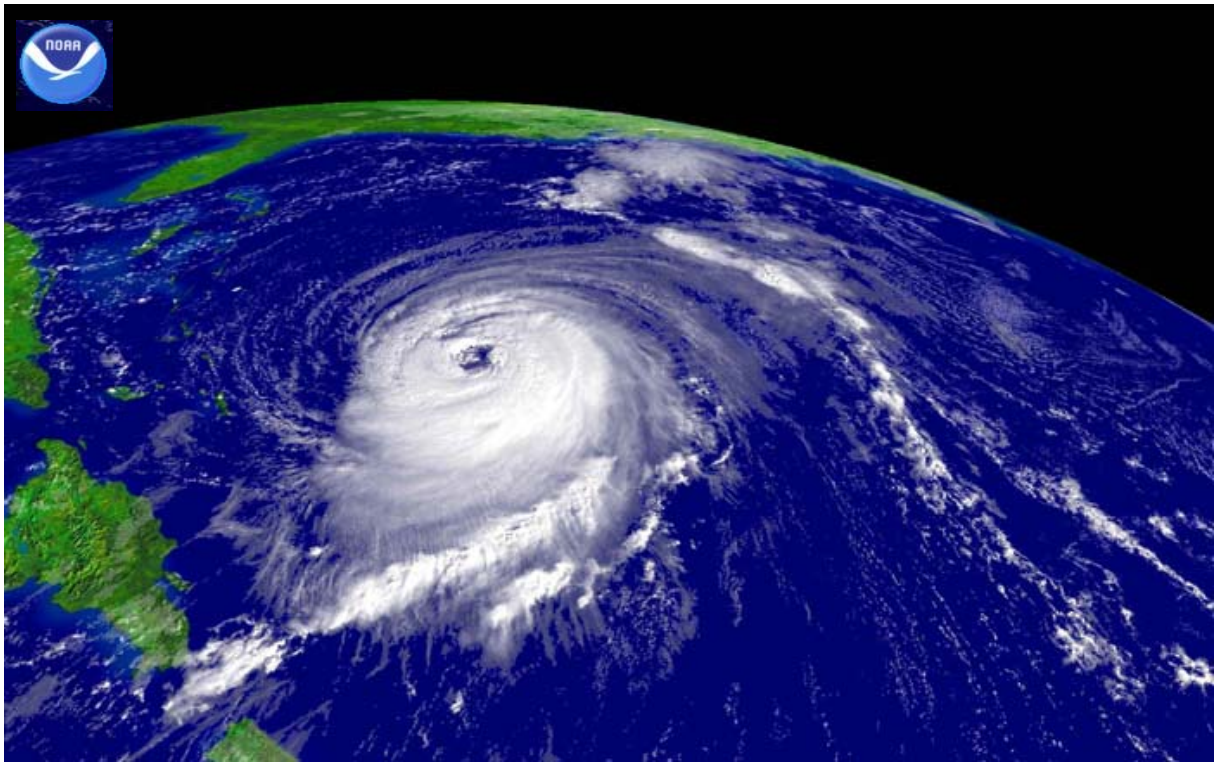
Florida Commission on Hurricane Loss Projection Methodology



Professional Team Report
2003 Standards

Applied Research Associates, Inc.

On-Site Review
April 15 – 17, 2004

Additional Verification Review
May 7, 2004

On April 15-17, 2004, the Professional Team visited on-site at Applied Research Associates, Inc. (ARA) in Raleigh, North Carolina. The following individuals participated in the review.

ARA

Chris Driscoll, Staff Scientist
Brian Grant, Software Developer, Southeast Division
Srinivas R. Kadasani (Reddy), M.S., Software Developer
Francis M. Lavelle, Ph.D., P.E., Principal Engineer
Rick Pearson, Software Developer
Peter J. Vickery, Ph.D., P.E., Principal Engineer

Professional Team

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

The review began with introductions and an overview of the audit process. ARA gave a presentation outlining the model changes since the February 2003 submission and the effect of those changes on loss costs:

- Update from 2001 to 2003 ZIP Code boundaries included changes in ZIP Code centroid locations and surface roughness
- Update through the 2002 hurricane season and starting locations from the observed starting locations of actual storms

Discussed and reviewed corrections to be made in the submission that will be provided to the Commission prior to the May 12 & 13, 2004 meetings.

- Pages 205-213, reference list updated with publication dates
- Vickery, et al. 2000a and 2000b papers provided
- Page 19, G-2.2.A, Professional Credentials for Brian Grant
- Page 26, G-2.3.B, documentation of independent peer reviews
- Page 43, M-4, response to radii of hurricane force winds
- Page 59, V-1.1, Figure 13 include validation process
- Page 60, V-1.7, clarification of response
- Page 65, Form V-2, correction to reflect correct Form reference
- Page 86, Figure 19 x-axis label correction
- Page 87, S-1.1, correction to confidence level
- Page 88, S-1.5, response reworded and examples provided
- Page 91, S-2.4, response reworded
- Page 93, S-3.4, response reworded
- Page 100, S-6.1, figure references corrected
- Page 120, Form S-7, corrections to 1926 and 1935 storms

At the completion of the on-site review, several standards could not be verified, as detailed in the subsequent report.

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Additional Verification Review – May 7, 2004

Applied Research Associates, Inc. (ARA) submitted corrections to the ARA model submission under the 2003 standards on May 1, 2004. A subset of the Professional Team received the ARA re-submission and reviewed it. A conference call took place May 7 among the subset of the Professional Team, ARA, and SBA staff. On the basis of this review, **all standards are now verified.** The primary change involved the increase in simulated years from 100,000 to 300,000 in order to ensure that the contribution due to sampling error is deemed negligible. New report values and output ranges are consistent with this change.

Additional minor corrections were also provided in the re-submission, as noted in the Professional Team report.

The following people participated in the additional verification review:

ARA

Francis M. Lavelle, Ph.D., P.E., Principal Engineer

Professional Team

Mark Johnson, Ph.D., Statistician, Team Leader
Marty Simons, ACAS, Actuary
Anne Bert, Staff
Donna Sirmons, Staff

Deficiencies from March 18, 2004 Meeting

1. G.1.2 (page 12), G-2.3.A (page 25), M-2.4 (page 40) – provide current list of references cited.

   ARA Response – The references were inadvertently omitted from the submission. The references are provided in revised submission pages 205 through 213.

   Verified: Yes

2. G-2.2.A (page 19) – tenure not provided for Larry Twisdale, Frank Lavelle, and Marshall Hardy.

   ARA Response – Requested information is provided on revised submission pages 20, 23, and 24.

   Verified: Yes

3. G-2.2.C (page 25) – documentation not provided.

   ARA Response – Requested information is provided on revised submission page 25.

   Verified: Yes

4. G-2.3.B (page 26) – documentation not provided.

   ARA Response – Requested information is provided on revised submission page 26.

   Verified: Contingent upon additional documentation provided to the Commission.

5. Form G-1 (page 32) – titles not provided

   ARA Response – Requested information is provided on revised submission page 32.

   Verified: Yes

6. M-4.2 (page 43) – incorrect response provided (identical response given for 1 and 2).

   ARA Response – Corrected information is provided on revised submission pages 43 and 44.

   Verified: Yes

7. M-5.3 (page 48) – collection and publication dates of land use and land cover data not provided.

   ARA Response – Requested information is provided on revised submission page 48.

   Verified: Yes

8. M-5.4 (page 49) – incomplete plot of Hurricane Andrew simulation.

   ARA Response – The simulation data plotted for Hurricane Andrew ends when the storm exited South Florida. The same time scales are shown on each of the three plots for consistency.

   Verified: Yes

9. V-1.2 (page 59) – detail description not provided.

   ARA Response – Additional details are provided on revised submission page 59.

   Verified: Yes

10. A-7.2 (page 80) – minimum threshold not provided.

    ARA Response – Requested information is provided on revised submission page 80.

    Verified: Yes

11. S-7.2 (page 104) – justification not provided.

    ARA Response – Requested information is provided on revised submission pages 104 and 105.

    Verified: Yes

12. Form S-1A – hard copy not provided in submission.

    ARA Response – Output ranges for Form S-1A have been inserted as pages 128 through 162.

    Verified: Yes

13. Form S-1B – hard copy not provided in submission

    ARA Response – Output ranges for Form S-1B have been inserted as pages 163 through 197.

    Verified: Yes

Applied Research Associates, Inc. – 2003 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. Be prepared to respond to questions and requests for material as outlined in the Audit section under each Standard. 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 will 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 also be presented to the Pro Team during the on-site review.

All aspects of the computer software will be reviewed including software either developed off-site or contracted out. Spot checks will occur during the review process, and all relevant personnel for the software being reviewed will need to be present when called upon. If software component authors are not present during the on-site review, the modeler shall have proxies for those components.

In the course of preparing for the on-site review, the Pro Team has identified some specific areas and questions 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 Pro Team will also be considering material in response to the Commission's designation(s) of omissions or responses deemed non-responsive.

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.

General Standards

1. **G1.2** (page 13-14) – Be prepared to discuss the hurricane windfield model. Is the initial 3D wind distribution input to this boundary layer model dependent on the radial profiles from the Emanuel model? If so, how are above-surface winds derived from the surface values (i.e., what is the assumed wind decay profile with height)? If not, what is the windfield profile used?
2. **G2.1.G** (page 19) – Discuss client relationships with insurers and re-insurers with particular emphasis on any new clients since last review by the FCHLPM.
3. **G2.3.D** (page 26) – Clarify response provided.
4. **G3** (page 27) – Provide ZIP Code boundary maps with the associated centroids.
5. **Form G-1** (page 32) – Provide any written reports from consultants not on staff in regards to "Expert Certification" along with resolution of any issues that may have been raised.

Meteorological Standards

6. **M2** (page 38) – Define φ.
7. **M2** (page 38-39) – Be prepared to discuss the wind model as driven by sea surface temperature (SST). In particular:
   - Describe the SST input data file used. What is its temporal component (e.g., climatological or individual years)? What is its spatial resolution?
   - Is there a stochastic component to the actual storm intensity? To what extent, if any, is the concept of a SST-dependent *potential intensity* (*PI,* was formalized by Emanuel, 1986) extended to compromise more than a theoretical upper bound of possible intensities under favorable environmental conditions.
   - Extent to which historical storms have reached their PI.
   - How does storm intensity shift to match the SST when a storm re-emerges over water (after making landfall)? Does equation (2), page 39 apply for such a case?
   - Be prepared to discuss the relationship between SST and outflow temperature (T_{OUT}).
   - How are PI, relative humidity (RH), the environmental RH, and the environmental surface pressure assigned for each simulated storm?
   - Be prepared to discuss the transition from minimum pressure to maximum surface winds.
8. **M2.3** (page 40) – Be prepared to discuss in more detail the response provided.
9. **M2.5** (page 40) – Does the storm track set include the updated Hurricane Andrew?
10. **M4.3** (page 45), Figures 6 – Be prepared to discuss consistent overestimation of Cat 3 frequency.
11. **M5.1** (page 47) – Be prepared to discuss where the air-sea temperature difference comes into the calculations.
12. **M5.4** (page 49), Figure 8 – Provide graphs in larger format during on-site review.
13. **Form M-2** (page 53) – Be prepared to discuss to what extent, if any, Rmax is varying with latitude and how this variation is taken into account.
14. **Form M-2** (page 54) – Provide graphical representation of Rmax vs. Central Pressure using a point plot.
15. **Form M-3** (page 56) – Provide detailed description of Figure 12.

Vulnerability Standards

16. **V1.4** (page 60) – Provide name for acronym BPAT.
17. **Form V-1** (page 63) – For future submissions we anticipate a revision to Form V-1 with higher wind speeds and the addition of mitigated frame and masonry structure. Do you have any comments?
18. **Form V-2** (page 65) – Results of the runs at the various wind speeds for individual mitigation measures should be available and selected examples will be reviewed. Be prepared to discuss changes in instructions such as choice of required ZIP Codes, range of wind speed, list of required mitigation measures, use of "Renters' and "Condo Unit Owners" sections, weighted average, change in damage at specific wind speeds rather than a range, adding structures with specific combinations of mitigation measures, etc.
19. **Form V-2** (page 67) – Be prepared to discuss magnitude of changes shown for various mitigation measures.

Actuarial Standards

20. **A1** (page 68) – Provide any insurance data obtained since the prior review of your model by the FCHLPM.
21. **A1.4** (page 69) – Be prepared to present details of assumptions.
22. **A2.2** (page 70) – Describe how separate studies are documented in the analysis report.
23. **A3.2** (page 72) – Be prepared to present model input requirements documented in the HurLoss User Manual.
24. **A4** (page 76-77) – Be prepared to provide evidence in support of these assertions.
25. **A4.F** (page 76) – Describe cases where building code enforcement is quantified and how the model produces decreasing loss costs with improved building code enforcement.
26. **A5** (page 78) – Be prepared to discuss in detail the approach and validation for deductibles and policy limits.
27. **A6.2** (page 79) – Provide explanation of Figure 17 and provide units on axes.
28. **A7.2** (page 80) – Provide explanation of Figure 18 and provide units on axes.
29. **Form A-1** (page 82) – Discuss the slight increase in wind speeds and increase in losses from previous submission. Provide an explanation for category 5 and category 4 storms with category 3 wind speeds.

Statistical Standards

30. **S1** (page 86) – Be prepared to present results of all statistical tests performed.
31. **S1.1** (page 87) – Discuss use of 5% confidence level.
32. **S1.5** (page 88) – Be prepared to present results of uncertainty analysis.
33. **S2** (page 90) – Be prepared to present results of the sensitivity study.
34. **S2.3** (page 91) – Be prepared to present "additional examples showing the impact of the different parameters used in the model on loss cost estimates."

35. **S5** (page 96) – Be prepared to present "additional detail of actual and modeled ZIP Code level losses." Provide insurance company names.
36. **S5.1** (page 96) – Be prepared to present additional "results for damage estimation."
37. **S5.1** (page 97) – Provide axes labels for Figure 24.
38. **S5.2** (page 98) – Provide interpretation for Figure 25.
39. **S6.1** (page 100) – Figure 26 is difficult to read.
40. **S7.2** (page 104) – Be prepared to present maps referenced in response.
41. **Form S-1A** (page 106) – Be prepared to discuss change in weighted average from previous year in Liberty and Santa Rosa counties for Frame and Masonry structures.
42. **Form S-1B** (page 107) – Be prepared to show why there is very little change in the loss costs for the individual counties for the 2002 exposure (Form S-1B) compared to the 1998 exposure (Form S-1A) and why the statewide shows a much larger difference.
43. **Form S-1B** (page 107) – Be prepared to discuss zero values for low and high (e.g., Baker) and zero values for weighted averages.
44. **Form S-2** (page 113) – Be prepared to provide justification for the increases throughout.
45. **Form S-3** (page 114) – Provide an explanation for the situation with Santa Rosa County.
46. **Form S-5** (page 117) – Describe in detail the values presented under column labeled "Produced by Model".
47. **Form S-7** (page 120) – Provide explanation for 1926 No Name storms 6 and 10. Provide justification for the inclusion of Frederic.

Computer Standards

48. **C1** (page 128) – Confirm the presence of the primary document binder. Provide confirmation for C1.B and C1.C.
49. **C2** (page 129) – Provide a list of the requirements documentation.
50. **C3** (page 130) – Provide information on the architecture.
51. **C4** (page 131) – Provide confirmation that the software is traceable starting at the flow diagrams.
52. **C5** (page 132) – Be prepared to discuss the testing software that was used to assist in the testing process.
53. **C7** (page 134) – Be prepared to provide additional details.

GENERAL STANDARDS – Mark Johnson, Leader

G-1 Scope of the Computer Model and Its Implementation

The computer model shall project loss costs for personal lines residential property from hurricane events.

Audit

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. Copies of all representative or primary technical papers that describe the underlying model theory shall be made available.

Verified: YES

Professional Team Comments:

Discussed in detail ARA's hurricane wind field model and the technical papers that describe the underlying model theory. Copies of all relevant papers were made available to the Professional Team.

G-2 Qualifications of Modeler Personnel and Independent Experts

A. 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.

B. 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), meteorology (advanced degree), and computer/information science (advanced degree). These individuals shall abide by the standards of professional conduct if adopted by their profession.

Audit

The Professional Team will 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. Background information on individuals providing testimonial letters in the submission shall be provided.

The Professional Team will review Form G-1 and all independent peer reviews of the model.

Discuss any incidents where model personnel have failed to abide by the standards of professional conduct adopted by their profession.

Verified: **YES~~, Contingent upon additional documentation provided to the Commission~~**

Professional Team Comments:

*****Initial Review Comments*****

Discussed work ARA has completed since the previous review.

Reviewed the following resumes:

- Steven Businger, Ph.D., Atmospheric Sciences, University of Washington, Seattle, Washington
- Brian Grant, M.S. Computer Science, University of North Carolina at Chapel Hill

Reviewed written reports from consultants in regards to expert certification:

- Actuarial Review of ARA Hurricane Model by Douglas J. Collins, FCAS, MAAA, Consulting Actuary, Tillinghast-Towers Perrin, London

- Meteorological Review of ARA hurricane model for modeling hurricane impact by Steven Businger, Professor, University of Hawaii, School of Ocean and Earth Science and Technology, Department of Meteorology.

Reviewed correspondence between ARA and Doug Collins regarding the actuarial review of the model.

Discussed with Brian Grant in detail his independent review and assessment of the ARA model in compliance with the computer standards.

Documentation of independent peer reviews to be provided.

*****Additional Verification Review Comments*****

Additional documentation of independent peer reviews (Appendix A and Appendix B) was provided to the Commission and reviewed by a subset of the Professional Team.

G-3 Risk Location

A. 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 reasonable.

B. ZIP Code centroids, when used in the model, shall be based on population data.

C. ZIP Code information purchased by the modeler shall be verified by the modeler for accuracy and appropriateness.

Audit

Provide geographic displays for selected ZIP Codes. The Professional Team will review the location of specific centroids.

Verified: YES

Professional Team Comments:

Reviewed ZIP Code boundary maps showing the changes in boundaries, centroids, and roughness.

G-4 Units of Measurement

A. All units of measurement for model inputs and outputs shall be clearly identified.

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

C. 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.

Audit

The Professional Team will review the model to assess the appropriateness and accuracy of the measurements, conversion factors, and techniques.

Verified: YES

Professional Team Comments:

Appropriate units of measurement were verified throughout the review process.

Corrected Figure 19 to be resubmitted.

G-5 Independence of Model Components

The meteorology, vulnerability, and actuarial components of the model shall each 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 reasonable.

Audit

Demonstrate that the model components adequately portray hurricane phenomena and effects (damage and loss costs). Attention will be paid to an assessment of (1) the theoretical soundness of each component and (2) the basis of their integration. For example, a model would not meet this Standard if an artificial calibration adjustment had been made to improve the match of historical and model results for a specific storm.

Describe all changes in the model since the previous submission that might impact the independence of the model components.

Verified: YES

Professional Team Comments:

The independence of the meteorology, vulnerability, and actuarial components were verified throughout the course of the review.

There was no evidence discovered to imply dependence.

METEOROLOGICAL STANDARDS – Jenni Evans, Leader

M-1 Official Hurricane Set*

*(*Significant Revision)*

For landfall frequency analyses, the modeler shall use the latest updated Official Storm Set. Updates to HURDAT approved by the Tropical Prediction Center/National Hurricane Center are acceptable modifications to the storm set.

Audit

The modeler will provide the storm set used. Failure to update the storm set, as specified in the Standard, is not acceptable.

Verified: YES

Professional Team Comments:

Reviewed stochastic storm set and verified its update through 2002.

M-2 Hurricane Characteristics*

*(*Significant Revision)*

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, tracks, and the time variant wind fields, shall be based on information documented by currently accepted scientific literature or modeler information accepted by the Commission.

Audit

Prepare graphical depictions (e.g., histograms overlaid with fitted density functions) of storm characteristics as used in the model. Describe:

- the data set basis for the fitted distributions,
- the assessments of correlated characteristics (e.g., central pressure and radius of maximum winds),
- the fitting methods used and any smoothing techniques employed, and defend the choices of distributions used,
- the spatial distribution of hurricane force winds associated with both modeled and historical events.

The goodness-of-fit of distributions to historical data will be reviewed.

The modeler will present time-based contour animations (capable of being paused) of wind and pressure fields to demonstrate scientifically reasonable wind field characteristics.

The Professional Team will compare the treatment of uncertainties associated with the conversion of gradient winds to surface winds with currently accepted literature.

Map the location of the peak hurricane intensity compared to the western most point of a random selection of recurving storm tracks for hurricanes affecting Florida.

Verified: YES

Professional Team Comments:

Reviewed graphical representations of various storm characteristics and goodness-of-fit distributions to historical data.

Reviewed time-based animated contour plots of the wind and pressure fields for Cat 1, 3, and 5 storms. Reviewed maximum winds recorded in each county based on these simulations.

Clarified details of the SST data file used.

Reviewed scatter plots of relative intensity and sea surface temperature and discussed their correlation.

Discussed the relationship between sea surface temperature and outflow temperature.

Reviewed the fraction of storms reaching their potential intensity.

Discussed the transition from minimum pressure to maximum surface wind speed and the dependency and relationships of the different variables.

Discussed in detail the conversion of upper level, gradient winds to surface level winds and the conversion to sustained or gust speeds. Reviewed validation comparisons of modeled winds to actual dropsonde data. Reviewed formulas for calculation and curves depicting gust duration.

Reviewed wind speeds and peak gusts by ZIP Code for Hurricane Andrew and verified the match between actual and modeled. Reviewed wind speeds and peak gusts for a number of other storms and locations.

Reviewed a sample of simulated storms for the relationship of storm intensity and track recurvature.

M-3 Landfall Intensity

Models shall use maximum one-minute sustained 10-meter wind speed when defining hurricane landfall intensity. This applies both to the Official Storm Set 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):

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

Audit

Demonstrate the goodness-of-fit of the frequency distributions of category 3-5 hurricanes.

Demonstrate that the hurricane intensity at landfall is consistent with the Saffir-Simpson wind range for the stochastic storm set.

Verified: YES

Professional Team Comments:

Reviewed goodness-of-fit plots on the frequency distributions of category 3, 4, and 5 hurricanes.

Discussed the effect of changing the direction of an event on estimates of average annual loss costs.

Reviewed scatter plots of Rmax versus Central Pressure and Central Pressure at landfall versus Return Period.

M-4 Hurricane Probabilities

A. 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.

B. Modeled hurricane probabilities shall reasonably reflect the historical record through 2002 for category 1 to 5 hurricanes and shall be consistent with those observed for each coastal segment of Florida and neighboring states (Alabama, Georgia, and Mississippi).

Audit

Probabilities are compared with observed hurricane frequency using methods documented in currently accepted scientific literature. The Professional Team will review the goodness-of-fit of modeled to historical hurricane frequencies for the four regions of Florida and overall as provided in Form M-1.

Demonstrate that the quality of fit extends beyond the Florida border by showing results for appropriate coastal segments in Alabama, Georgia, and Mississippi.
Describe and support the method of selecting stochastic storm tracks and angles of landfall.

Describe and 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.

Demonstrate the goodness-of-fit of parametric distributions to historical hurricane characteristics.

Verified: ~~**NO**~~ **YES**

Professional Team Comments:

*****Initial Review Comments*****

Discussed basis for storm track strike intervals.

Verified approach used in compiling bypassing storm frequencies.

Examined code for accumulating frequencies and characteristics of storms passing any selected geographical location in the model domain.

Reviewed and discussed annual landfall counts of modeled hurricanes versus historical by category in Form M-1 by region in Florida and in neighboring states.

Response to radii of hurricane force winds to be provided.

Verification pending review of Form M-1 and Figure 6 to be revised and presented to the Professional Team.

*****Additional Verification Review Comments*****

Revised response to radii of hurricane force winds (page 43), Form M-1 (page 51) and Figure 6 (page 45) provided to the Commission and reviewed by a subset of the Professional Team. The changes are consistent with the increased precision due to a 300,000 year simulation period.

M-5 Land Friction and Weakening*

A. *The magnitude of land friction coefficients shall be consistent with currently accepted scientific literature, consistent with geographic surface roughness, and implemented with appropriate geographic information system data.
*(*Significant Revision)*

B. The hurricane overland weakening rate methodology used by the model shall be reasonable in comparison to historical records.

Audit

Justify the collection and publication dates of the land use and land cover data used in the model.

Maps depicting land friction effects are required. Describe the representation of land friction effects in the model.

Comparisons of the model's weakening rates to historical Florida storms and to weakening rates will be reviewed.

Transition of winds from over water to over land (i.e. landfall) will be reviewed.

Verified: YES

Professional Team Comments:

Discussed the land use and land cover database used in the model. Reviewed roughness maps by county with ZIP Code boundaries and water management district boundaries.

Reviewed representation of land friction effects in the model.

Reviewed graphical representations comparing selected storms decay rates to Kaplan-DeMaria and discussed the transition of winds from over water to over land.

Reviewed code relevant to gradient to surface wind conversion, near wind to 3-second gust conversion, weakening over land, assignment of roughness parameters for land and ocean based storms, and treatment of winds during landfall.

Discussed the changes in intensity simulation procedure for a landfalling storm that re-emerges over water.

M-6 Logical Relationships of Hurricane Characteristics

A. The radius of maximum winds shall reflect historical hurricane characteristics.

B. The magnitude of asymmetry shall increase as the translation speed increases, all other factors held constant.

C. The wind speed shall decrease with increasing surface roughness (friction), all other factors held constant.

Audit

Forms M-2, M-3, and the modeler's sensitivity analyses provide the information used in auditing this Standard.

Verified: ~~**NO**~~ **YES**

Professional Team Comments:

*****Initial Review Comments*****

Reviewed scatter plot of Rmax vs Central Pressure data in Form M-2.

Discussed the correlation between Rmax and latitude.

Reviewed plots of wind speed asymmetry due to storm motion.

Reviewed wind speed reduction at landfall and over land.

Verification pending review of Form M-3 and Figure 12 to be revised and presented to the Professional Team.

*****Additional Verification Review Comments*****

Revised Form M-3 (pages 55-56) and Figure 12 (page 56) provided to the Commission and reviewed by a subset of the Professional Team. The changes are consistent with the increased precision due to a 300,000 year simulation period.

VULNERABILITY STANDARDS – Fred Stolaski, Leader

V-1 Derivation of Vulnerability Functions*

A. Development of the vulnerability functions is to be based on a combination of the following: (1) historical data, (2) tests, (3) structural calculations, (4) expert opinion, or (5) site inspections. Any development of the vulnerability functions based on structural calculations or expert opinion shall be supported by tests, site inspections, or historical data.

B. The method of derivation of the vulnerability functions shall be theoretically sound.

C. Any modification factors/functions to the vulnerability functions or structural characteristics and their corresponding effects shall be clearly defined and be theoretically sound.

D. Construction type and construction characteristics shall be used in the derivation and application of vulnerability functions.

E. In the derivation and application of vulnerability functions, assumptions concerning building code revisions and building code enforcement shall be reasonable and be theoretically sound.
*(*Significant Revision)*

F. Vulnerability functions shall be separately derived for building structures, mobile homes, appurtenant structures, contents, and additional living expense.

G. The minimum wind speed that generates damage shall be reasonable.

Audit

Historical data should 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, demonstrate the goodness-of-fit of the data to fitted models. 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 should be available for review.

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

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

Justify the construction types and characteristics used, and provide validation of the range and direction of the variations in damage.

Document and justify all modifications to the vulnerability functions due to building codes and their enforcement.

Provide validation material for the disclosed minimum wind speed. Provide the computer code showing the inclusion of the minimum wind speed at which damage occurs.

Describe how the duration of wind speeds at a particular location over the life of a hurricane is considered.

Form V-1 will be reviewed.

Verified: **YES, ~~Contingent upon revised documentation provided to the Commission~~**

Professional Team Comments:

*****Initial Review Comments*****

Verified no changes were made to the vulnerability functions or the method of derivation.

Discussed post-event damage surveys conducted by ARA engineers and their involvement with FEMA BPAT (Building Performance Assessment Team) and the FEMA HAZUS wind loss model.

Reviewed the following reference material used in the derivation of the vulnerability functions.

- Analysis of Hurricane Windborne Debris Impact Risk for Residential Structures: Part I, L.A. Twisdale, P.J. Vickery, J.X. Lin, and A.C. Steckley
- Analysis of Hurricane Windborne Debris Impact Risk for Residential Structures: Part II, L.A. Twisdale, P.J. Vickery, J.X. Lin, and A.C. Steckley
- Florida DCA Report "Development of Loss Relativities for Wind Resistive Features of Residential Structures"

Reviewed loss curves comparing damage ratios to wind speeds.

Reviewed several vulnerability functions based on different structures by regions.

Reviewed examples of vulnerability curves comparing the effect of peak gust and open terrain on different coverages (building, contents, ALE).

Reviewed ranges of loss relativities as documented in the Florida DCA study for wind resistive features for residential structures.

Reviewed computer code for inclusion of the minimum wind speed at which damage starts to occur.

Reviewed plots of actual and modeled loss for appurtenant structures given peak gust wind speeds in open terrain.

Reviewed examples of the number of categories of building classes considered in other loss projection studies completed by ARA.

Discussed preliminary data from site inspection of Hurricane Isabel damage in September 2003.

Reviewed documentation of calculations and details dealing with vulnerability contained in the following binders:

- Building Component Load Models, Volume II-A
- Individual Building Damage Model, Part I, Volume II-B
- Individual Building Damage Model, Part II, Volume II-C
- Building Damage Comparisons, Volume II-D
- Vulnerability Standard Binder

Reviewed Form V-1 and discussed refinements to format.

An updated flowchart in Figure 13 to be provided to the Commission.

Discussed how the duration of wind speeds are captured in the loss functions. Clarification of response provided in submission to be provided to the Commission.

*****Additional Verification Review Comments*****

Revised Figure 13 (page 59) and response to disclosure #7 (duration of wind speeds, page 60) received by the Commission and reviewed by a subset of the Professional Team.

V-2 Mitigation Measures*

*(*Significant Revision due to Form V-2)*

A. Modeling of mitigation measures to improve a building's wind resistance and the corresponding effects on vulnerability shall be theoretically sound. These measures shall include 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.***

B. Application of mitigation measures shall be reasonable both individually and in combination.

Audit

Form V-2 provides the information used in auditing this Standard.

Total effect on damage due to use of multiple mitigation measures will be reviewed and shown to be reasonable. Any variation in the change over the range of wind speeds for individual and multiple mitigation measures will be reviewed and shown to be reasonable.

Mitigation measures used by the model that are not listed as required in this Standard will be disclosed and shown to be theoretically sound and reasonable.

Verified: **YES~~, Contingent upon revised documentation provided to the Commission~~**

Professional Team Comments:

*****Initial Review Comments*****

Reviewed results of the mitigation runs for Form V-2, including mapping of mitigation measures to model categories and description of base structure used. Also reviewed computer runs at a higher wind speed resolution than required giving the required change in damage due to an individual mitigation measure. Verified how the loading values are changed to determine damage to specific mitigation measures such as shutters – plywood, steel, or engineered.

Reviewed the methodology for estimating the effects of individual and multiple mitigation measures.

Reviewed Form V-2 and discussed the inclusion by the modeler of several additional mitigation measures to the ones required.

Refinements to format of Form V-2 were discussed.

Revised response with correction to reference of Form V-1 to Form V-2 to be provided to the Commission.

*****Additional Verification Review Comments*****

Revised page 65 received by the Commission and reviewed by a subset of the Professional Team.

ACTUARIAL STANDARDS – Marty Simons, Leader

A-1 Underwriting Assumptions

A. 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 upon accepted actuarial, underwriting, and statistical procedures.

B. For loss cost 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, as well as any actuarial modifications, shall be reasonable and appropriate.

Audit

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

Demonstrate 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." Provide the methods used to delineate among the insurer claim practices in the use of historical claims data to verify model outputs.

Verified: YES

Professional Team Comments:

Discussed the use of insurance data and the process of validation for model components.

Discussed timeliness of insurer data. Discussed benefits of multi-insurer data.

Discussed in detail the assumptions used in the repair/replacement model and the assumptions used for property value.

A-2 Loss Cost Projections

A. Loss cost projections produced by hurricane loss projection models shall not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin.

B. Loss cost projections shall not make a prospective provision for economic inflation.

C. Loss cost projections shall not explicitly include demand surge.

Audit

Demonstrate how the presence of demand surge has been considered 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.

Describe how the model handles expenses, risk load, investment income, premium reserves, taxes, assessments, profit margin, and economic inflation.

Verified: YES

Professional Team Comments:

Discussed how demand surge is handled and verified that it was not used in preparation of the loss cost projections.

Modeler methods preclude the inclusion of prohibited items in loss costs.

A-3 User Inputs

All modifications, adjustments, assumptions, defaults, and treatments of missing values used in the model shall be actuarially sound and included with the model output.

Audit

All insurer inputs and assumptions will be reviewed.

Verified: YES

Professional Team Comments:

Discussed the assumptions and default settings used for unknown construction characteristics.

Reviewed HurLoss User Manual documenting model input requirements and procedures.

Discussed usage of insurer data (including treatment of missing values, etc.) in validation of model outputs.

A-4 Logical Relationship to Risk

A. 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.

B. Loss costs produced by the model shall be positive and non-zero for all valid Florida ZIP Codes.

C. Loss costs cannot increase as friction or roughness increase, all other factors held constant.

D. Loss costs cannot increase as the quality of construction type, materials and workmanship increases, all other factors held constant.

E. Loss costs cannot increase as the presence of fixtures or construction techniques designed for hazard mitigation increases, all other factors held constant.

F. Loss costs cannot increase as the quality of building codes and enforcement increases, all other factors held constant.

G. Loss costs shall decrease as deductibles increase, all other factors held constant.

H. The relationship of loss costs for individual coverages (A, B, C, D) shall be consistent with the coverages provided.

Audit

Graphic representations of loss costs by ZIP Code and county will be reviewed.

Color-coded maps depicting the effects of land friction on loss costs by ZIP Code will be reviewed.

Individual loss cost relationships will be reviewed. Forms A-1 and A-2 will be used to assess coverage relationships.

Verified: ~~**NO**~~ **YES**

Professional Team Comments:

*****Initial Review Comments*****

Verified there were no changes to the model from the previous submission.

Discussed the changes in Form A-1 from the previous submission and verified the changes were due to ZIP Code centroid movements. Reviewed several individual ZIP Code movements.

Verification pending review of Form A-2 to be revised and presented to the Professional Team.

*****Additional Verification Review Comments*****

Revised Form A-2 (electronic copy) provided to the Commission and reviewed by a subset of the Professional Team. The changes are consistent with the increased precision due to a 300,000 year simulation period.

A-5 Deductibles and Policy Limits

A. The methods used in the development of mathematical distributions to reflect the effects of deductibles and policy limits shall be actuarially sound.

B. The relationship among the modeled deductible loss costs shall be reasonable. Differences in these relationships from those previously found acceptable shall be reasonable.

Audit

The modeler actuary may be asked to attest to the actuarial soundness of the procedure for handling deductibles and policy limits. To the extent that historical data are used to develop mathematical depictions of deductibles and policy limit functions, demonstrate the goodness-of-fit of the data to fitted models. Justify changes from the prior submission in the relativities among corresponding deductible amounts for the same coverage.

Verified: YES

Professional Team Comments:

Verified no change in the methodology for handling deductibles and policy limits.

Reviewed Actuary's report and correspondence between actuary and modeler personnel.

A-6 Contents

A. The methods used in the development of contents loss costs shall be actuarially sound.

B. The relationship between the modeled building and contents loss costs shall be reasonable, based on the relationship between historical building and contents losses. Differences in the relationship of building and contents loss costs from those previously found acceptable shall be reasonable.

Audit

The modeler actuary may be asked to attest to the actuarial soundness of the procedure for calculating loss costs for contents coverage. To the extent that historical data are used to develop mathematical depictions of contents functions, demonstrate the goodness-of-fit of the data to fitted models. Justify changes from the prior submission in the relativities between loss costs for buildings and the corresponding loss costs for contents.

Verified: YES

Professional Team Comments:

Verified no changes were made to the methodology for handling contents losses.

Reviewed the data presented in Figure 17, Comparison of Modeled and Observed Mean Content Damage versus Mean Building Damage.

Reviewed Actuary's report and correspondence between actuary and modeler personnel.

Reviewed several differences between current and previous submissions.

A-7 Additional Living Expenses (ALE)

A. The methods used in the development of Additional Living Expense (ALE) loss costs shall be actuarially sound.

B. ALE loss cost derivations shall consider the estimated time required to repair or replace the property.

C. The relationship between the modeled building and ALE loss costs shall be reasonable, based on the relationship between historical building and ALE losses. Differences in the relationship of building and ALE loss costs from those previously found acceptable shall be reasonable.

Audit

The modeler actuary may be asked to attest to the actuarial soundness of the procedure for calculating loss costs for ALE coverage. Documentation and justification of the following will be reviewed:

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. The effects of demand surge on ALE for Hurricane Andrew;
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 condo unit owners exposure;
H. The methods used to incorporate the estimated time required to repair or replace the property;
I. The methodology and available validation for determining the extent of infrastructure damage and its effect on ALE costs.

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

Verified: YES

Professional Team Comments:

Discussed in detail the methodology for calculating ALE and reviewed scatter plots comparing actual and modeled ALE loss ratio versus peak gust wind speed for validation.

Discussed ALE data provided in Figure 18, Comparison of Modeled and Observed Mean ALE Damage versus Mean Building Damage.

Reviewed Actuary's report and correspondence between actuary and modeler personnel.

Reviewed several differences between current and previous submissions.

STATISTICAL STANDARDS – Mark Johnson, Leader

S-1 Use of Historical Data

A. The use of historical data in developing the model shall be supported by rigorous methods published in currently accepted scientific literature.

B. Modeled and historical results shall reflect agreement using currently accepted scientific and statistical methods.

Audit

Graphical comparisons of modeled and historical data and goodness-of-fit tests will be reviewed. Examples include hurricane frequencies, tracks, intensities, and physical damage. Forms S-10 and S-11 will be reviewed.

The modeler's characterization of uncertainty for wind speed, damage estimates, annual loss, and loss costs will be reviewed.

Verified: ~~**NO**~~ **YES**

Professional Team Comments:

*****Initial Review Comments*****

Reviewed results of statistical tests and graphical comparisons of modeled and historical frequency rates, tracks, intensity, and damage ratios.

Correction to confidence level stated in response to disclosure #1 and response to disclosure #5 to be reworded and examples given.

Verification pending review of Forms S-10 and S-11 and Figures 19 and 20 to be revised and presented to the Professional Team.

*****Additional Verification Review Comments*****

Revised Forms S-10 (page 125) and S-11 (page 126), Figures 19 and 20 (pages 86 and 87), and responses to disclosures #1 and #5 (pages 87 and 88) provided to the Commission and reviewed by a subset of the Professional Team. The changes are consistent with the increased precision due to a 300,000 year simulation period.

S-2 Sensitivity Analysis for Model Output

The modeler shall have assessed the sensitivity of temporal and spatial outputs with respect to the simultaneous variation of input variables using currently accepted scientific and statistical methods and have taken appropriate action.

Audit

The modeler's sensitivity analysis will be reviewed in detail. Statistical techniques used to perform sensitivity analysis shall be explicitly stated. The results of the sensitivity analysis displayed in graphical format (e.g., contour plots with temporal animation) will be reviewed.

Form S-12 will be reviewed for new modeling companies which have not previously provided the Commission with this analysis.

Verified: **YES~~, Contingent upon revised documentation provided to the Commission~~**

Professional Team Comments:

*****Initial Review Comments*****

Reviewed results of the sensitivity study and discussed other factors that are not in the model but may have a significant impact on the sensitivity of the output results.

Reviewed animated contour plots of wind speed from the previous sensitivity study completed for Form S-12 (Form F) last year.

Response to disclosure #4 to be reworded.

*****Additional Verification Review Comments*****

Revised response to disclosure #4 (page 91) received by the Commission and reviewed by a subset of the Professional Team.

S-3 Uncertainty Analysis for Model Output

The modeler shall have performed an uncertainty analysis on the temporal and spatial outputs of the model using currently accepted scientific and statistical methods and have taken appropriate action. The analysis shall identify and quantify the extent that input variables impact the uncertainty in model output as the input variables are simultaneously varied.

Audit

The modeler's uncertainty analysis will be reviewed in detail. Statistical techniques used to perform uncertainty analysis shall be explicitly stated. The results of the uncertainty analysis displayed in graphical format (e.g., contour plots with temporal animation) will be reviewed.

Form S-12 will be reviewed for new modeling companies which have not previously provided the Commission with this analysis.

Verified: **YES~~, Contingent upon revised documentation provided to the Commission~~**

Professional Team Comments:

*****Initial Review Comments*****

Reviewed results of the uncertainty study previously conducted on Form S-12 (Form F).

Response to disclosure #4 to be reworded.

*****Additional Verification Review Comments*****

Revised response to disclosure #4 (page 93) received by the Commission and reviewed by a subset of the Professional Team.

S-4 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 negligible based upon currently accepted scientific and statistical methods.

Audit

Provide a graph assessing the accuracy associated with a low impact area such as Nassau County. We would expect that if the contribution error in an area such as Nassau County is small, the error in the other areas would be small as well. Assess where appropriate, the contribution of simulation uncertainty via confidence intervals.

Verified: ~~**NO**~~ **YES**

Professional Team Comments:

*****Initial Review Comments*****

Discussed in detail the effect of changing the random number seed in the sampling process on the loss costs produced. Reviewed percentage changes in the output ranges by county as a result.

Reviewed Figure 22, page 94.

Discussed the standard deviation and reviewed scatter plots showing the percentage change based on the number of ZIP Codes in county.

Verification pending review of response and Figure 22 to be revised and presented to the Professional Team.

*****Additional Verification Review Comments*****

Revised response to Standard S-4 and Figure 22 (page 94) provided to the Commission and reviewed by a subset of the Professional Team. The changes are consistent with the increased precision due to a 300,000 year simulation period.

S-5 Replication of Known Hurricane Losses

The model shall 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, to the extent data are available, to mobile homes. Personal residential experience may be used to replicate building-only and contents-only losses. The replications shall be produced on an objective body of loss data by county or an appropriate level of geographic detail.

Audit

The following information for each insurer and hurricane will be reviewed:

1. The validity of the model assessed by comparing expected losses produced by the model to actual observed losses incurred by insurers at both the state and county level,
2. The version of the model used to calculate modeled losses for each storm provided,
3. A general description of the data and its source,
4. A disclosure of any material mismatch of exposure and loss data problems, or other material consideration,
5. The date of the exposures used for modeling and the date of the hurricane,
6. An explanation of differences in the actual and modeled storm parameters,
7. 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,
8. 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,
9. The inclusion of demand surge, storm surge, loss adjustment expenses, or law and ordinance coverage in the actual losses, or the modeled losses.

The following documentation will be reviewed:

1. Publicly available documentation referenced in the submission,
2. The 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. User input sheets for each insurer and hurricane detailing specific assumptions made with regard to exposed property.

The confidence intervals used to gauge the comparison between historical and modeled losses will be reviewed.

Form S-6 will be reviewed.

Verified: YES

Professional Team Comments:

Reviewed details of actual and modeled ZIP Code losses and underlying insurance company data. Discussed the data presented in Figures 23, 24, and 25.

S-6 Comparison of Estimated Hurricane Loss Costs

The difference, due to uncertainty, between historical and modeled annual average statewide loss costs shall be statistically reasonable.

Audit

Forms S-4, S-5, S-7, S-8, and S-9 will be reviewed.

Justify the following:

1. Meteorological parameters,
2. The effect of by-passing storms,
3. The effect of actual storms that have two landfalls impacting Florida,
4. 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, and
5. Exposure assumptions.

Verified: ~~**NO**~~ **YES**

Professional Team Comments:

*****Initial Review Comments*****

Reviewed maps provided in Form S-4 and discussed the differences between loss costs by county.

Revised Form S-7 to be provided to the Commission with corrections to 1926 and 1935 storms. Figure references to be corrected in response to disclosure #1.

Verification pending review of Forms S-4, S-5, S-7 and S-9 and Figures 26, 27, and 28 and response to disclosure #3 to be revised and presented to the Professional Team.

*****Additional Verification Review Comments*****

Revised Forms S-4 (pages 115-166), S-5 (page 117), S-7 (page 120), and S-9 (page and Figures 26 (page 100), 27 (page 101), and 28 (page 102) and response to disclosure #3 (page 102) provided to the Commission and reviewed by a subset of the Professional Team. The changes are consistent with the increased precision due to a 300,000 year simulation period.

S-7 Output Ranges

For a model previously found acceptable by the Commission, the differences in the updated output ranges shall be reasonable.

Audit

Forms S-1A, S-1B, S-2, and S-3 will be reviewed.

Justify the following:

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

Verified: ~~**NO**~~ **YES**

Professional Team Comments:

*****Initial Review Comments*****

Reviewed maps of ZIP Code centroid movements and the resulting impact on the loss costs produced in the output ranges and the change in surface roughness.

Discussed changes in Form S-2 attributed to ZIP Code centroid movements closer to the coast resulting in a slight overall increase in the return period wind speeds and a moderate overall increase in loss costs.

Verification pending review of Forms S-1A, S-1B, S-2, and S-3 to be revised and presented to the Professional Team.

*****Additional Verification Review Comments*****

Revised Forms S-1A, S-1B, S-2 (page 113), and S-3 (page114) provided to the Commission and reviewed by a subset of the Professional Team. The changes are consistent with the increased precision due to a 300,000 year simulation period.

COMPUTER STANDARDS – Paul Fishwick, Leader

C-1 Documentation

A. The modeler shall maintain a complete set of documents specifying the model structure, detailed software description, and functionality. Development of each section shall be indicative of accepted software engineering practices.

B. All computer software (i.e., user interface, scientific, engineering, actuarial) relevant to the modeler's submission shall be consistently documented.

C. Documentation shall be created separately from the source code.

Audit

The primary document binder, in either electronic or physical form, and its maintenance process will be reviewed. The binder shall contain fully documented sections for each Computer Standard.

Complete user documentation, including all recent updates, will be reviewed.

Modeler personnel, or their designated proxies, responsible for each aspect of the software (i.e. user interface, quality assurance, engineering, actuarial) shall be present when the Computer Standards are being audited. The Professional Team will interview internal users of the software.

Verified: YES

Professional Team Comments:

Reviewed (1) component designs and implementation provided in binders and source code, (2) the input file that controls the building stock mappings for each county, and (3) the source code that controls the coverage limits, deductibles, and ZIP Code weights used in the output ranges. Verified that all computer software relevant to ARA's submission was consistently documented. Reviewed the primary document binder which references and organizes the following document binders:

HURLOSS RISK ANALYSIS SUITE documentation

Volume	Binder	Section	Title
0			Primary Documents Binder
	0-A		**Primary Documents Binder**
I			Hurricane Simulation Model
	I-A		**LIFESIMi Model**
	I-B &C		**Hurricane Model:** Validation Results/ Statistical Tests/Verification/Testing Results
	I-D		**Hurricane Model:** Sensitivity and Uncertainty Studies
	I-E		**Windfield Model**
II			Individual Building Damage & Loss Model
	II-A		**Building Component Load Models**
	II-B		**Individual Building Damage Model Part 1**
	II-C		**Individual Building Damage Model Part 2**
	II-D		**Building Damage Comparisons FHC99 vs. FHC00**
	II-E		**Individual Ground-Up Building Loss**
	II-F		**Individual Risk Analysis Building Database**
	II-G1		**Individual Risk Sensitivity Study (Primary)**
	II-G2		**Individual Risk Sensitivity Study (Secondary)**
	II-H		**HurReport Utility**
	II-R		**Regression Test Results**
III			Portfolio Analysis Model
	III-A		**Actuarial and Aggregation Models**
	III-A2		**Florida Building Construction Characteristics**
	III-A3		**Analysis of FL Building Stock**
	III-B		**Terrain Database (by Zip Code)**
	III-C		**DOQQ's**
	III-D		**HurLoss Portfolio Analysis Application**
	III-E		**Historical Storm Validation**

C-2 Requirements

The modeler shall maintain a complete set of requirements for the model, its computer implementation, and all appropriate model documentation.

Audit

The documentation of the requirements specifications will be reviewed.

Verified: YES

Professional Team Comments:

Requirements documentation was provided in each document binder.

C-3 Model Architecture and Component Design

The modeler shall maintain information defining the model architecture and design of model components and sub-components.

Audit

The following will be reviewed:

1. Detailed control and data flow diagrams,
2. Interface specifications for all components in the model,
3. Documentation for schemas for all data files, along with field type definitions,
4. Each network diagram including components, sub-component diagrams, arcs, and labels.

A model component custodian, or designated proxy, should be available for the review of each component.

Verified: YES

Professional Team Comments:

Reviewed component designs, data flow diagrams, and implementation provided in binders and source code. Reviewed the Model Custodian Primary and Secondary Reviewer chart.

Reviewed flowchart of the track and wind field generation software.

Verified documented data file formats including structure and data types/sizes in the IntraWind File Format Specification (Vol III-D).

C-4 Implementation

The software shall be traceable from the flow diagrams down to the code level.

Audit

The traceability among components at all levels of representation will be reviewed.

Model components and the method of mapping to elements in the computer program will be reviewed.

The interfaces and the coupling assumptions will be reviewed.

Verified: YES

Professional Team Comments:

Reviewed component designs and implementations documented in the source code and the binders listed under Standard C-1.

Verified traceability between flow diagram “Group II: Individual Risk Group” and related engineering models (Vol. II-A, Building Component Model).

C-5 Verification

A. General

The modeler shall maintain procedures for verification, such as code inspections, reviews, calculation crosschecks, and walkthroughs, sufficient to demonstrate code correctness.

B. Testing

Tests shall be performed for each software component, independent of all other components, to ensure that each component provides the correct response to inputs. The modeler shall use testing software to assist in documenting and analyzing all component test procedures and cases.

Audit

The code will be reviewed for containment of 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.

The testing of each component will be reviewed.

Verified: YES

Professional Team Comments:

Discussed ARA's computer verification methods documented in the HurLoss Model Revision Policy. Reviewed the policy and ARA's methods for inspecting internal variables in a debugging environment, independent code reviews, and code walkthroughs. Spot checked examples of logical assertions and error checking in Fortran and exception handling in C++ source.

Discussed ARA procedures for unit/system testing. Viewed code from HLIMportTest, which is a test application for the HLImport Component of HurLoss.

Viewed an example test import data file that incorporated variability of location, and structure and policy parameters for a Florida insurance portfolio.

C-6 Model Maintenance and Revision

A. The modeler shall have developed and implemented a clearly written policy for model revision with respect to methodologies and data.

B. A revision to any portion of the model that results in a change in any Florida residential hurricane loss cost shall result in a new model version number.

C. The modeler shall use tracking software to identify all errors, as well as modifications to code, data, and documentation.

Audit

All policies and procedures used to maintain the code, data, and documentation will be reviewed. For each component in the system decomposition, the modeler should provide the installation date under configuration control, the current version number, and the date of the most recent change(s).

Verified: YES

Professional Team Comments:

Reviewed ARA's Version Control and Source Code Control Procedures in the primary document binder.

Reviewed the updated policy on revisions to the model.

C-7 Security*

*(*New Standard)*

The modeler shall have implemented security procedures for access to code, data, and documentation in accordance with standard industry practices.

Audit

Provide a written policy for all procedures and methods used to ensure the security of code, data, and documentation. Specify all security procedures.

Verified: YES

Professional Team Comments:

Reviewed ARA code, data, and security policy documentation in the primary document binder.