes.

Reviewed a summary of the Uncertainty Analysis for Form F's loss cost showing the expected percentage reduction in var(loss cost) by storm category for each input variable.

Reviewed results of uncertainty studies showing losses including one-parameter at-a-time as well as multi-parameter studies.

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 127)
Module 3, Section V, #4 (output ranges), (page 209)
#5 (explanation of differences in output ranges from prior year), (page 176)
#6 (output ranges % change by county) (page 177)
#7 (maps of output ranges % change by county) (Attachment H)
Module 3, Section VII, Form D (Loss Costs)
Standard 5.6.3 (Uncertainty Characterization) (page 65)

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:

Verified that the sampling contribution to loss cost errors was negligible.

Modules Verification:

Module 1

Reviewed detailed program flow charts for event generation and class diagrams for other portions of the hurricane model.

Reviewed goodness-of-fit test results for storm frequency, landfall location, landfall angle, storm intensity, radius of maximum wind, and wind speed.

Further reviewed in the course of pre-visit letter and in conjunction with standards review.

Module 2

Reviewed list of client data used for validation purposes. Reviewed list of current AIR clients.

Further reviewed in the course of pre-visit letter and in conjunction with standards review.

Module 3

Reviewed in the course of pre-visit letter and in conjunction with standards review.

Form A

Reviewed change in Form A results due to the model ZIP Code database update.

Form B

Reviewed change in Form B results. Verified the maximum wind speed changes were due to a change in methodology. Reviewed storm tracks for the five storms generated in Form B. Discussed why the methodology was changed and how.

Reviewed relationships among Form B columns.

Form C

Reviewed changes in Form C results including total loss by construction type. Verified changes in loss were consistent with model and physical parameter changes. Reviewed comparison of total loss by construction type.

Form D

Reviewed changes in Form D results from previous year. Verified changes were consistent with the changes in the model.

Form E

Reviewed changes in Form E results from previous year. Verified changes were consistent with changes in the model. Queried modeler relative to Form E, Part B results.

Reviewed revised Form E to be resubmitted prior to the May 29&30, 2003 Commission meeting.

Form F

Greta Ljung provided a presentation on the Uncertainty/Sensitivity Analysis results. Reviewed graphical representations of Cat 3 hurricane wind speeds showing the standardized regression coefficients at a particular hour for Central Pressure, Rmax, Forward Speed, and AIR's Conversion Factor. Discussed the methodology used in determining the conversion factor and how the factor is used in the model.

Reviewed varying ratios for Cat 3 wind speeds and the expected percent reduction in var(wind) for Central Pressure, Rmax, Forward Speed, and AIR's conversion factor. Reviewed numerous contour plots.

Reviewed AIR's analysis for loss cost including contour plots showing the average loss cost for Cat 1, Cat 3, and Cat 5 hurricanes.

Reviewed a summary of the Sensitivity Analysis for Form F's loss cost and the standardized regression coefficients for loss cost by category for each input variable.

Reviewed a summary of the Uncertainty Analysis for Form F's loss cost showing the expected percentage reduction in var(loss cost) by storm category for each input variable.

The conversion factor was shown to be a significant variable. For the output ranges, the factor was set to 0.90 per the NWS-23 reference.