Willis Towers Watson

Texas Windstorm Insurance Association

Residential and Commercial Rate Level Indications

September 4, 2020

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Section 1: Purpose and Scope

Willis Towers Watson ("we" or "us") was engaged by Texas Windstorm Insurance Association ("TWIA" or "you") to assist TWIA in determining an indicated rate level change for TWIA's Residential and Commercial business incepting during the January 1, 2021 to December 31, 2021 period.

The purpose of this report is to assist TWIA management in determining rate level actions for the January 1, 2021 to December 31, 2021 underwriting year (UY 2021). This report is not intended or necessarily suitable for any other purpose. While there is technically a timing mismatch between the projected reinsurance expenses developed in Exhibit 11.2 (which reflects an expected reinsurance premium, effective June 1, 2021; exhibit is available in both the Residential and Commercial documents) and the assumed effective date of the rate indication (which is January 1, 2021), we've confirmed with TWIA Actuarial Committee that this is acceptable, as what we're producing is an estimated indication, not one to be filed with the Texas Department of Insurance.

The exhibits attached in support of our conclusions are an integral part of this report. These sections have been prepared so that our actuarial assumptions and judgments are documented. Judgments about the analysis and findings presented in this report should be made only after considering the report in its entirety. Our projections are predicated on a number of assumptions as to future conditions and events. These assumptions are documented in subsequent sections of this report and should be understood in order to place the actuarial estimates in their appropriate context. In addition, these projections are subject to a number of reliances and limitations, as described in subsequent sections of this report.

We are available to answer any questions that may arise regarding this report. We assume that the user of this report will seek such explanation on any matter in question.

Section 2: Distribution

Our report is delivered under the following terms and conditions:

- This report is provided to TWIA solely for the intended purpose, and may not be referenced or distributed to any other party without our prior written consent
- This report has been prepared for use by persons technically competent in the areas covered and with the necessary background information
- Draft versions of this report must not be relied upon by any person for any purpose
- You shall not refer to us or include any portion of this report in any shareholder communication or in any offering materials or fairness opinion provided by your professional advisors prepared in connection with the public offering or private placement of any security
- You shall not refer to us in any communications with state insurance regulators without our prior consent, and
- This report may be shared with your affiliates, provided that you ensure that each such affiliate complies with the terms above and the applicable statement of work as if it were a party to them, and you remain responsible for such compliance

We accept no responsibility for any consequences arising from any third party relying on this report. If we agree to provide this report to a third party, you are responsible for ensuring that the report is provided in its entirety, that the third party is made aware of the fact that they are not entitled to rely upon it, and that they may not distribute the report to any other party.

Section 3: Reliances and Limitations

Loss cost indications, and therefore indicated rate changes, are subject to potentially large errors of estimation, since the occurrence and ultimate disposition of claims is subject to the outcome of events that have not yet occurred. Examples of these events include employment, prevalence of occupational injuries, propensity to file a claim, medical treatment, jury decisions, court interpretations, legislative changes, public attitudes or statutory changes. Any estimate of future costs is subject to the inherent limitation on one’s ability to predict the aggregate course of future events. It should therefore be expected that actual loss experience will vary, perhaps materially, from any estimate. Thus, no assurance can be given that TWIA’s actual loss costs will not ultimately exceed the estimates underlying the indicated rates contained in its analysis. In our judgment, we have employed techniques and assumptions that are appropriate, and the estimates presented herein are reasonable, given the information currently available.

Note that a quantification of this uncertainty would likely reflect a range of reasonable favorable and adverse scenarios, but not necessarily a range of all possible outcomes. Further, the proper application of any range is dependent on the context.

Throughout this analysis, we have relied on quantitative and qualitative information supplied by TWIA. We have not independently audited or verified this information; however, we have reviewed it for reasonableness and internal consistency. We have assumed that the information is complete and accurate, and that we have been provided with all information relevant to the development of the indicated rate changes. The accuracy of our results is dependent upon the accuracy and completeness of the underlying data; therefore, any material discrepancies discovered in this data should be reported to us and this report amended accordingly, if warranted.

Given the condensed timeline associated with delivering TWIA our results, we used TWIA’s internally developed rate indication workbook. While we have endeavored to ensure that all of the calculations within the workbook are accurate, we did not perform a technical review of every formula within the rate indication workbook in their entirety. We understand that the rate indication workbook was developed by technically competent personnel, and that those personnel consider the rate indication workbook as suitable for the purposes of developing the estimates therein.

Additionally, we have not anticipated any extraordinary changes to the legal, social, or economic environment that might affect the cost, frequency, or future reporting of claims.

COVID-19

Sudden unforeseen events such as the COVID-19 pandemic can have significant impacts on the level of economic activity, investment markets and TWIA’s business and its experience. Our rate level indications do not contemplate any impact due to COVID-19. At this point, it is not possible to reliably forecast and quantify these impacts, and whether they will affect policies issued during the prospective underwriting period covered in our analysis. Sources of uncertainty related to the impacts of COVID-19 likely include the following. This list is not intended to or claim to be exhaustive.

- Public, corporate and government responses to COVID-19, and the extent to which these responses impact commercial activity and economic conditions
- Potential legislative changes or judicial decisions as regards coverage
- Impact on expense ratios due to changes in volume of business
- Impact on loss ratios due to changes in mix of business

Section 4: Summary of Rate Level Indications

We have prepared separate rate level indications by hurricane projection method. The following table presents the indicated rate level changes by projection method:

Hurricane Projection Method	Residential Indicated Rate Level Change	Commercial Indicated Rate Level Change
Actual Experience and Models (50%/50%)	32%	42%
Actual Experience	21%	34%
Hurricane Models (25% AIR/ 75% RMS)	42%	49%
AIR Model	54%	54%
RMS Model	39%	47%

The total rate change achieved by TWIA may deviate from the selected rate level change due to variations in actual UY 2021 experience (e.g., amount/mix of business written, losses, expenses, investment income) from the assumptions in this report.

Here is a summary of the major differences between the Willis Towers Watson indications and the TWIA indications:

1. Storm surge provision: We removed the storm surge provision from the indication. More details can be found in Section 7.

2. LAE: We developed separate LAE loads for non-hurricane and hurricane. For the development of both the non-hurricane ALAE and ULAE loads, we removed the hurricane year of 2017. For hurricane, we selected a combined ALAE/ULAE provision of 17.2% based on the loss and LAE data supplied for Hurricanes Ike and Harvey as well as TWIA's estimated Hurricane Ike litigation cost reduction stemming from House Bill 3. Based on this same data, a LAE provision of 17.2% was used in the calculation of the reinsurance expense provision.

3. Hurricane year frequency: For the hurricane loss ratio based on industry experience, we changed the frequency to be a measure of the frequency of hurricane years and not of hurricanes.

4. Reinsurance provision: This provision reflects our recommendation that less reinsurance limit can be purchased, which is detailed in Section 7. We also differed the provision between commercial and residential.

Section 5: Residential Indication

Data Reconciliation

In performing the rate level indication, we relied on data provided by TWIA. The main data file we used is the *2020 Data* workbook. This workbook contains both TWIA's internal premium and loss data, and premium and loss data provided by TICO (Texas Insurance Checking Office, Inc.). The data provided by TICO includes both industry data and TWIA data.

The TICO-provided experience consists of paid loss data for accident years ending September 30 evaluated as of December 31, 2019, whereas TWIA's internal experience reflects paid loss data for accident years ending December 31 evaluated as of December 31, 2019. Because of this difference, we expect some variation when comparing the two sets of loss data. We compared both hurricane and non-hurricane paid losses by year:

AY	TICO TWIA Paid Loss			TWIA Paid Loss			Difference = TWIA/TICO – 1		
	Hurricane Loss	Non-Hurricane Loss	Total Loss	Hurricane Loss	Non-Hurricane Loss	Total Loss	Hurricane Loss	Non-Hurricane Loss	Total Loss
2008	1,711,578,878	2,802,388	1,714,381,266	1,706,313,221	2,754,253	1,709,067,474	-0.3%	-1.7%	-0.3%
2009		6,521,624	6,521,624		8,479,585	8,479,585	0.0%	30.0%	30.0%
2010	1,251,439	11,557,131	12,808,570		10,958,718	10,958,718	-100.0%	-5.2%	-14.4%
2011		76,656,054	76,656,054		76,980,633	76,980,633	0.0%	0.4%	0.4%
2012		50,467,223	50,467,223		52,332,695	52,332,695	0.0%	3.7%	3.7%
2013		65,565,099	65,565,099		63,503,334	63,503,334	0.0%	-3.1%	-3.1%
2014		5,013,683	5,013,683		6,114,172	6,114,172	0.0%	21.9%	21.9%
2015		113,519,286	113,519,286		119,859,509	119,859,509	0.0%	5.6%	5.6%
2016		33,096,128	33,096,128	32,984	25,856,315	25,889,298	0.0%	-21.9%	-21.8%
2017	885,447,193	32,538,230	917,985,423	879,897,311	21,341,252	901,238,563	-0.6%	-34.4%	-1.8%
2018		10,306,333	10,306,333	400,850	11,248,445	11,649,295	0.0%	9.1%	13.0%
2019		14,549,172	14,549,172		12,384,305	12,384,305	0.0%	-14.9%	-14.9%
Grand Total	2,598,277,510	422,592,351	3,020,869,861	2,586,644,366	411,813,215	2,998,457,581	-0.4%	-2.6%	-0.7%

In 2010, there is a $1.2 million hurricane loss recorded by TICO but not by TWIA. Despite fluctuations from year to year between the two sets of data, the total paid losses between the two datasets appear reasonably similar.

We also compared the TICO-provided TWIA earned premium data from 2010 to 2019 to the TWIA earned premium provided by TWIA:

CY	TICO TWIA EP	TWIA EP	Difference = TWIA/TICO -1
2010	271,890,346	273,154,916	0.8%
2011	286,281,776	292,239,327	2.1%
2012	315,773,226	323,323,869	2.4%
2013	340,251,357	346,955,938	2.0%
2014	367,422,606	372,022,089	1.3%
2015	394,735,548	403,803,905	2.3%
2016	400,592,831	405,934,590	1.3%
2017	382,767,033	376,421,384	-1.7%
2018	347,747,840	341,468,875	-1.8%
2019	325,328,865	322,259,386	-0.9%

The TWIA-provided earned premium was consistently higher from 2010 through 2016 and consistently lower from 2017 through 2019. A recommendation for TWIA is to work with TICO and reconcile the premiums.

Summary of Methodology

Due to the condensed timeline associated with delivering TWIA our results, we used TWIA's 2019 Excel file as the starting point for our indication work. In deriving the indicated residential rate level changes for the January 1, 2021 to December 31, 2021 policy year, we first brought earned premiums to the current rate level. We developed separate loss adjustment expense (LAE) loadings for hurricane and non-hurricane losses. Next, we calculated the combined trend factors for non-hurricane losses and premiums to obtain the projected ultimate loss ratio. We also calculated hurricane loss ratios using an average of industry experience and modeled results. After adding in the respective LAE loadings, we combined the non-hurricane loss ratio and hurricane loss ratio to obtain the projected ultimate loss and LAE ratio. Fixed and variable expenses were calculated separately based on historical expenses. The indicated rate change to achieve TWIA's target underwriting profit provision (which is break-even) was then derived by comparing the indicated loss and LAE ratio and fixed expenses with the permissible loss, LAE and fixed expense ratio.

Earned Premium at Current Rate Level

Exhibit 10.2 shows the derivation of the current rate level factors based on TWIA-provided data. The current rate level factors are based on the parallelogram method and are the same for every territory since the rates and historical rate changes are the same throughout. These current rate level factors are applied to the TICO-provided TWIA earned premium in Exhibit 10, Sheets 1a through 1d to bring the premiums for each territory to current rate level. These premiums are used in Exhibit 2, Sheets 2a through 2d in the calculation of the non-hurricane loss & LAE ratios.

Loss Adjustment Expense (LAE) Loading

The LAE loading was calculated as Schedule P Defense and Cost Containment (DCC) and Adjusting and Other (AAO) expenses combined as a percentage of loss. (Throughout this indication document, DCC is labelled as ALAE and AAO is labelled as ULAE.) We used 2010 through 2019 paid losses, paid DCC and paid AAO from TWIA's 2019 Schedule P for Residential and Commercial combined, and calculated the 10-year weighted average DCC to loss ratio and AAO to loss ratio. The selected non-hurricane LAE ratio is the sum of the average DCC to loss ratio and AAO to loss ratio.

For hurricane LAE, TWIA provided the loss, ALAE, and ULAE amounts for two of the most recent hurricanes, Ike (2008) and Harvey (2017). This detail was not available for any other hurricanes. Additionally, TWIA provided the estimated Hurricane Ike litigation cost reduction stemming from House Bill 3. We restated the loss for Hurricane Ike by subtracting the estimated litigation cost reduction from the unadjusted Hurricane Ike loss. We then calculated the LAE ratio for each hurricane and selected the loss-weighted average as the hurricane LAE ratio.

Exhibit 4, Sheets 1 and 2, provide details on the deviation of both the hurricane and non-hurricane LAE loadings.

Historical and Projected Trend Factors

The net trend factor is calculated as the loss trend factor divided by the premium trend factor. Both trend factors are calculated using a two-step trending method.

The current premium trend factors are calculated as the ratio of the latest available average written premium to the historical written premiums, using written premium provided by TWIA. The details of such calculations can be found in Exhibit 2, Sheet 5. The selected prospective premium trend factor is 0.1%, which is an average of the 3-year, 4-year, and 5-year exponential fitted trends. The premium trend data is very stable and there is little variation in these three trends. More details are provided in Exhibit 3, Sheet 2.

TWIA provided three different indices for loss trend calculations: Boeckh Residential Construction Index (Statewide), Boeckh Residential Construction Index (Coastal), and Modified Consumer Price Index (CPI). For the purposes of trend calculations, we assigned 75% weight to Boeckh Residential Construction Index (Coastal) and 25% weight to Modified CPI.

The current loss trend factors for accident years 2010 through 2019 are calculated using the September 30, 2019 index divided by the September 30 index of each respective year. We calculated trend factors for all three indices and used the weights mentioned above to arrive at the current loss trend factors for each year. We also calculated 3-year, 4-year, and 5-year exponential fitted trends for all three indices. The 5-year exponential fit factors are selected for the purpose of calculating prospective loss trend. The factors are weighted as mentioned above, and the selected prospective loss trend factor is 1.7%. The details of the calculations can be found in Exhibit 2, Sheet 5 and Exhibit 3, Sheets 3a-d.

Projected Ultimate Non-Hurricane Loss and LAE Ratio

In order to derive the projected ultimate non-hurricane loss and LAE ratio, we first calculated the loss development factors (LDFs) to bring the non-hurricane losses in historical periods to an ultimate basis.

TICO provided statewide industry non-hurricane paid losses, and from there we selected the corresponding paid LDFs. (Note: It would be preferable to have this data for only the territories in which TWIA writes business). For loss development, we used the 5-year average paid LDFs shown on Exhibit 3, Sheet 1 since the data is relatively stable and reflects the most recent experience. The projected ultimate non-hurricane loss and LAE ratio can now be calculated as follows:

1. Develop non-hurricane paid losses to ultimate using paid LDFs.
2. Apply the selected non-hurricane LAE loading to result of step 1 to obtain the ultimate non-hurricane loss and LAE.
3. Divide the result in step 2 by on-leveled earned premium to obtain the non-hurricane loss and LAE ratio.
4. Apply the combined premium and loss trend factors to obtain the projected non-hurricane loss and LAE ratio.

The details of the calculations can be found in Exhibit 2, Sheets 1 through 4 and Exhibit 3, Sheet 1, on both an aggregated and by-territory basis.

Projected Hurricane Loss and LAE Ratio

Two different projected hurricane loss ratios are calculated: one based on industry loss experience, and one based on hurricane models.

Industry Loss Experience

To develop the projected hurricane loss ratio, we looked at industry hurricane experience for the last 54 years and 169 years, respectively. TWIA provided the industry seacoast dwelling extended coverage premium and losses for the 54-year period of 1966 through 2019. For years where sufficient information is available (2003 through 2019), the earned premium is brought to the current TWIA rate level using the parallelogram method. For years prior to 2003, we adopted the same methodology used by TWIA in the 2019 rate indication.

We calculated the average loss ratio for every year from 1966 to 2019. We calculated an average loss ratio of 105.8% for the 14 hurricane years and an average loss ratio of 9.1% for the non-hurricane years. We subtracted the non-hurricane loss ratio from the hurricane year loss ratio to obtain the average hurricane loss ratio of 96.7%.

Due to the infrequent nature of hurricanes, in addition to the 54-year frequency of 0.241, we also calculated a 169-year frequency of 0.320 (where frequency here measures the presence of at least one hurricane in a given year). We selected 0.320 as the frequency since a common belief is that this longer-term average is more representative of the true hurricane year frequency. We then multiplied the average hurricane loss ratio of 96.7% by the 169-year hurricane year frequency to arrive at the projected hurricane loss ratio of 30.9%. Although intuitive, methods relying on actual industry hurricane loss experience often lack refinement and produce less credible projections as compared to hurricane models, particularly due to changes in land use, population densities, construction techniques and materials, engineering techniques and building codes over time, which can greatly impact loss costs. Such differences could render calculated industry loss ratios ineffective for projection purposes.

The details of the calculations can be found in Exhibit 6 and Exhibit 9.

Hurricane Models

In addition to using industry loss experience, we also calculated the projected hurricane loss ratio by using results from more refined hurricane simulation models. TWIA provided the modeled average annual loss (AAL) results from both catastrophe modeling vendors Applied Insurance Research (AIR) and Risk Management Solutions (RMS). Both sets of modeled losses include impacts of demand surge but exclude storm surge and LAE. We validated the gross AAL by county output provided by TWIA. The RMS modeled loss ratio is 42.4% and the AIR modeled loss ratio is 52.4%. We selected a 75% RMS/25% AIR weighting which results in a modeled projected hurricane loss ratio of 44.9%.

For details, please see the Hurricane Model Results section of the report.

The details of the calculations can be found in Exhibits 7 and 8.

Projected Loss & LAE Ratio

The last step is to add the hurricane LAE load of 17.2% to the hurricane loss ratios obtained from industry experience and modeled results. The projected loss ratios are 49.7% and 61.4% for RMS and AIR models, respectively.

The details of the above calculations can be found in Exhibit 5.

Fixed and Variable Expenses

TWIA provided a combination of historical and prospective expense, Catastrophe Reserve Trust Fund (CRTF) contribution, and Class 1 public security interest and principal repayment schedule data. TWIA also provided underwriting contingency and uncertainty provision of 5%. Using this data, we developed both fixed and variable expense provisions. The total fixed expense provision (42.2%) includes general expenses (8.5%, details below), Class 1 public security interest and principal repayment (17.9%), and the reinsurance expense ratio (15.8%; details below). The total variable expense provision (17.9%) includes commissions (16.0%) and taxes, licenses and fees (1.9%).

Per Note 13 of TWIA's 2019 Annual Statement, TWIA "is required to use the net gain from operations of the Assocation to make payments to the CRTF, procure reinsurance, or use alternative risk financing mechanisms." Given this requirement, we believe including a provision for a CRTF contribution will artificially inflate the rate indication (since the CRTF is ultimately used to pay TWIA's catastrophe claims and help lower TWIA's net payments). However, we do believe that including an undewriting contingency and uncertainty provision is appropriate, and we have selected 5%. This provision is effectively treated as a variable expense.

The details of the above are presented in Exhibit 11, Sheet 1.

General Expenses Breakdown

General expenses come from TWIA's Annual Statement U&IE Part 3 for the past 3 years. For each year, general expenses consist of values from Line 19: Totals (Line 3 to 18) in Column 2 (Other Underwriting Expenses) of U&IE, Line 24: Aggregate write-ins for miscellaneous expenses in Column 2, and Line 30: Total Expenses Paid in Column 3 (Investment Expenses). Aggregate write-in items for other underwriting expenses include IT expenses, HB3 Ombudsman Program expenses, Depopulation Service Fee, and miscellaneous expenses. Aggregate write-in items for investment expenses in general include bond issuance expenses, line of credit related expenses, and investment expenses.

General Expenses from Annual Statement

UW Expense Category	2017	2018	2019
Total (excluding miscellaneous items below)	$24,365,480	$25,792,502	$24,171,890
IT Exp less Capitalization of HW/SW	2,200,127	2,482,613	
IT Systems Support & Product Development			4,876,568
HB3 Ombudsman Program	113,028	110,701	132,297
Miscellaneous Expenses	30,542	92,255	14,778
Depopulation Service Fee	-520,882	-248,371	-120,463
Subtotal	26,188,295	28,229,700	29,075,070
Investment Expense Categories	**2017**	**2018**	**2019**
Bond Issuance Expense	$171,536	$42,018	$563,706
Line of Credit Issuance Expenses		1,436,569	526,856
Line of Credit Fees		783,333	1,022,222
Investment Expenses		195,557	274,082
Less unpaid expenses - current year	-69,324		
Add unpaid expenses - prior year	199,434	69,324	
Subtotal	301,646	2,526,801	2,386,866
Total General Expenses	$26,489,941	$30,756,501	$31,461,936

Projected Reinsurance Expense Ratio

We revised the methodology to calculate the projected reinsurance expense ratio.

As explained in Section 7, we developed 2021-2022 expected reinsurance premium and AIR and RMS expected average annual losses (AALs) by reinsurance layer. (Note: The expected layer AALs would likely be lower than the amounts shown due to negative exposure trend, while the expected reinsurance premium would likely be higher than the amount shown due to higher reinsurance costs.) We selected a total AAL based on a 50% RMS/50% AIR weighting and loaded LAE. We calculated the net cost of reinsurance by subtracting the projected AAL+LAE from the reinsurance premium. We then calculated the projected reinsurance expense ratio as the expected net cost of reinsurance divided by TWIA 2019 earned premium at present rates. The calculated ratio is 15.8%.

The details are contained in Exhibit 11, Sheet 2.

Indicated Rate Level Change

Permissible Loss and LAE Ratio

The permissible loss & LAE ratio is 77.1%, which equals 1 – total variable expenses – underwriting contingency and uncertainty provision.

Dividing the projected ultimate loss, LAE and fixed expense ratio by the permissible loss & LAE ratio gives us the indicated rate level change.

Details of this calculation can be found in Exhibit 1.

Section 6: Commercial Indication

Data Reconciliation

In performing the rate level indication, we relied on loss and premium data provided by TWIA. The main data file we used is the *2020 Data* workbook. The paid loss data provided reflects loss data for accident years ending December 31 evaluated as of December 31, 2019. We reconciled the losses and premium provided to the 2019 Annual Statement. Both losses and premiums reconciled within a 0.1% margin.

Summary of Methodology

Due to the condensed timeline associated with delivering TWIA our results, we used TWIA's 2019 Excel file as the starting point for our indication work. In deriving the indicated commercial rate level changes for the January 1, 2021 to December 31, 2021 policy year, we first brought earned premiums to the current rate level. We developed separate loss adjustment expense (LAE) loadings for hurricane and non-hurricane losses. Next, we calculated the combined trend factors for non-hurricane losses and premiums to obtain the projected ultimate loss ratio. We also calculated hurricane loss ratios using an average of industry experience and modeled results. After adding in the respective LAE loadings, we combined the non-hurricane loss ratio and hurricane loss ratio to obtain the projected ultimate loss and LAE ratio. Fixed and variable expenses were calculated separately based on historical expenses. The indicated rate change to achieve TWIA's target underwriting profit provision (which is break-even) was then derived by comparing the indicated loss and LAE ratio and fixed expenses with the permissible loss, LAE and fixed expense ratio.

Earned Premium at Current Rate Level

Exhibit 10.2 shows the derivation of the current rate level factors based on TWIA-provided data. The current rate level factors are calculated based on the parallelogram method and are the same for every territory since the rates and historical rate changes are the same throughout. These current rate level factors are applied to the written premiums in Exhibit 10, Sheet 1 to bring the historical premiums to current rate level. These premiums are used in Exhibit 2, Sheet 1 in the calculation of the non-hurricane loss & LAE ratios.

Loss Adjustment Expense (LAE) Loading

The LAE loading was calculated as Schedule P Defense and Cost Containment (DCC) and Adjusting and Other (AAO) expenses combined as a percentage of loss. (Throughout the indication, DCC is labelled as ALAE and AAO is labelled as ULAE.) We used 2010 through 2019 paid losses, paid DCC and paid AAO from TWIA's 2019 Schedule P combining both Residential and Commercial programs, and calculated the 10-year weighted average DCC to loss ratio and AAO to loss ratio. The selected non-hurricane LAE ratio is the sum of the average DCC to loss ratio and AAO to loss ratio.

For hurricane LAE, TWIA provided the loss, ALAE, and ULAE amounts for two of the most recent hurricanes, Ike (2008) and Harvey (2017). This detail was not available for any other hurricanes. Additionally, TWIA provided the estimated Hurricane Ike litigation cost reduction stemming from House Bill 3. We restated the loss for Hurricane Ike by subtracting the estimated litigation cost reduction from the unadjusted Hurricane Ike loss. We then calculated the LAE ratio for each hurricane and selected the loss-weighted average as the hurricane LAE ratio.

Exhibit 4, Sheets 1 and 2, provide details on the deviation of both the hurricane and non-hurricane LAE loadings.

Historical and Projected Trend Factors

The net trend factor is calculated as the loss trend factor divided by the premium trend factor. Both trend factors are calculated using a two-step trending method.

The current premium trend factors are calculated as the ratio of the latest available average written premium to the historical written premiums, using written premium provided by TWIA. The details of such calculations can be found in Exhibit 2, Sheet 4. The prospective premium trend factor of 1.0% was selected, by taking into consideration the 3-year, 4-year, and 5-year exponential fitted trends. In recent years, there appears to be a moderate increase in the premium trend data. More details are provided in Exhibit 3, Sheet 2.

TWIA provided three different indices for loss trend calculations: Boeckh Commercial Construction Index (Statewide), Boeckh Commercial Construction Index (Coastal), and Modified Consumer Price Index (CPI). For the purposes of trend calculations, we assigned 75% weight to Boeckh Commercial Construction Index (Coastal) and 25% weight to Modified CPI.

The current loss trend factors for accident years 2010 through 2019 are calculated using the December 31, 2019 index divided by the December 31 index of each respective year. We calculated trend factors for all three indices and used the weights mentioned above to arrive at the current loss trend factors for each year. We calculated an all-year exponential fitted trend for all three indices and a 3-year, 4-year and 5-year exponential trend for the Modified CPI. For the purpose of calculating the prospective loss trend, we selected the all-year exponential fit factor for the Boeckh Commercial Construction Index (Coastal) and the 5-year exponential fit factor for the Modified CPI. The factors are weighted as mentioned above, and the selected prospective loss trend factor is 1.9%. The details of the calculations can be found in Exhibit 2, Sheet 4 and Exhibit 3, Sheets 3a to 3d.

Projected Ultimate Non-Hurricane Loss and LAE Ratio

In order to derive the projected ultimate non-hurricane loss and LAE ratio, we first calculated the loss development factors (LDFs) to bring the non-hurricane losses in historical periods to an ultimate basis.

TWIA provided statewide industry non-hurricane paid losses, and from there we selected the corresponding paid LDFs. (Note: It would be preferable to have this data for only the territories in which TWIA writes business). For loss development, we used the 5-year average paid LDFs shown on Exhibit 3, Sheet 1 since the data is relatively stable and reflects the most recent experience. The projected ultimate non-hurricane loss and LAE ratio can now be calculated as follows:

1. Develop non-hurricane paid losses to ultimate using paid LDFs.
2. Apply the selected non-hurricane LAE loading to the result of step 1 to obtain the ultimate non-hurricane loss and LAE.
3. Apply the combined premium and loss trend factors to the result in step 2 to obtain the projected non-hurricane loss and LAE
4. Divide the result in step 3 by on-leveled earned premium to obtain the non-hurricane loss and LAE ratio.

The details of the calculations can be found in Exhibit 2, Sheets 1 through 2 and Exhibit 3, Sheet 1.

Projected Hurricane Loss and LAE Ratio

Two different projected hurricane loss ratios are calculated: one based on industry loss experience, and one based on hurricane models.

Industry Loss Experience

To develop the projected hurricane loss ratio, we looked at industry hurricane experience for the last 50 years and 169 years, respectively. TWIA provided the industry commercial extended coverage premium and losses for the 50-year period of 1970 through 2019 for each territory. For years where sufficient information is available, the earned premium is brought to the current TWIA rate level using the parallelogram method. For all other years, we adopted the same methodology used by TWIA in the 2019 rate indication.

We calculated the average loss ratio for every year from 1970 to 2019. We calculated an average loss ratio of 140.7% for the 13 hurricane years and an average loss ratio of 7.0% for the non-hurricane years. We subtracted the non-hurricane loss ratio from the hurricane year loss ratio to obtain the average hurricane loss ratio of 133.7%.

Due to the infrequent nature of hurricanes, in addition to the 50-year frequency of 0.240, we also calculated a 169-year frequency of 0.320 (where frequency here measures the presence of at least one hurricane in a given year). We selected 0.320 as the frequency since a common belief is that this longer-term average is more representative of the true hurricane year frequency. We then multiplied the average hurricane loss ratio of 133.7% by the 169-year hurricane year frequency to arrive at the projected hurricane loss ratio of 42.8%. Although intuitive, methods relying on actual industry hurricane loss experience often lack refinement and produce less credible projections as compared to hurricane models, particularly due to changes in land use, population densities, construction techniques and materials, engineering techniques and building codes over time, which can greatly impact loss costs. Such differences could render the calculated industry loss ratios ineffective for projection purposes.

The details of the calculations can be found in Exhibit 6 and Exhibit 9.

Hurricane Models

In addition to using industry loss experience, we also calculated the projected hurricane loss ratio by using results from more refined hurricane simulation models. TWIA provided the modeled average annual loss (AAL) results from both catastrophe modeling vendors Applied Insurance Research (AIR) and Risk Management Solutions (RMS). Both sets of modeled losses include impacts of demand surge but exclude storm surge and LAE. We validated the gross AAL by county output provided by TWIA. The AIR modeled loss ratio is 55.8% and the RMS modeled loss ratio is 51.0%. We selected a 75% RMS/25% AIR weighting, which results in a modeled projected hurricane loss ratio of 52.2%.

For details, please see the Hurricane Model Results section of the report.

The details of the calculations can be found in Exhibits 7 and 8.

Projected Loss & LAE Ratio

The last step is to add the hurricane LAE load of 17.2% to the hurricane loss ratios obtained from industry experience and modeled results. The projected loss ratios are 65.4% and 59.8% for AIR and RMS models, respectively.

The details of the above calculations can be found in Exhibit 5.

Fixed and Variable Expenses

TWIA provided a combination of historical and prospective expense, Catastrophe Reserve Trust Fund (CRTF) contribution, and Class 1 public security interest and principal repayment schedule data. TWIA also provided an assumed CRTF contribution and underwriting contingency and uncertainty provision of 5%. Using this data, we developed both fixed and variable expense provisions. The total fixed expense provision (44.3%) includes general expenses (8.5%, details below), Class 1 public security interest and principal repayment (17.9%), and the reinsurance expense ratio (17.9%; explained below). The total variable expense provision (17.9%) includes commissions (16.0%) and taxes, licenses and fees (1.9%).

Per Note 13 of TWIA's 2019 Annual Statement, TWIA "is required to use the net gain from operations of the Assocation to make payments to the CRTF, procure reinsurance, or use alternative risk financing mechanisms." Given this requirement, we believe including a provision for a CRTF contribution will artificially inflate the rate indication (since the CRTF is ultimately used to pay TWIA's catastrophe claims and help <u>lower</u> TWIA's net payments). However, we do believe that including an undewriting contingency and uncertainty provision is appropriate, and we have selected 5%. This provision is effectively treated as a variable expense.

The details of the above are presented in Exhibit 11, Sheet 1.

General Expenses Breakdown

General expenses come from TWIA's Annual Statement U&IE Part 3 for the past 3 years. For each year, general expenses consist of values from Line 19: Totals (Line 3 to 18) in Column 2 (Other Underwriting Expenses) of U&IE, Line 24: Aggregate write-ins for miscellaneous expenses in Column 2, and Line 30: Total Expenses Paid in Column 3 (Investment Expenses). Aggregate write-in items for other underwriting expenses include IT expenses, HB3 Ombudsman Program expenses, Depopulation Service Fee, and miscellaneous expenses. Aggregate write-in items for investment expenses in general include bond issuance expenses, line of credit related expenses, and investment expenses.

General Expenses from Annual Statement

UW Expense Category	2017	2018	2019
Total (excluding miscellaneous items below)	$24,365,480	$25,792,502	$24,171,890
IT Exp less Capitalization of HW/SW	2,200,127	2,482,613	
IT Systems Support & Product Development			4,876,568
HB3 Ombudsman Program	113,028	110,701	132,297
Miscellaneous Expenses	30,542	92,255	14,778
Depopulation Service Fee	-520,882	-248,371	-120,463
Subtotal	26,188,295	28,229,700	29,075,070
Investment Expense Categories	**2017**	**2018**	**2019**
Bond Issuance Expense	$171,536	$42,018	$563,706
Line of Credit Issuance Expenses		1,436,569	526,856
Line of Credit Fees		783,333	1,022,222
Investment Expenses		195,557	274,082
Less unpaid expenses - current year	-69,324		
Add unpaid expenses - prior year	199,434	69,324	
Subtotal	301,646	2,526,801	2,386,866
Total General Expenses	$26,489,941	$30,756,501	$31,461,936

Projected Reinsurance Expense Ratio

We revised the methodology to calculate the projected reinsurance expense ratio.

As explained in Section 7, we developed 2021-2022 expected reinsurance premium and AIR and RMS expected average annual losses (AALs) by reinsurance layer. (Note: The expected layer AALs would likely be lower than the amounts shown due to negative exposure trend, while the expected reinsurance premium would likely be higher than the amount shown due to higher reinsurance costs.) We selected a total AAL based on a 50% RMS/50% AIR weighting and loaded LAE. We calculated the net cost of reinsurance by subtracting the projected AAL+LAE from the reinsurance premium. We then calculated the projected reinsurance expense ratio as the expected net cost of reinsurance divided by TWIA 2019 earned premium at present rates. The calculated ratio is 17.9%.

The details are contained in Exhibit 11, Sheet 2.

Indicated Rate Level Change

Permissible Loss and LAE Ratio

The permissible loss & LAE ratio is 77.1%, which equals 1 – total variable expenses – underwriting contingency and uncertainty provision.

Dividing the projected ultimate loss, LAE and fixed expense ratio by the permissible loss & LAE ratio gives us the indicated rate level change.

Details of this calculation can be found in Exhibit 1.

Section 7: Hurricane Model Evaluation

Executive Summary

Willis Towers Watson (WTW) was chosen by Texas Windstorm Insurance Association (TWIA) to perform an independent study of TWIA's rate adequacy and use of hurricane models to estimate potential losses in its rate-setting process. This section of the report focuses on the hurricane modeling aspect of this engagement, particularly providing insights into the significant differences between the RMS and AIR North Atlantic Hurricane model outputs with respect to Average Annual Loss estimates and the 100-year probable maximum loss for TWIA's portfolio. We are pleased to offer our summary of TWIA's current approach and our recommended adjustments:

Cat model approach for reinsurance and rate filings

Metric	Hurricane Loss and LAE Ratio (HuLR)[1] or Reinsurance Spend part of Fixed Expenses[2]	TWIA's Current Approach[3]	WTW Recommendation
Model Weight (RMS/AIR)	Both	50% / 50%	75% / 25%
Long-term / Medium-term	Both	Medium term	Long term
Loss Adjustment Expense	Both	15% load	17.2% load[5]
Storm Surge (flood)	HuLR	10% load on AAL	excluded
	Reinsurance	excluded	excluded
1-100 yr (11/30/19 data)	Reinsurance	3,600,000,000	3,180,000,000
LAE Load		15.00%	17.20%
1-100 yr w/ LAE (rounded)		4,200,000,000	3,740,000,000
Assumed Reinsurance Limit (2020)		2,100,000,000	1,640,000,000
Assumed Reinsurance Retention (2020)		2,100,000,000	2,100,000,000
2020 Net Reinsurance Spend $[4]		102,066,436	85,227,815
2020 Reinsurance Cost % for Rate Indication	Residential	18.7%	15.8%
	Commercial	18.7%	17.9%
2019 Earned Premium at Present Rates		384,669,667	384,669,667

[1] Hurricane Loss and LAE Ratio found in Indication Exhibit 5

[2] Reinsurance Spend as a part of Fixed Expenses found in Indication Exhibit 11

[3] This figure represents the methodology TWIA is currently using and the actual limit purchased.

[4] Current Net Spend = 107,500,000 gross spend less broker discount, depopulation policies and applicable commissions. See Indication Exhibit 11.2

[5] Details on the calculation of the Loss Adjustment Expense for the HuLR can be found in Indication Exhibit 4.2

We also outline a data improvement plan which develops a strategy to improve the data quality of TWIA's policy information and historical claims data, and endeavor to outline an estimated range of financial impacts on the PML and reinsurance purchase. As an extension of the data quality initiative, we outline several secondary modifiers that could improve the accuracy of TWIA's model loss and could potentially reduce TWIA's reinsurance cost.

Data Collection from TWIA

The following includes data provided by TWIA and data limitations to consider in reviewing this report:

- Gross modeling output for RMS RiskLink v18.1 and AIR Touchstone v7, based on exposure data as of November 30, 2019. WTW also received the underlying exposure data, which allowed us to remodel the book in order to provide an in-depth study of TWIA modeled loss results (county-level gross AAL provided by TWIA was used in our rate indications work). This exposure file is the same file TWIA's reinsurance broker received for the 2020 renewal.
- Modeling assumptions for the 2020 reinsurance program by TWIA and their reinsurance broker.

- The total limit modeled is about 1.5% less than what TWIA used for the 2020 reinsurance purchase due to:
  - Our adjustment of building limit down to building value for instances where the limit is higher than value.
  - We excluded 1,831 policies that were marked as depopulated from modeling (approximately 0.9% of total TIV).
- Hurricane Ike and Hurricane Harvey claims data including bulk ULAE amounts.
- Individual losses from other historical hurricanes before 2008 were not available for review.
- 2008 policy level exposure information at the time of Hurricane Ike was not provided.

Hurricane Fundamentals

Tropical cyclones are non-frontal, low-pressure systems with closed wind circulation and deep convection to the top of the troposphere. In the northern hemisphere, the winds rotate counterclockwise around the low-pressure center, while in the southern hemisphere the winds rotate in a clockwise direction. Tropical cyclones with peak winds greater than 74 mph are called hurricanes in the North Atlantic and Eastern/Central Pacific oceans. The North Atlantic basin spawns an average of 12 tropical cyclones a year, 6 of which become hurricanes. On average the U.S. coastline (from Texas through Maine) will experience between 1 and 2 hurricane landfalls per year, but hurricane landfalls have an even stronger seasonal variance than the overall basin total.

Saffir Simpson Hurricane Wind Scale

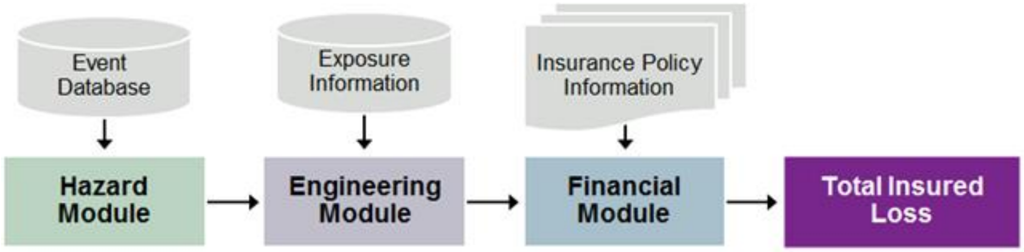
Category	Sustained Wind (mph)
1	74 - 95
2	96 - 110
3	111 - 129
4	130 - 156
5	157+

When a hurricane makes landfall, the force of strong winds can destroy buildings, bring down power lines and trees and blow vehicles off roads. High winds cause differential pressures acting on the building envelope, which includes roofs and walls and their associated components. A significant amount of the damage to structures associated with high winds is produced by windborne debris impacting the buildings and damaging the building exterior including roof covering, windows, and doors. Rainwater damage to a building's interior will normally result after damage to the building envelope has occurred. Along the coast, storm surge is often the greatest threat to life and property from a hurricane. Storm surge is defined as the abnormal rise of water generated by a storm, above the natural astronomical tide. This abnormal elevation results from water being pushed towards the shore by the hurricane wind and the bump in the ocean level caused by the decreased air pressure found in the hurricane. As it relates to the timing of a landfall hurricane, a high tide or low tide could impact the amount of storm surge pushed onto shore as we have seen with Hurricane Harvey in 2017 (TX) and more recently with hurricane Isaias (2020, North Carolina). Riding on top of the storm surge are wind induced waves that increase the energy of the surge and its height, which in turn can significantly increase the damage at a location that experiences this type of flow. In addition to high winds and storm surge, hurricanes also threaten coastal areas with their heavy rains.

Overview of Model Components

Willis Re licenses several catastrophe models, but the two most widely used are RMS and AIR. Below is a brief overview of the model components applicable to both RMS and AIR that serve as base framework for the follow up discussion on catastrophe model results and understanding of the driving forces behind the significant loss differences between the models for the TWIA portfolio. A more complete examination of each model's construct, key components, and underlying assumptions and methodologies as it pertains to TWIA can be found under the ***Model Validation & Selection for TWIA.***

The chart below highlights the key building blocks found in both RMS and AIR catastrophe models:



- **Stochastic Event Component (Event Database)**
  This component contains events representing the full spectrum of likely events based on realistic meteorological parameters and historical data. Each stochastic event is described by its physical parameters, location, and frequency of occurrence. This component answers questions pertaining to chances of event occurring or frequency of events. Both AIR and RMS models provide two views of hurricane event rates for loss estimate. As such, results between models will depend on the view under consideration.

- **Hazard Component**
  This component assesses the level of physical hazard at a location against each of the stochastic event. Sources of hurricane data, wind speeds, and geocoding accuracy all play a factor in determining the hazard level at a location.

- **Engineering / Vulnerability**
  The calculation of mean damage ratio and associated uncertainty are influence by the characteristics of the location. Both models consider the same set of primary characteristics for calculating the damage ratio of a risk - the building's construction type, occupancy type, building height (number of stories), square footage, and year built. However, their methodologies and views of the vulnerability of these risks are different and can vary greatly across each state.

  Other important building features, called secondary risk characteristics or modifiers, are also considered by the models and they act to modify the damage ratio computed from a combination of primary characteristics. Currently, TWIA does not capture any secondary risk characteristics or if it is captured, the data was not provided to Willis Towers Watson. See *Data Quality & Improvement for TWIA* on more detailed discussion.

- **Financial component**
  This last component is where the physical damage is converted into monetary loss by applying policy specific information such as deductibles and limits. Loss amounts to different stakeholders, from policyholder, to insurance company and reinsurers based on policy terms are assigned. The main financial perspectives available are:
  - **Ground-up** – loss irrespective of policy terms/ deductibles. This is generally not used by an insurance company.
  - **Gross** – loss to the insurance policy after application of deductibles, limits or coinsurance. This is generally used by TWIA in rate filing work and reviewing reinsurance options.
  - **Net Loss Pre-Cat** – loss after applying all non-cat treaties (e.g. per risk) and facultative reinsurance, but before any cat treaties.

- **Net Loss Post-Cat** – loss after applying all reinsurance but before corporate cat xol and stop loss treaties

This report will focus on the gross loss, given that TWIA doesn't purchase any inuring reinsurance to the current program. These perspectives are often given in the context of average annual expected losses and probable maximum loss.

- **Average Annual Loss (AAL)** is the amount needed to cover loss over time. Actual loss sustained for any given year may be higher or lower than the modeled AAL.
- **Probable Maximum Loss (PML),** usually stated on an occurrence or aggregate basis, refers to the probability that at least one event (occurrence basis, or OEP) or sum of all events (aggregate basis or AEP) will occur that causes loss of at least a certain amount in any given year. TWIA's current program is placed on an aggregate basis.

It is important to note that loss adjustment expenses, debris removal, and inflation of claims due to political pressure or litigation are examples of loss elements not included in catastrophe models. Loss adjustment expenses are often added on top of modeled results in rate filings and reinsurance buying process. We analyze storm surge (flood) throughout this report, but precipitation induced inland flooding is not included in either the wind or storm surge in RMS, while AIR allows for explicit modeling of this flood peril.

Model Validation

The next several pages provide a scientific background on catastrophe models, and unless referenced, will not directly relate to Texas or TWIA's portfolio.

Stochastic Event Component

Both AIR and RMS models provide two views of hurricane activity rates for loss estimate. As such, results between models will depend on the view under consideration. Long-term view is based on historical average of hurricane landfall. Medium-term (aka Near-term) is often used synonymously between RMS and AIR but there is a subtle difference in definition. RMS utilizes historical average as baseline, however going further, it provides a 5-year forecast based on the understanding that hurricanes in the Atlantic are known to follow periods of heightened or diminished activity in terms of frequency of events, intensity, and landfall frequency. AIR on the other hand, measures hurricane risk based on years in which the sea surface temperature (SST) was above the historical mean, and therefore provides a measure of expected risk for any season/seasons in which the Atlantic is warmer than average.

- **Seasonal Variability in Hurricane Activity and Forecast of Multi-year Hurricanes Rates**
  The basin wide hurricane variability in the Atlantic is well correlated with the Atlantic Multidecadal Oscillation (AMO), whose positive phases have been noted to be closely linked to active periods for Atlantic hurricanes (**Figure 1**). Positive AMO phases are characterized by above-average far North and tropical Atlantic sea surface temperature (SSTs). The most recent warm phase began in 1995. Before the last two active hurricane seasons (2017 – 2018), even though we had some eminent storms like Sandy and Matthew, the northern Atlantic hurricane activity had been relatively quiet for few years, which has led to some speculations as to whether we have entered into a new persistent period of low hurricane activity similar to what was observed from the early 1970s to mid-1990s (Klotzbach et al. 2015). However, there is low confidence in this occurring.

The low confidence arises from our incomplete understanding of the AMO, evidenced by competing theories for its driving mechanisms. Also, any cool phase could be warmer due to climate change.

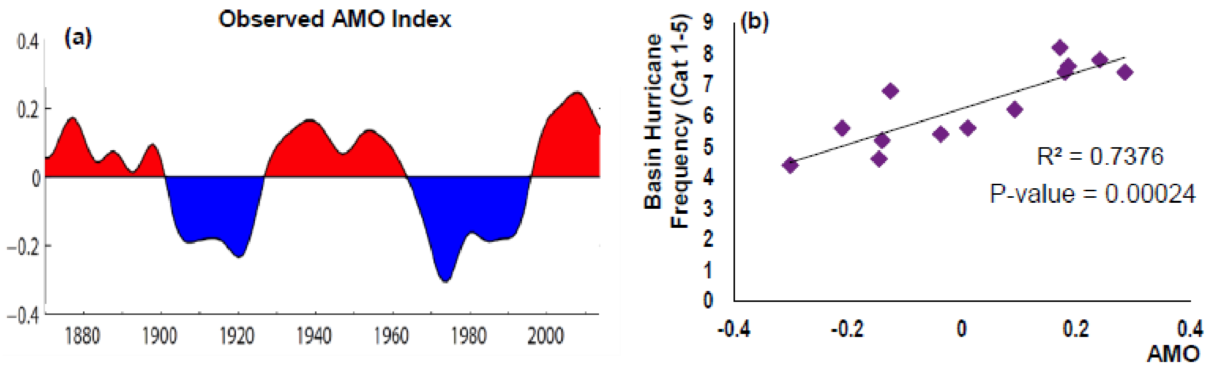


Figure 1. (a) Observed AMO index, defined as detrended 10-year low-pass filtered annual mean area-averaged SST anomalies over the North Atlantic basin (0N-65N, 80W-0E) for the period 1870-2015. Source: NCAR. (b) Correlation between 5-year average of AMO and Atlantic basin hurricane activity (Cat 1-5).

Even though the basin wide Atlantic hurricane activity is well correlated with SST and vertical wind shear (VWS), they are not good measures of the landfall frequency in the U.S. Some research studies indicate that during the period of warm SST and low VWS in the main development region (MDR), an enhanced hurricane activity in the basin is observed along with high VWS along the U.S. coast. VWS hinders hurricanes from maintaining the thermodynamic potential intensity. Therefore, higher VWS during the active period in the basin would weaken hurricanes that tend to approach the U.S. coastline. Prof. Kossin (2017) demonstrated that the probability of higher intensification of a hurricane near the U.S. coast during cold/inactive periods was higher than a hurricane near the U.S. coast during active periods.

There are other environmental drivers of hurricane activity, such as El Niño-Southern Oscillation (ENSO), which could drive seasonal hurricane activity. ENSO is an ocean-atmosphere interaction in the tropical Pacific that influences weather and climate patterns around the world. El Niño events are characterized by warmer than usual sea surface temperature (SST) in the eastern and central tropical Pacific, and La Niña events are characterized by cooler than usual SST in the eastern and central tropical Pacific. The impact of ENSO on hurricane activity has been well documented. Gray (1984) showed that El Niño conditions reduce hurricane activity in the North Atlantic basin due to stronger vertical wind shear and trade winds and greater atmospheric stability. Conversely, La Niña conditions, which are accompanied by weaker vertical wind shear and trade winds and less atmospheric stability, tend to increase hurricane activity in the Atlantic. The left plot in **Figure 2** shows average number of hurricanes per year on the U.S. coast from 1950-2018 during years classified by average over July to September (JAS) index ENSO phases. The right plot shows the decreasing trend with increasing ENSO.

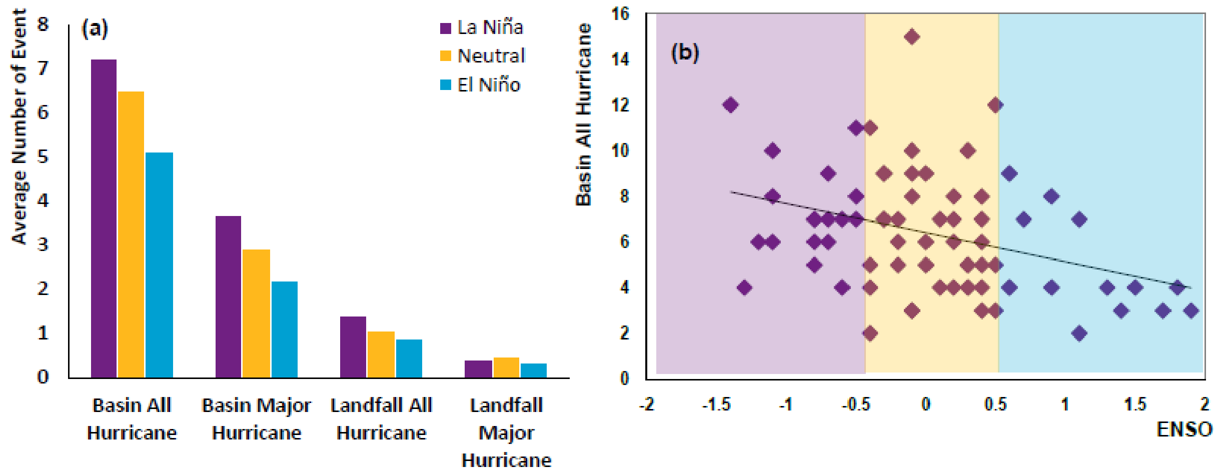


Figure 2. (a) Average number of hurricanes per year by ENSO phase; (b) Correlation between basin wide number of hurricanes and ENSO index.

In summary, our incomplete understanding of the AMO and competing theories for its driving mechanisms prevent us from having high confidence on multi-annual prediction of AMO. On the other side, ENSO is also a good indicator of basin activity during a hurricane season but is not reliable for more than a few months in advance. As an example, during the 2017 hurricane season when Harvey hit the Texas coast, the ENSO forecast changed drastically from El Niño phase to Neutral over a couple of months before the hurricane season began, which basically enforced the Atlantic hurricane activity forecast to shift from below average to above average. In comparison to seasonal hurricane forecasts, the field of multi-annual forecasting is very much in its infancy (Caron et al., 2017). One should keep in mind that even a season with a few hurricanes can yield highly destructive storms, such as Hurricane Andrew in 1992 and Hurricane Sandy in 2012.

Given the challenges in making a reliable forecast of multi-annual average hurricane rates and the current state of the knowledge on multi-annual forecast of the hurricane activity, **Willis Re suggests using the long-term rates (historical catalog) as the standard view for the risk assessment when modeling for hurricane in RMS. Medium-term rates should mainly be used for sensitivity analyses.**

AIR assumes SST is the major factor to influence Atlantic hurricane activity and ignores the impact of ENSO and the North Atlantic Oscillation (NAO) in the development of their WSST catalog. **Willis Re recommends using the Standard catalog for the risk assessment when modeling in AIR.** AIR believes their Warm SST catalog should be used as a supplement to, rather than a replacement for, its Standard catalog.

- **Frequency Comparison**

  From a risk perspective, the frequency of landfalling storms is important for assessing the probability of a given property's exposure to different levels of damaging wind. WTW performed the validation of landfall frequencies by comparing actual annual frequency from HURDAT2 data (1900 – 2019) with the modeled annual frequencies from AIR and RMS.

Figure 3

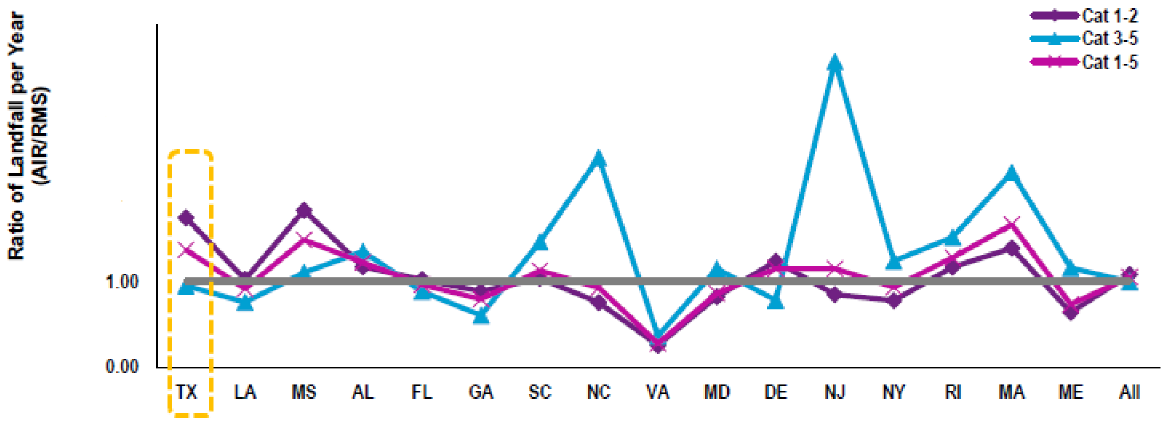


Figure 3 above shows the AIR to RMS ratio of hurricane rates for each state by region. While the overall landfall frequencies are very similar between models at the country-level, variability exist at the state level.

Figure 4.a) below shows comparison of <u>Texas frequency</u> while Figure 4.b) shows comparison of <u>Texas frequency distribution</u> by Cat size for historic data, and for RMS and AIR models. AIR generates a significantly larger rate of weaker and overall landfalling storms than the historic data while producing major hurricanes at a slightly lower rate. RMS meanwhile remains closer to the historic average but produces slightly less Cat 1-2 and overall hurricanes and slightly more Cat 3-5 hurricanes than historic average.

Figure 4.a Texas

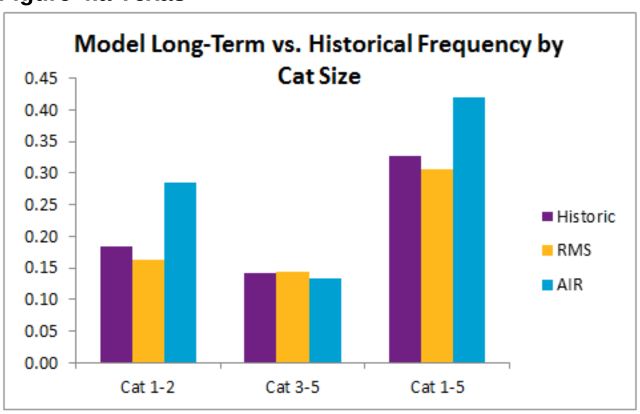


Figure 4.b Texas

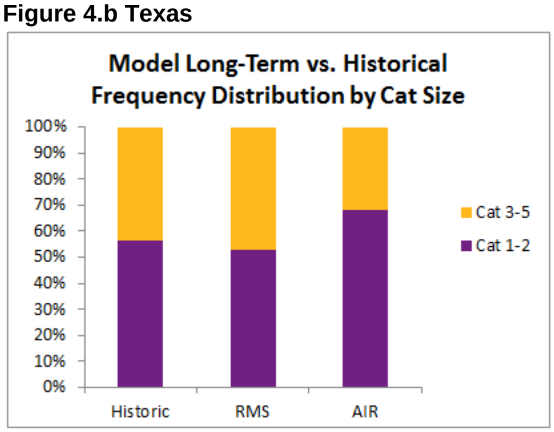


Figure 5 to the right is a comparison of hurricane frequency distribution by county in RMS and AIR for Tier I Texas. <u>Note this does not show the absolute frequency comparison between the models, but rather how each model distributes their total hurricane frequency by county</u>. Both models distribute fairly similar proportion of their total TX frequency to the Galveston region, TWIA's largest county. Brazoria, Cameron, and Aransas are also relatively similar. RMS assigned significantly more of

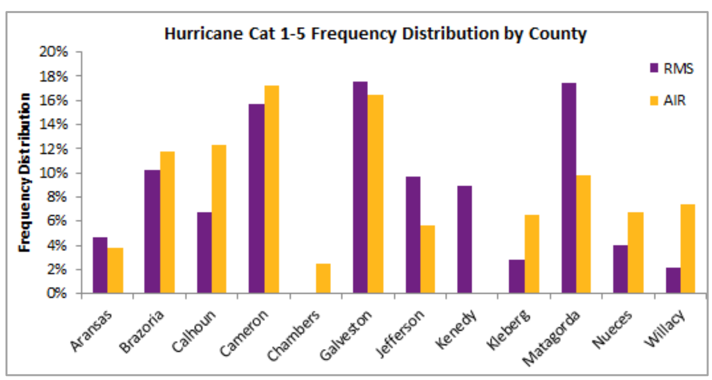


Figure 5

their total TX frequency to Matagorda and Kenedy relative to AIR. In fact, AIR assigned zero chance of a landfall to Kenedy County. Hurricane Hanna, the first Atlantic hurricane to make landfall in Texas for the 2020 season at the end of July, actually made its second landfall in Kenedy County. Kenedy was also subject to losses from Hurricane Brett in 1999, where it received most of the hurricane wind force, which was estimated to be as high as 115 mph over a small portion of the coast of Padre Island. Although TWIA's exposure is insignificant for Kenedy, this comment is intended to highlight that RMS recognizes the chance of landfall in regions where it has been demonstrated to experience landfall while AIR does not. This comparison is meant to show the extent of regional variation at county level and should take into consideration the fact that there may be some tracks making landfall right around the county borderlines and mapped to its neighboring county which may influence the frequency distribution. And of course, hurricane force winds can cause damage many miles away from the landfall area.

Hazard Component

The source of hurricane data that forms the base for which the models built their hazard database is NOAA's latest best track Atlantic hurricane database, also known as HURDAT2. HURDAT2 spans from 1851-2019 and contains hurricane related data including the six-hourly information on the location, maximum winds, and central pressure. The distribution is then smoothed to maintain areas of high and low risk while accounting for the possibility of future landfalls in regions where there have been none historically.

Both models generate a wind-speed radial profile based on work by same source (Willoughby et al 2006). Factors influencing the wind speeds include distance to coast & surface roughness. Geological factors also affect rate of inland decay. Geocoding accuracy will play an important part in the hazard determination since putting a location in a wrong place would ultimately impact the estimated loss.

The Radius of Maximum Wind (Rmax) influences the size of the hurricane wind footprint/swath. **Figure 6** to the right shows the distribution of stochastic events in the model by Radius of Maximum Wind (Rmax) for the Gulf region. RMS produces a wider distribution of radii while more of AIR's events fall within the 20 to 40-mile Rmax range. Large radii become more frequent for both models in the northeast region where the extra-tropical impacts of the high latitudes have the tendency to expand a storm's wind field.

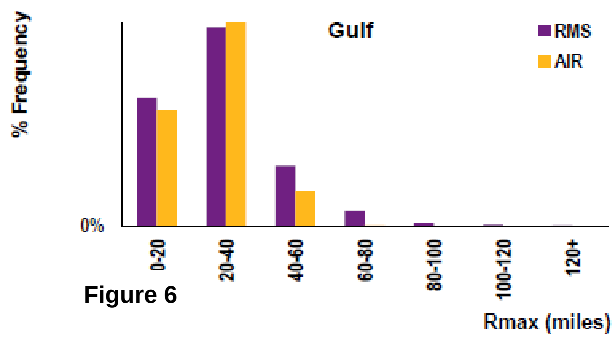


Figure 6

Vulnerability Comparison

Each model's methodology for determining vulnerability (i.e. damageability) by different primary risk characteristics are discussed in this section. The 5 primary risk characteristics considered by both models are: occupancy, year-built, construction, number of stories, and square footage. The methodologies and assumptions implemented by the models for each of the five primary characteristics as discussed below have a direct impact on TWIA's modeling results, particularly as it pertains to modeling differences and our recommendation. See ***Review of TWIA Modeled Loss Results*** section for a more detailed discussion.

Since both models utilize their respective building inventory during the model validation and calibration process, an understanding of its key differences is an important part in understanding the loss results in and between each model.

- RMS has region-specific damage functions for buildings with unknown occupancy, construction, year built or number of stories. Each region can be from a group of states or just single state. Texas is a region on its own in RMS. Vulnerability regions in Texas are further subdivided into inland vs. coastal region. This is to recognize that coastal regions tend to have building codes that are designed to withstand stronger wind speeds and stricter enforcement practices. The entire TWIA portfolio falls under RMS's coastal vulnerability region. RMS noted this in similar observations seen in Florida claims data and for context, Florida is separated into three regions (north, central, & south).

- AIR also has region-specific damage functions for buildings with unknown construction, occupancy or number of stories. In developing damage functions, AIR combines states with similar building inventory together. Texas belongs in a group that includes Louisiana and Mississippi. Note this does not mean AIR treats all Texas regions with same hazard view, only that AIR developed its damage functions and calibration using data from other states. Florida is its own region in AIR.

TWIA captures data for all primary risk characteristics, but none of the secondary characteristics. Therefore, how each model utilizes their building inventory to determine damage functions for the "unknown", particularly from the regional aspects, is an indicator for which model is better built for TWIA's portfolio.

To facilitate an understanding of each model's assumptions and methodology for determining vulnerability by different primary risk characteristics, WTW completed the following sensitivity analysis on a sample Texas coastal portfolio. The results from this analysis will be referenced throughout this report as ***WTW Sensitivity Analysis****,* and the portfolio from which it is based will be referenced as ***notional portfolio****.*

- WTW Sensitivity Analysis Description – A notional portfolio was created with locations set at the postal code centroid from the entire Texas Coastal region. Each of these locations has exactly the same amount of values by coverages and deductible. We used hurricane long-term view, wind-only, include demand surge but exclude storm surge in both RMS and AIR. Each of these locations has a number of policies representing all possible combinations of primary building characteristics that are most representative of TWIA's risk profile. For example, in terms of construction, only wood frame and brick veneer types were considered for the residential business while for commercial business, wood frame and masonry were considered in the sensitivity analysis. Therefore, results from this study are applicable to Texas Coastal region for a portfolio that resembles TWIA's portfolio characteristics and ignores large commercial, energy and industrial type of risks. Note whenever charts are used as it relates to this analysis, we intentionally removed the average loss cost, as represented by the vertical axis, in order to protect the models' intellectual property.

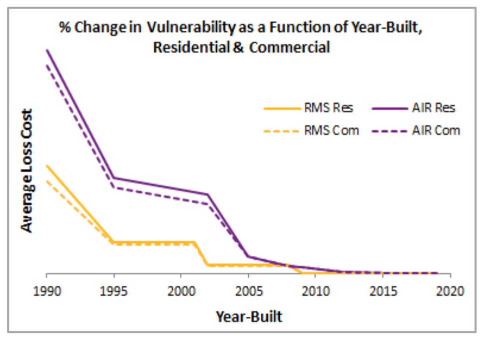
- **Year Built**

  A building's vulnerability to loss increases over time, driven by property deterioration and changes to building codes and construction practices. There is not a separate damage curve for each year of construction in either RMS or AIR. Rather, years are categorized into bands, representing periods of time when building provisions and construction practices are similar. **Below is a chart of the year-built bands in RMS and AIR applicable to the Texas region and for both Residential and Commercial business**. Note the only band that is similar across these models is the *Before 1995* band, which reflect the period before hurricane Andrew era building codes came into effect.

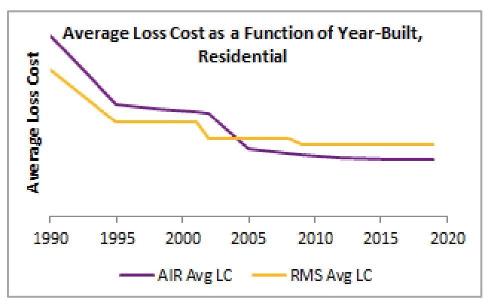
RMS Year-Built Bands	% of Total TWIA Commercial Risk Count	% of Total TWIA Residential Risk Count	Vulnerability Methodology
Before 1995	64.0%	63.2%	All structures with year built in this band have same vulnerability
1995 - 2001	8.1%	9.9%	All structures with year built in this band have same vulnerability
2002 - 2008	10.2%	14.9%	All structures with year built in this band have same vulnerability
2009 or Later	17.8%	11.6%	All structures with year built in this band have same vulnerability
Unknown	0.0%	0.4%	Vulnerability determined based on model default

AIR Year-Built Bands	% of Total TWIA Commercial Risk Count	% of Total TWIA Residential Risk Count	Vulnerability Methodology
Before 1995	64.0%	63.2%	All structures with year built in this band have same vulnerability
1995 - 2003	10.5%	14.1%	There is variation in vulnerability for each year built that falls in this band
2004 - 2012	11.2%	15.4%	There is variation in vulnerability for each year built that falls in this band
2013 or Later	14.4%	6.9%	All structures with year built in this band have same vulnerability
Unknown	0.0%	0.4%	Vulnerability determined based on model default

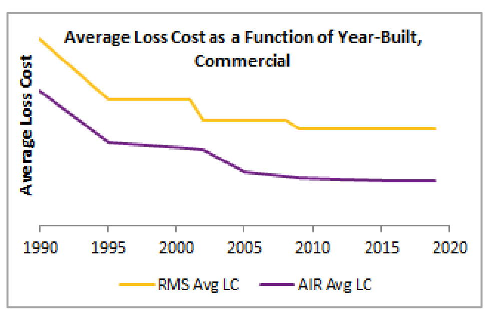
In RMS, buildings with different year-built falling under the same band will generate identical loss, all else equal. Relative to the newest year-built band, the modeled loss cost is about 100% higher for year-built *Before 1995*, 30% higher for *1995 – 2001*, and about 10% higher for *2002 – 2008*.



In AIR, all buildings belonging to either *Before 1995* and *2013 or Later* have same vulnerability within their respective band. Vulnerability to loss decreases with each newer year from 1995 to 2012, however there is a marked decrease between 2003 and 2004 which is reflected by the model's banding of the years for *1995 – 2003* and *2004 – 2012*. Relative to the newest year-built band, the modeled loss cost is about 200% higher for year-built *Before 1995,* 95% higher beginning with year 1995, and then gradually decreasing with each newer year until it stabilizes at the newest year-built band. AIR noted the gradual change to vulnerability was implemented to reflect for example, continuous changes in building construction materials and practices, code enforcement and aging.



For TWIA's residential book, a key factor in the delta between modeling results is due to AIR being much more punitive than RMS for older homes. For residential, the results from WTW sensitivity analysis shows that given TWIA mix of characteristics and dynamics of different risk characteristics at play, AIR models higher than RMS for year-built before 2004, while RMS models higher for homes built in 2004 or after. 77% of TWIA residential homes are built prior to 2004.



For commercial, WTW sensitivity analysis shows that RMS models higher than AIR across all year-built. This shows that even though AIR is more punitive than RMS for structures built before 2004, which is 71% of the TWIA Commercial book, there are other factors in the mix that could impact loss results. This includes the model's methodology for the determining vulnerability for other risk characteristics, which we will discuss further below.

Note the above bands do not apply to mobile homes. Both models use a different set of year-built bands for mobile home that aligns with the building codes and construction practices as set by the U.S. Department of Housing and Urban Development (HUD). Since mobile home business represent a tiny portion of TWIA portfolio (less than 1,000 policies), its impact to the overall TWIA modeled loss results is negligible for the purpose of this report.

- **Square Footage / Floor Areas**

As square footage of residential building increases, the mean damage ratio decreases. This is due to the size of the damage-causing corner vortex from wind not increasing proportionally with the total size of the building, which leads to smaller damage areas for larger buildings. In addition, larger homes tend to be more well-built and maintained.

Residential

RMS supports five floor area bands for residential single-family dwelling:

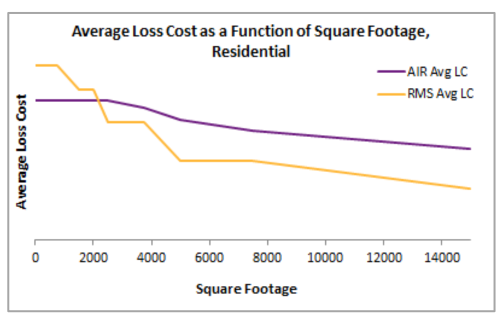
RMS Square Footage Bands	% of Total TWIA Residential Risk Count	Vulnerability Methodology
Less than 11 ft^2	3.3%	Considered to be invalid and will be modeled based on model default
11 - 1,506 ft^2	40.3%	All structures with square ft. in this band have same vulnerability
1,507 - 2,507 ft^2	41.2%	All structures with square ft. in this band have same vulnerability
2,508 - 5,005 ft^2	14.8%	All structures with square ft. in this band have same vulnerability
5,006 - 10,010 ft^2	0.5%	All structures with square ft. in this band have same vulnerability
Greater than 10,010 ft^2	0.0%	All structures with square ft. in this band have same vulnerability

Any risk that falls in the same band gets same vulnerability applied. Square footage from 1,507 – 2,507ft^2 represents RMS's view of the average size of residential homes. As the chart above shows, 41% of TWIA risk falls into this RMS default band. Between the RMS bands, homes under the smallest category models the worst, and it gets increasingly better for homes of larger size.

AIR's methodology for square footage-based vulnerability for residential business is divided into two key categories – small vs. larger homes. AIR considers homes with more than 3,000 ft^2 of livable space to be large homes. The underlying assumptions that go along with being a large home is that it is high-valued and generally exhibit higher quality of construction, engineering and better maintained. As such, large homes are less vulnerable to wind damage than smaller homes. Based on AIR's detailed study using detailed company claims data, they developed a vulnerability curve that is uniform across all homes below the 3,000 ft^2 threshold; above this, a reduction factor is applied that decreases the vulnerability to wind damage linearly with the increase in size of homes. Under AIR's methodology, 93% of TWIA residential risk is considered small and thus all get the same damageability treatment.

AIR Square Footage Bands	% of Total TWIA Residential Risk Count	Vulnerability Methodology
Less than or equal to 3,000 ft^2	92.6%	All structures with square footage in this band have same vulnerability
Greater than 3,000 ft^2	7.4%	A reduction factor is applied that decreases the vulnerability linearly with increase in size

Between the two models, AIR generally gives relatively lower credits for larger homes than RMS. The dynamic of RMS's damage function that looks more like a decreasing step function combine with AIR's damage



function that decreases more linearly above 3,000 ft^2 leads to AIR being lower than RMS for smaller homes up to around the 2,000 ft^2 to 2,500 ft^2 breakpoint based on WTW sensitivity analysis for the notional portfolio. For relatively larger homes, AIR models higher than RMS at an increasingly higher rate as square footage increases. This relationship between RMS and AIR is summarized in the chart to the right. Given that most of the TWIA portfolio has property with less than 3,000 ft^2, around where RMS models higher, yet AIR is still higher when considering the mix of all characteristics, it shows that square footage has a lower impact on losses than year-built (see year-built section above).

Commercial

RMS applies similar methodology for low rise commercial business as they do for residential, except there are fewer vulnerability banding.

RMS Square Footage Bands	% of Total TWIA Commercial Risk Count	Vulnerability Methodology
Less than 11 ft^2	9.2%	Considered to be invalid and will be modeled based on model default
11 - 2,507 ft^2	37.2%	All structures with square ft. in this band have same vulnerability
2,508 - 10,010 ft^2	40.6%	All structures with square ft. in this band have same vulnerability
Greater than 10,010 ft^2	13.0%	All structures with square ft. in this band have same vulnerability

Although AIR noted that low-rise commercial structures are generally similar to single family homes, it does not currently have a square footage-based vulnerability function implemented for commercial business. This means that the size of commercial building, regardless of how big or small, will not have a direct impact on modeled losses.

➢ Construction Type

Hurricane wind damage to building varies by construction type such as wood frame, brick veneer, masonry, light metal and others. Two of the most widely reported residential construction types in the TWIA residential portfolio are wood frame and brick veneer, while for commercial business, it is wood frame and masonry. The key difference between these construction types are the materials that provide support to the building structure against the gravity and wind loads from hurricane wind.

Construction Type	% of Total TWIA Residential Risk Count	% of Total TWIA Commercial Risk Count
Wood Frame	44.5%	51.4%
Masonry/Brick Veneer	51.3%	1.8%
Masonry	2.3%	32.7%

WTW sensitivity analysis indicates that AIR models higher than RMS for both types of constructions by about 4% for residential single-family dwelling. RMS also gives slightly more credit to a brick veneer relative to a wood frame home (brick veneer is a wood frame structure with brick cladding / wall siding).

For commercial business, the two most prevalent construction types are wood frame and masonry. Unlike brick veneer where the wood frame is actually providing the support, the material of support for masonry is of course, masonry. Masonry construction models significantly better than wood frame and this is clearly recognized in both models, although AIR gives more credit to the masonry than RMS.

➢ Occupancy Type

A model's view of building damageability can vary significantly by occupancy type. The two relevant occupancy types for TWIA are *Single Family Dwelling* and *General Commercial*.

% of Total TWIA Residential Risk Count	% of Total TWIA Commercial Risk Count
94%	6%

Overall, TWIA commercial modeled loss cost is about double the residential loss cost in RMS and approximately 80% higher in AIR. Commercial business makes up approximately 10% of TWIA's total limit but contributes 18% to gross modeled AAL in RMS and 16% in AIR. A given location with identical primary risk characteristics and coverage value will produce much larger loss if modeled as general commercial vs single family dwelling. One of the key reasons has to do with features around the building that are more prominent in commercial structures, which may include mechanical equipment, cladding materials, and more ornamentation, windows and doors that make it more prone to wind damage. A relatively small roof damage may cause big loss to the contents for commercial business. While these features are not directly captured by TWIA, the model accounts for it when they develop the damageability based on occupancy type. The models use other sources in the development of vulnerability for commercial business, including input from engineers and post disaster surveys.

TWIA does not capture detail breakdown of its commercial business by occupancy type. As such, it was modeled as *General Commercial* to reflect a mix of different types of business. However, vendor models differentiate the vulnerability among various commercial occupancy classes, e.g., retail trade, restaurants, gas stations, large commercial offices, etc. For example, in RMS, the most vulnerable commercial subtype is gasoline stations, with the least being office buildings followed by parking garages. **Modeled loss results will be more accurate for commercial business if TWIA can capture more detailed information**.

➢ Number of Stories

In general, a building's exposure to wind speed increases with the building height, however for most occupancies and for a given combination of risk characteristics, vulnerability to loss decreases with the increase in number of stories. One of the reasons is because taller buildings tend to be more engineered as they must adhere to stricter building code standards.

<u>Residential</u>

In RMS, there are different number of stories vulnerability banding based on the mix of occupancy and construction. Below is the banding for residential single family for TWIA's most dominant construction types.

RMS # Story Band	% of Total TWIA Residential Risk Count	Vulnerability Methodology
1 Story	76.2%	All wood frame, brick veneer or mansonry structures with # story in this band have same vulnerability
Greater than 1 Story	21.8%	All wood frame, brick veneer or mansonry structures with # story in this band have same vulnerability
Unknown	1.6%	Vulnerability determined based on model default

WTW sensitivity analysis in RMS suggests that relative to 1-story buildings, taller buildings model higher by about 10% and unknown story is mapped 1-story building for residential single-family occupancy.

AIR does not have separate vulnerability bandings based on number of stories for residential single-family occupancy for wind loss. This means the number of stories will not have an impact on modeled losses in AIR.

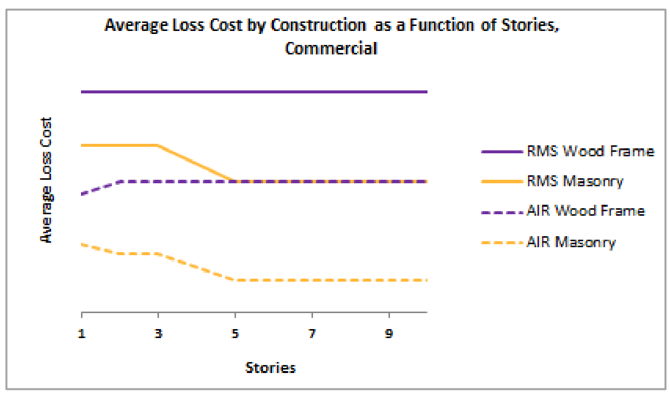
Commercial

Below is the vulnerability banding for RMS and AIR commercial business. Note the % shown in charts do not add up to 100% because we focus only on TWIA's number of stories banding for the most dominant construction type.

RMS # Story Band	% of Total TWIA Commercial Risk Count	Vulnerability Methodology
1 Story or Greater	41.9%	All wood frame/ brick veneer structures with # story in this band have same vulnerability
Unknown	11.2%	Vulnerability determined based on model default
1 - 3 Story	29.6%	All masonry structures with # story in this band have same vulnerability
4 Story or Greater	0.2%	All masonry structures with # story in this band have same vulnerability
Unknown	2.9%	Vulnerability determined based on model default

AIR # Story Band	% of Total TWIA Commercial Risk Count	Vulnerability Methodology
1 Story	25.9%	All wood frame/ brick veneer structures with # story in this band have same vulnerability
Greater than 1 Story	16.1%	All wood frame/ brick veneer structures with # story in this band have same vulnerability
Unknown	11.2%	Vulnerability determined based on model default
1 Story	25.7%	All masonry structures with # story in this band have same vulnerability
2-3 Story	3.9%	All masonry structures with # story in this band have same vulnerability
4 Story or Greater	0.2%	All masonry structures with # story in this band have same vulnerability
Unknown	2.9%	Vulnerability determined based on model default

The vulnerability of commercial building by construction, as a function of number of stories in RMS and AIR is summarized in the chart below (average loss cost on the vertical axis and stories on horizontal axis).



RMS (solid lines) considers all buildings with wood frame or brick veneer construction to experience same vulnerability for all story levels. For masonry construction, vulnerability is the same for 1 to 3 story buildings; buildings taller than 3-story modeling less by about 16%.

In AIR (dotted lines), for wood frame or brick veneer construction, the average loss cost of a 1-story building is about 7% less than a taller building, with all buildings taller than 1-story having the same vulnerability. For masonry construction, relative to 1-story building, a 2 – 3 story building models lower by about 8%, while a building taller than 3 story are less vulnerable by as much as 30%.

Between the models, RMS is higher than AIR across all number of stories for commercial book, as shown by RMS lines for wood frame and masonry being higher on the vertical axis relative to AIR lines.

Number of stories-based vulnerability is not applicable to manufactured homes, which consist of just .4% of TWIA total residential risk count, in both RMS and AIR.

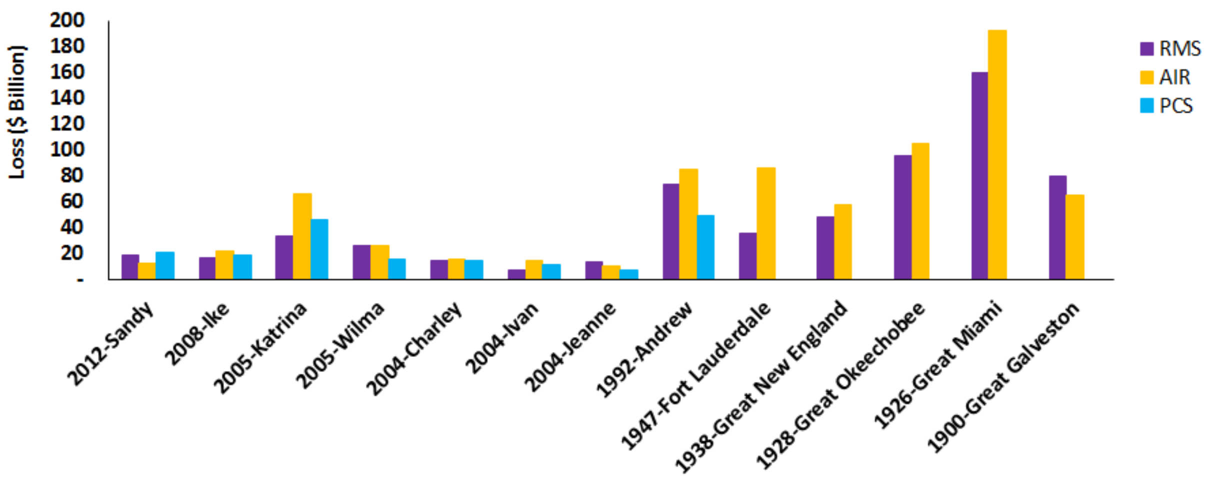
The methodologies and assumptions implemented by the models for each of the five primary characteristics as discussed above have a direct impact on the modeling loss results observed for

TWIA, particularly as it pertains to modeling differences. See ***Review of TWIA Modeled Loss Results*** section for a more detailed discussion.

Validation of Model Results against Actual Historical Losses

WTW completed a validation of the industry losses from RMS and AIR models against the actual industry losses available from Property Claim Services (PCS). As PCS provides the loss estimates at the time of hurricane, they have to be normalized to current dollars before comparing them to RMS and AIR. In order to normalize the PCS losses to current dollars, we used the approach taken by Pielke et al. (2008) which considers population change in the impacted area, inflation and wealth change per capita. **Figure 7** shows the comparison of actual PCS industry losses to RMS and AIR losses for the major historical events. PCS data was not available for some of the older storms. It is important to note that stochastic models should not be assessed purely based on the performance of a single historical event; rather it should be assessed based on a series of events.

Figure 7: Comparison of industry loss estimates for some major historical storms from RMS and AIR. The modeled historical losses are also compared with the PCS losses.



For the eight large U.S landfall events where comparisons to PCS are available, **the average difference between modeled losses to PCS is 17% higher for RMS and 31% higher for AIR**. Since PCS develops industry loss estimates based on the data collected from the insurers, there is a general perception in the market that PCS estimates might be on the lower side since not all companies may report their losses to PCS. Some of this is offset by non-modeled losses that are not considered by the models but may be included in PCS figures. On an absolute basis, RMS is closer to PCS for five of these eight events, with 2004 Hurricane Jeanne being the exception. For 2008 Hurricane Ike that made landfall in the Galveston region, RMS is approximately 10% lower while AIR is 19% higher than the PCS loss. Purely between the two models, **AIR is higher than RMS by an average of 25% for these eight historical events**, and 29% higher when including the four events where PCS historical losses are not available. This difference is consistent with TWIA current modeled loss results for hurricane, where AIR is higher than RMS by about 30% at the 100-year return period (long-term view that include each model's provision for storm surge leakage).

Review of TWIA Modeled Loss Results

Given the background to the underlying model assumptions and methodologies in above sections, the below discussion will focus on TWIA's portfolio. Specifically, we will discuss the following key topics:

1) Hurricane Near-Term & Long-Term Rates
2) Hurricane Average Annual Loss Comparison
3) Hurricane PML Comparison
4) Storm Surge
5) Loss Adjustment Expense & Reinsurance Provision

Unless specifically stated, all results discussed in this section are hurricane wind-only, including demand surge but excluding storm surge.

Before we address our recommendations, this section will provide modeling observations and assumptions directly related to the TWIA portfolio. The modeled losses below are based on WTW independent modeling, which is slightly different than results from TWIA's current broker. As stated in the Data Collection from TWIA section of this report, our starting figure for the below impact analysis is about 1.5% less than what TWIA used for the 2020 reinsurance purchase due to our adjusting building limit down to building value when the limit is higher than the value, and our exclusion of policies marked as depopulated from modeling.

Hurricane Near-Term & Long-Term Rates

For both RMS and AIR, WTW recommends the use of long-term hurricane rates in both the rate indication and reinsurance placement process (see *Model Validation, Stochastic Event Component*). A comparison of the difference between these two views in RMS and AIR is discussed below.

- RMS Near-Term vs. Long-Term Comparison

  Long term view is based on historical average of hurricane landfall. For Near-Term, RMS utilizes historical average as a baseline, however it forecasts hurricanes for the next 5-years based on the understanding that hurricanes in the Atlantic are known to follow periods of heightened or diminished activity in terms of frequency of events, intensity, and landfall frequency. **Based on public information, TWIA has used the Near-Term view since at least 2008 for reinsurance purchases and we suggest adopting the Long-Term view.**

  Comparison between these two hurricane views in RMS shows Near-Term results are slightly below Long-Term for the TWIA portfolio. WTW suggests that the RMS Near-Term view should be used mainly for sensitivity analyses.

		RMS RLv18.1 Gross Modeled Losses					
		Hurricane Near-Term		Hurricane Long-Term		Near-Term vs. Long-Term	
Critical Probability	Return Period	OEP	AEP	OEP	AEP	OEP	AEP
0.10%	1,000	$9,098,979	$9,280,506	$9,039,422	$9,224,228	0.66%	0.61%
0.20%	500	$6,654,817	$6,832,053	$6,646,747	$6,826,633	0.12%	0.08%
0.40%	250	$4,565,501	$4,732,625	$4,580,315	$4,750,745	-0.32%	-0.38%
1.00%	**100**	**$2,755,098**	**$2,874,586**	**$2,775,782**	**$2,897,604**	**-0.75%**	**-0.79%**
2.00%	50	$1,685,234	$1,780,352	$1,704,779	$1,801,756	-1.15%	-1.19%
4.00%	25	$933,072	$993,330	$946,595	$1,008,367	-1.43%	-1.49%
5.00%	20	$753,256	$802,471	$764,709	$815,279	-1.50%	-1.57%
10.00%	10	$331,818	$351,331	$338,120	$358,423	-1.86%	-1.98%
Average Annual Loss		$159,308	$159,308	$161,255	$161,255	-1.21%	-1.21%

- AIR Near-Term vs. Long-Term Comparison

Similar to RMS, the Long-Term view is also based on historical average of hurricane landfall in AIR. For Near-Term, AIR measures hurricane risk based on years in which the sea surface temperature (SST) was above the historical mean, and therefore provides a measure of expected risk for any season/seasons in which the Atlantic is warmer than average. Near-Term is often used synonymously between RMS and AIR, but technically, AIR refers to Near-Term as Warm Sea Surface Temperature (WSST) catalog of event rates.

Comparison between these two hurricane views in AIR shows Near-Term results is higher than Long-Term for TWIA's portfolio by an average of 7%. This means that relative to the historical average, the rate of hurricane landfall when based on years with warmer than average sea surface temperature (WSST) only (instead of all years) is higher by about 7%. It should be noted that AIR believes results using WSST catalog should be used as a supplement to, rather than a replacement for its Standard Event rates catalog, i.e., Long-Term view rates.

		AIR Touchstone v7 Gross Modeled Losses					
		Hurricane Near-Term		Hurricane Long-Term		Near-Term vs. Long-Term	
Critical Probability	Return Period	OEP	AEP	OEP	AEP	OEP	AEP
0.10%	1,000	$10,538,620	$10,538,620	$10,538,620	$10,538,620	0.00%	0.00%
0.20%	500	$9,069,100	$9,155,937	$9,059,212	$9,091,720	0.11%	0.71%
0.40%	250	$6,333,162	$6,601,103	$6,178,063	$6,320,512	2.51%	4.44%
1.00%	**100**	**$4,247,046**	**$4,307,255**	**$3,826,594**	**$3,999,750**	**10.99%**	**7.69%**
2.00%	50	$2,331,263	$2,477,318	$2,142,343	$2,331,263	8.82%	6.27%
4.00%	25	$1,183,998	$1,277,671	$1,089,810	$1,192,761	8.64%	7.12%
5.00%	20	$933,842	$1,017,487	$864,685	$939,418	8.00%	8.31%
10.00%	10	$359,626	$391,160	$330,912	$354,559	8.68%	10.32%
Average Annual Loss		$206,872	$206,872	$193,385	$193,385	6.97%	6.97%

Hurricane Average Annual Loss (AAL) Comparison

This section reviews the Average Annual Loss (AAL) for the TWIA book based on Hurricane Long-Term Rates, which is most relevant to the rate filings and location level expected catastrophe losses (Data Audit Report Exhibit 5) rather than reinsurance purchase and corresponding cost in fixed expenses (Data Audit Report Exhibit 11).

Below are the summarized gross modeled average annual losses (AAL) in RMS and AIR. Results are shown by county, for Commercial, Residential and Combined. Modeled loss cost per $1,000 limit insured is also shown in order to facilitate the comparison of results by region on the same basis.

- Gross AAL is a measure of the amount needed to cover loss over time, after consideration of policy limits and deductibles. Actual loss sustained for any given year may be higher over lower than the modeled AAL. A model's performance should not be judge based on whether its estimated expected loss comes close to TWIA's actual performance for any individual year, but rather over a long period of time. AAL is used in rate filings but is often ignored for reinsurance buying purposes.

- Modeled loss cost per $1,000 limit insured is defined as $1,000*(gross AAL/ total limit). It is a measure of how much loss each county is expected to sustain for any given year. For example, the gross modeled loss cost for Galveston is $3.55 in RMS and $4.82 in AIR. This means for every $1,000 limit insured, RMS expects TWIA to pay out $3.55 just to cover hurricane wind-only losses, not including loss adjustment expense; AIR expects TWIA to pay out $4.82. Counties with relatively higher loss cost are deemed riskier than those with lower modeled loss cost.

RMS Modeled Hurricane (Long-Term) Modeled Gross AAL & Loss Cost by County

Note, the AAL figures in the exhibit below are provided by TWIA, as it is used directly in the Hurricane Loss and LAE rate indications found in Exhibit 5 of the Data Audit Report.

	Modeled RMS RLv18.1 Hurricane Long-Term View (excl. storm surge)								
	Gross AAL						Loss Cost per $1K Limit		
County	Commercial	% of Total	Residential	% of Total	Combined	% of Total	Commercial	Residential	Combined
Galveston	$14,226,702	48.3%	$59,618,675	45.0%	$73,845,377	45.6%	$6.28	$3.22	$3.55
Nueces	$5,750,449	19.5%	$21,208,047	16.0%	$26,958,496	16.6%	$4.01	$2.07	$2.31
Brazoria	$1,457,235	4.9%	$16,568,400	12.5%	$18,025,635	11.1%	$3.57	$1.72	$1.80
Jefferson	$921,853	3.1%	$11,425,895	8.6%	$12,347,748	7.6%	$2.79	$1.86	$1.91
Cameron	$4,618,466	15.7%	$4,478,722	3.4%	$9,097,189	5.6%	$4.91	$2.05	$2.91
Aransas	$825,864	2.8%	$3,705,013	2.8%	$4,530,877	2.8%	$3.84	$2.37	$2.55
San Patricio	$365,239	1.2%	$3,179,005	2.4%	$3,544,245	2.2%	$3.35	$1.96	$2.05
Chambers	$169,691	0.6%	$2,314,527	1.7%	$2,484,218	1.5%	$3.11	$1.64	$1.70
Matagorda	$319,860	1.1%	$3,066,293	2.3%	$3,386,153	2.1%	$3.95	$2.82	$2.90
Harris	$173,080	0.6%	$3,166,744	2.4%	$3,339,824	2.1%	$5.01	$2.87	$2.93
Calhoun	$489,386	1.7%	$3,148,799	2.4%	$3,638,185	2.2%	$4.59	$3.56	$3.67
Kleberg	$27,325	0.1%	$267,952	0.2%	$295,278	0.2%	$2.01	$1.44	$1.48
Refugio	$63,532	0.2%	$173,582	0.1%	$237,114	0.1%	$2.70	$2.34	$2.42
Willacy	$53,800	0.2%	$217,298	0.2%	$271,097	0.2%	$3.96	$2.83	$3.00
Kenedy	$1,647	0.0%	$12,762	0.0%	$14,410	0.0%	$2.37	$2.26	$2.27
Grand Total	$29,464,129	100.0%	$132,551,714	100.0%	$162,015,844	100.0%	$4.88	$2.42	$2.67

AIR Modeled Hurricane (Long-Term) Modeled Gross AAL & Loss Cost by County

	Modeled AIR TSv7 Hurricane Long-Term View (excl. storm surge)								
	Gross AAL						Loss Cost per $1K Limit		
County	Commercial	% of Total	Residential	% of Total	Combined	% of Total	Commercial	Residential	Combined
Galveston	$19,598,002	60.8%	$80,652,773	49.2%	$100,250,775	51.1%	$8.65	$4.35	$4.82
Nueces	$5,299,838	16.5%	$27,506,251	16.8%	$32,806,090	16.7%	$3.69	$2.69	$2.81
Brazoria	$1,251,300	3.9%	$17,422,331	10.6%	$18,673,631	9.5%	$3.07	$1.81	$1.86
Jefferson	$908,703	2.8%	$13,072,112	8.0%	$13,980,815	7.1%	$2.75	$2.13	$2.16
Cameron	$3,114,923	9.7%	$3,992,197	2.4%	$7,107,120	3.6%	$3.31	$1.83	$2.27
Aransas	$768,015	2.4%	$4,195,184	2.6%	$4,963,199	2.5%	$3.58	$2.69	$2.80
San Patricio	$267,643	0.8%	$3,323,670	2.0%	$3,591,313	1.8%	$2.45	$2.05	$2.07
Chambers	$136,702	0.4%	$2,468,157	1.5%	$2,604,859	1.3%	$2.51	$1.75	$1.78
Matagorda	$241,129	0.7%	$3,103,721	1.9%	$3,344,850	1.7%	$2.98	$2.86	$2.87
Harris	$204,760	0.6%	$4,849,825	3.0%	$5,054,585	2.6%	$5.93	$4.39	$4.44
Calhoun	$334,880	1.0%	$2,847,688	1.7%	$3,182,568	1.6%	$3.14	$3.22	$3.21
Kleberg	$15,713	0.0%	$181,406	0.1%	$197,120	0.1%	$1.16	$0.98	$0.99
Refugio	$34,929	0.1%	$119,729	0.1%	$154,658	0.1%	$1.48	$1.61	$1.58
Willacy	$34,544	0.1%	$167,096	0.1%	$201,640	0.1%	$2.54	$2.18	$2.23
Kenedy	$890	0.0%	$6,086	0.0%	$6,976	0.0%	$1.28	$1.08	$1.10
Grand Total	$32,211,972	100.0%	$163,908,226	100.0%	$196,120,198	100.0%	$5.34	$3.00	$3.23

We will discuss the gross modeled AAL and loss cost for Commercial & Residential in tandem rather than separately as they have common ground in terms of frequency, regional hazard and methodology for some of the vulnerability components.

Commercial vs. Residential

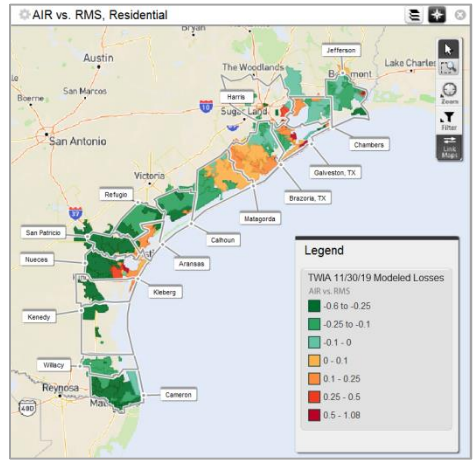
- Commercial is approximately 10% of the total TWIA TIV while driving 18% of total gross AAL in RMS and 16% in AIR. Residential makes up approximately 90% of TWIA's total business while driving 82% of total gross AAL in RMS and 84% in AIR.
- TWIA's commercial policies model significantly higher than Residential in both models. In RMS, Commercial loss cost is about 100% higher than Residential while in AIR, it is about 78% higher.
- One the key reasons for the above has to do with features around the buildings that are more prominent in commercial structures and the modeling assumptions, which may include mechanical equipment, cladding materials, and more ornamentation, windows and doors that make it more prone to wind damage. A relatively small roof damage may cause a large insured loss to the contents for a commercial business. While these features are not directly captured by TWIA, the model accounts for it when they develop the damageability based on occupancy type. The models use other sources in the development of vulnerability for commercial business, including input from engineers and post disaster survey.
- **Therefore, Occupancy type is one of the most important characteristics in the determination of modeled losses and TWIA has not captured the necessary commercial risk characteristics to appropriately model the risks with an accurate assessment of loss cost.** Given the lack of detailed location information, we modeled TWIA commercial as *General Commercial* in both RMS and AIR. However, there are 8 commercial subtypes in AIR and 9 in RMS that can be modeled if the nature of the insured business can be appropriately determined. Modeled loss results will be more accurate for commercial business if TWIA can capture more detailed information.

AIR vs. RMS Average Annual Loss (AAL) Comparison

Residential

- For the entire residential portfolio, AIR gross AAL is higher than RMS by about 24%.
- The map shows the AIR vs. RMS average loss cost comparison at the postal code level for TWIA's coastal counties, where regions with shade of green indicate AIR is lower, and orange/red shaded indicate AIR is higher.
- AIR is generally lower than RMS, except in TWIA's most concentrated territories. As you can see from the map, AIR is higher in Galveston, Brazoria, parts of Matagorda, and outermost part of Nueces counties.
- A combination of factors cause AIR to be higher for these regions:
  - In terms of frequency, AIR has higher frequency of landfalling hurricanes in these counties than RMS
  - In terms of severity, *WTW sensitivity analysis* shows that for a proforma portfolio with geographic and risk characteristics that resembles the TWIA Residential portfolio, AIR is more punitive than RMS for homes built before 2004; 77% of TWIA residential homes were built before 2004. AIR is also 4% higher than RMS for homes with wood frame/brick veneer construction; TWIA has 95% of homes with this type of construction.

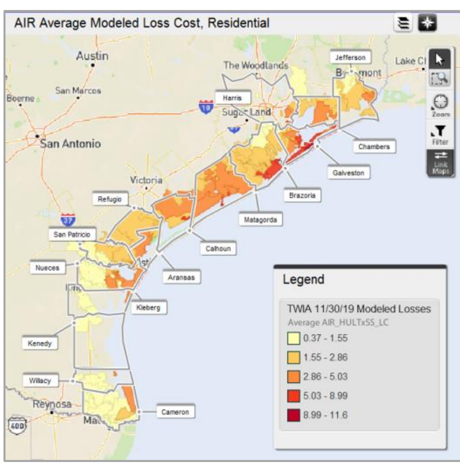
AIR vs. RMS Average Loss Cost



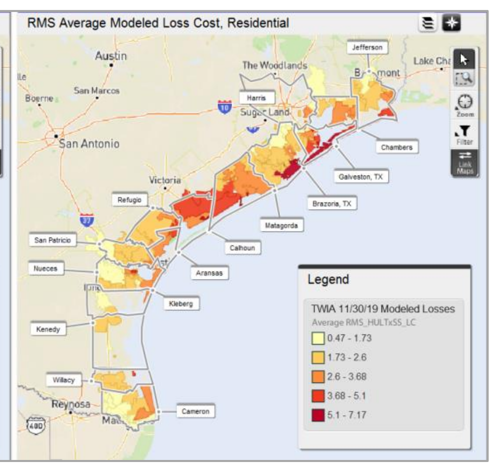
Darker green are regions where AIR is lower than RMS, while darker red are regions where AIR is higher than RMS.

- Despite TWIA's rating methodology on a county level basis regardless of distance to coast, it's necessary to review the average modeled loss cost at postal code level, whereby the average is calculated from each of TWIA's location-level results (i.e., each location have equal weight regardless of value). The color codes are unique to each map and are meant to communicate the level of variation in loss cost across regions within each model.

AIR Average Loss Cost



RMS Average Loss Cost



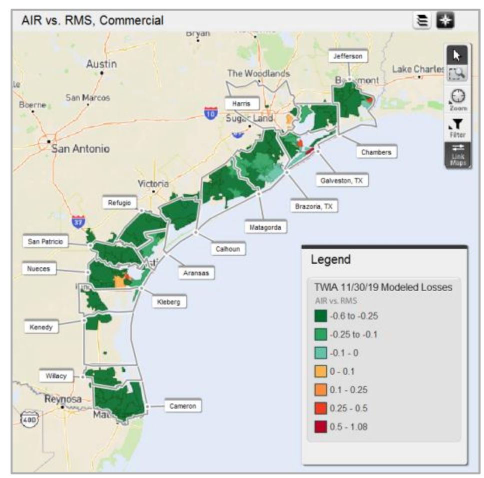
The color codes are unique to each map and meant to communicate the level of variation in loss cost results across regions within each model. Darker red color indicate region with higher modeled loss cost.

- There are variations at the postal code level in AIR and RMS beyond county level, and it is clear that both models deem postal codes in the outermost part of Galveston and Brazoria as the worst modeled regions, followed by Matagorda, Calhoun and outermost regions of Nueces and Cameron counties.

- RMS map shows relatively more variation in loss cost across counties and within the counties than AIR. For example, RMS shows the northeastern part of Matagorda with lower loss cost than the more southern region, while AIR shows more uniformity. This goes back to the methodology that was implemented for residential business (see *Vulnerability Comparison, Square Footage* section):
  - AIR building inventory, which is utilized as part of their model validation and calibration process, grouped Texas with data from Louisiana and Mississippi, while RMS treats Texas as its own region. This may have indirectly impacted the relatively less regionalization of losses observed in AIR compared to RMS.
  - For square footage, RMS has five different vulnerability bands for residential single-family dwelling occupancy, whereby there is variation in terms of damageability across each band. Homes under the smallest square footage band models the worst and it gets increasingly better for larger homes. AIR's methodology for square footage-based vulnerability for residential business is divided into two key categories – small vs. larger homes. All homes with less than 3,000 ft^2 in livable space get the same vulnerability. This means about 93% of TWIA's residential risk is considered small and thus all get the same damageability treatment in terms of square footage.
  - For number of stories, unlike RMS, AIR does not have separate vulnerability bandings based on number of stories for residential single-family occupancy for wind-only loss.

Commercial

AIR vs. RMS Average Loss Cost

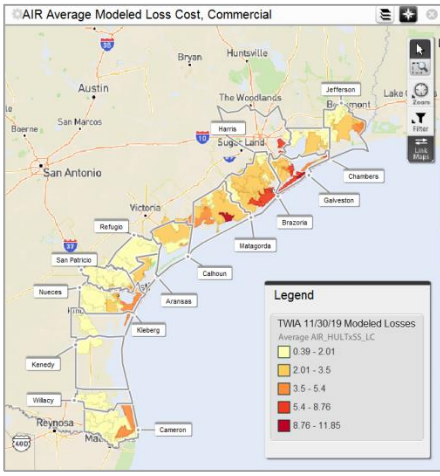


Darker green are regions where AIR is lower than RMS, while darker red are regions where AIR is higher than RMS.

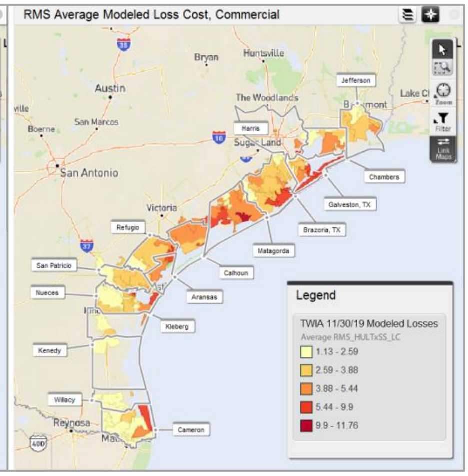
- AIR gross AAL is higher than RMS by about 9% on a combined basis for Commercial business.
- The map shows the AIR vs. RMS average loss cost comparison at the postal code level for TWIA's coastal counties; shades of green indicate AIR is lower, and orange/red shaded indicate AIR is higher.
- Although AIR is higher on combined basis, the map shows that this is driven largely from a few postal zones within the Galveston, Nueces & Jefferson counties. Everywhere else, AIR is lower than RMS for Commercial business.
- As noted under the Residential section above, AIR generally has higher frequency of landfalling hurricanes than RMS for these regions so the factor behind RMS being higher ties to the damageability component rather than frequency for Commercial.
- *WTW sensitivity analysis* shows that for a proforma portfolio with geographic and risk characteristics profile that resembles TWIA's Commercial portfolio, RMS models higher than AIR across all primary risk characteristics. There are pockets where this does not hold true, which is evident in the few postal codes noted above where AIR is higher than RMS. This speaks to the complexity of the models and the importance of having detailed location-level data, as the dynamics of different factors, including wind speeds from different stochastic events at a particular location/region can impact the loss result.

- The below maps show the AIR and RMS average modeled loss cost at a postal code level, whereby the average is calculated from each of TWIA's location-level results. The color codes are unique to each map and are meant to communicate the level of variation in loss cost across regions within each model.

AIR Average Loss Cost



RMS Average Loss Cost



The color codes are unique to each map and meant to communicate the level of variation in loss cost results across regions within each model. Darker red color indicate region with higher modeled loss cost.

- Similar to Residential risks, there are variations at the postal code level beyond county level, and it is clear that both models deem postal codes in the outermost part of Galveston and Brazoria as the worst modeled regions (and one particular postal code within Matagorda).
- RMS map shows relatively more variation in loss cost across counties and within the counties than AIR. This goes back to the methodology that was implemented for Commercial business (see *Vulnerability Comparison, Square Footage* section):
  - AIR building inventory, which is utilized as part of their model validation and calibration process, grouped Texas with data from Louisiana and Mississippi, while RMS treats Texas as its own region. This may have indirectly impacted the relatively less regionalization of losses observed in AIR compared to RMS.
  - An AIR damage function does not consider square footage for low-rise commercial structures, which is essentially all of TWIA commercial business. This means regardless of how big or small the building, it will not have an impact on modeled loss results.

Hurricane Probable Maximum Loss (PML) Comparison

Unlike the prior AAL section that is more applicable to expected loss cost per location, the below PML section is more applicable to reinsurance purchase and the resulting cost that TWIA considers as part of fixed expenses in the rate filing (Data Audit Report Exhibit 11).

Our review of the PML is on a combined Commercial & Residential basis, consistent with how it was used during the 2020 reinsurance purchase. It is based on our recommended Long-Term view, rather than the Near-Term that TWIA has been using for reinsurance placements (see ***Hurricane Near-Term vs. Long-Term Rates*** section above for comparison).

RMS RLv18 Gross Hurricane Long-Term

Critical Probability	Return Period	RMS RLv18.1 Gross Modeled Losses Hurricane Long-Term OEP	AEP	AEP vs. OEP
0.10%	1,000	$9,039,422	$9,224,228	2.04%
0.20%	500	$6,646,747	$6,826,633	2.71%
0.40%	250	$4,580,315	$4,750,745	3.72%
1.00%	**100**	**$2,775,782**	**$2,897,604**	**4.39%**
2.00%	50	$1,704,779	$1,801,756	5.69%
4.00%	25	$946,595	$1,008,367	6.53%
5.00%	20	$764,709	$815,279	6.61%
10.00%	10	$338,120	$358,423	6.00%
Average Annual Loss		$161,255	$161,255	

AIR Touchstone v7 Gross Hurricane Long-Term

Critical Probability	Return Period	AIR Touchstone v7 Gross Modeled Losses Hurricane Long-Term OEP	AEP	AEP vs. OEP
0.10%	1,000	$10,538,620	$10,538,620	0.00%
0.20%	500	$9,059,212	$9,091,720	0.36%
0.40%	250	$6,178,063	$6,320,512	2.31%
1.00%	**100**	**$3,826,594**	**$3,999,750**	**4.53%**
2.00%	50	$2,142,343	$2,331,263	8.82%
4.00%	25	$1,089,810	$1,192,761	9.45%
5.00%	20	$864,685	$939,418	8.64%
10.00%	10	$330,912	$354,559	7.15%
Average Annual Loss		$193,385	$193,385	

There are two types of PML perspectives – OEP and AEP:

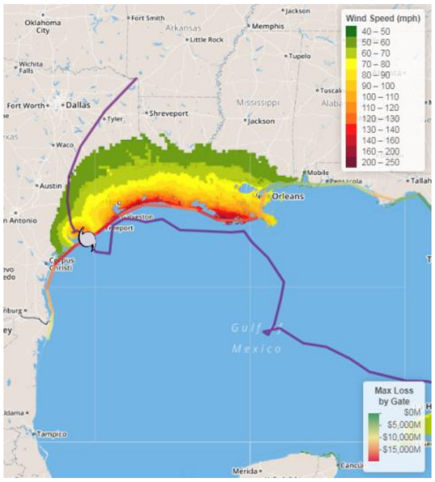
- OEP, which stands for "occurrence exceedance probability", is the probability that at least one event will occur that causes loss of at least a certain amount in any given year. This is generally used to estimate probabilities for occurrence-based reinsurance treaties.
- AEP, which stands for "aggregate exceedance probability", is the probability the sum of losses from all events will be at least a certain amount in any given year. TWIA's reinsurance program has been placed on an aggregate basis for several years, thus for the purpose of this engagement, we discuss reinsurance implications based on AEP to be consistent with what TWIA is currently using for reinsurance.

The difference between OEP vs. AEP PML depends on the peril, territory and the return period under consideration. AEP is always equal to or greater than OEP because it considers the aggregate of losses from all events in a given year rather a single event. For TWIA, the hurricane 100-yr AEP is higher than OEP by about 4 to 5% at the 100-yr return period in both RMS and AIR. The PML exhibit above shows that for return period below 100-yr, the delta between AEP vs. OEP is larger in AIR than in RMS, while for return period above 100-yr, the delta is larger in RMS than in AIR. This is consistent with what we observed and discussed under the frequency validation section, which is that AIR generates a larger rate of weaker landfalling storms than RMS, while RMS produces slightly more severe hurricanes than AIR.

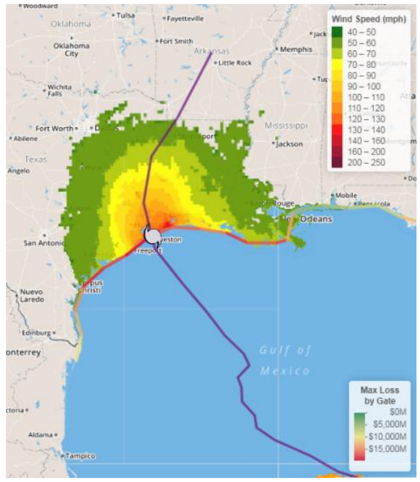
Although TWIA's 2020 reinsurance purchase is based on aggregate PML (AEP), we will focus the rest of this section discussing differences between AIR and RMS using OEP, as it allows us to focus on the key events that drive the 100-yr PML. Unlike a policy's AAL metric where the expected loss does not change because of the existence of other locations within the portfolio, the dynamics of where locations are concentrated will have a material impact on the portfolio PML. TWIA's combined gross AAL is higher in AIR by about 21% across all regions, while its 100-yr PML is 38% higher ($2.78B in RMS and $3.83B in AIR). When looking at county-level modeled loss cost, TWIA's most concentrated regions also happen to model higher in AIR.

Identifying events impacting TWIA's 100-year PML - To better understand the modeled loss results, particularly around the 100-yr PML events, we used our proprietary Willis Re application called ***Event Analyzer*** which provides an intuitive, visual and transparent approach to assessing hurricane risk for RMS and AIR. This allows for better understanding of the event characteristics (e.g., storm tracks, wind fields) and area impacted for both the historical and stochastic events. Below are samples of 3 stochastic tracks from RMS and AIR around the 100-yr PML.

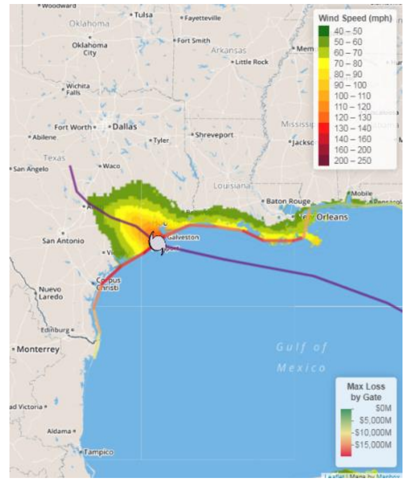
RMS Sample Stochastic Track 1: Produced gross loss of $2.76B for TWIA. Track made landfall in Matagorda as a Cat 3 hurricane with max wind speed of 118 mph.



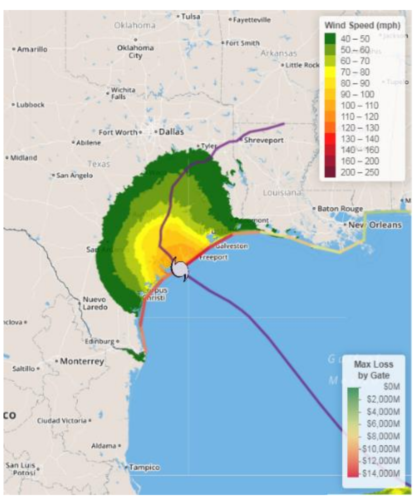
RMS Sample Stochastic Track 2: Produced gross loss of $2.78B for TWIA. Track made landfall in Galveston as a Cat 3 hurricane with max wind speed of 123 mph.



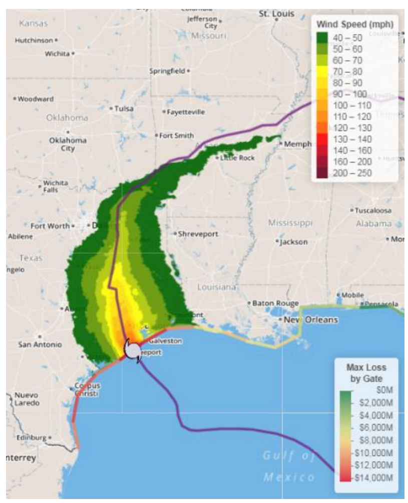
RMS Sample Stochastic Track 3: Produced gross loss of $2.71B for TWIA. Track made landfall in Galveston as a Cat 4 hurricane with max wind speed of 135 mph.



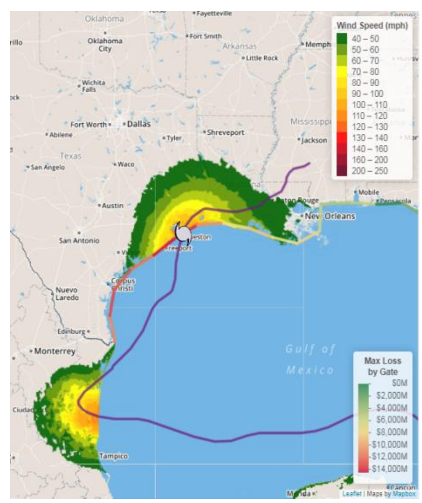
AIR Sample Stochastic Track 1: Produced gross loss of $3.83B for TWIA. Track made landfall in Matagorda as a Cat 4 hurricane with max 1-min sustained wind speed of 130.4 mph.



AIR Sample Stochastic Track 2: Produced gross loss of $3.84B for TWIA. Track made landfall in Brazoria as a Cat 5 hurricane with max 1-min sustained wind speed of 157.3 mph.



AIR Sample Stochastic Track 3: Produced gross loss of $3.73B for TWIA. Track made landfall in Galveston as a Cat 3 hurricane with max 1-min sustained wind speed of 120.7 mph.



There are few takeaways from reviewing these sample events around the 100-yr PML:

- **The type of events that can cause loss at a similar level to TWIA 100-yr PML can look very different from each other, regardless of model.** For example, a Cat 3 and Cat 4 hurricane both making landfall in Galveston produced a very similar modeled loss as seen in the RMS sample track 2 and 3 above. This is because the Cat 3 hurricane has a much wider windfield path while Cat 4 has much narrower path, thereby impacting fewer numbers of locations on its track. A similar situation is depicted in AIR sample track 1 and 2.

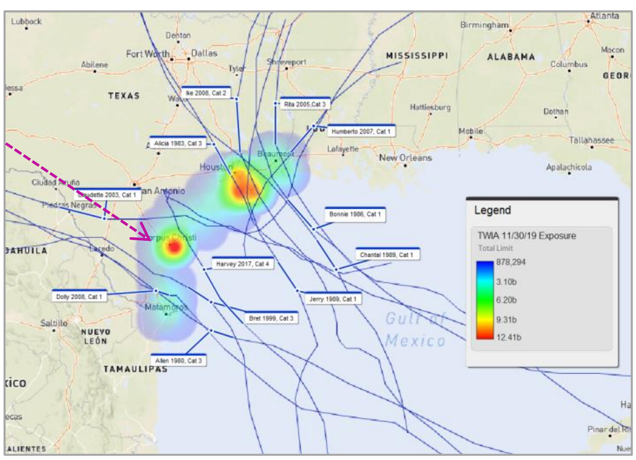
- **An event does not have to make landfall in TWIA concentrated region in order to cause a loss at the 100-yr PML level.** An example is a Cat 3 making landfall in Matagorda with a narrow wind field path that covers the entire upper Texas coastal region through Louisiana, as can be seen in RMS sample 1 track. Another example is seen in AIR sample track 1, where a Cat 4 hurricane making landfall in Matagorda with a wind field profile large enough to impact locations from more concentrated region, thereby resulting loss at the 100-yr PML level.
- The notion of a 100-yr event is not something that has absolute meaning across models. That is, the magnitude of the loss size is not an indicator of the chance of that event causing an n-year level PML to any one particular portfolio. Reference to 100-yr event (or any other target return period) is portfolio and model dependent. For TWIA's current portfolio, AIR deems a 100-yr level loss is about $3.83B while in RMS it is $2.78B. **If we put AIR's 100-yr PML against the RMS loss curve, it would equate to about a 180-yr event in RMS; an RMS 100-yr PML on AIR's loss curve would equate to about a 65-yr event**. This means, when looking at TWIA's modeled loss in the context of historical events, such as Hurricane Ike in 2008 or Rita in 2005, it is important to distinguish between impact to the industry and impact to TWIA specifically.

When managing to a 100-yr PML (or any other target return period), the focus should not be on a Cat event of a specific category or hurricanes that make landfall only in an area with the most concentration. **Rather, the risk management approach should be a holistic one that considers a range of all possible events of different characteristics, size and path which could lead to loss level around the target 100-yr return period (plus any additional non-modeled loss like LAE).**

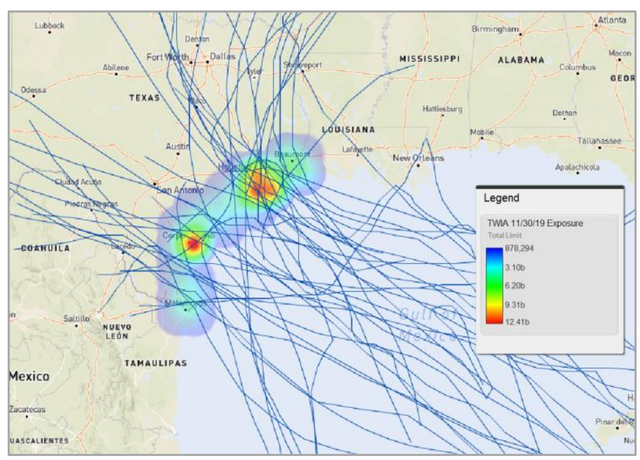
TWIA hurricane data that was provided as part of the WTW independent rate filing review only goes back to 1980. The figure on the left below shows all Texas landfalling hurricanes since 1980 overlaid on TWIA current exposure, while the figure on the right shows Texas landfalling hurricanes since 1900. It is clear that TWIA's hurricane data going back to 1980, a 40-yr time span, is not long enough to account for the chances of a hurricane occurring in different regions.

TX landfalling hurricanes since 1980 overlaid on TWIA exposure

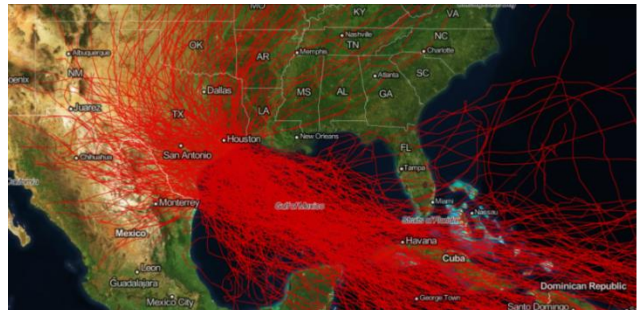
Significant underestimation of potential losses in this region if using only company data for managing / pricing risk



TX landfalling hurricanes since 1900 overlaid on TWIA exposure



Due to the infrequent nature of hurricane events, using company experience to manage or price for risk would have leave out the potential for losses in many regions, most noticeably in the concentrated Nueces region. Catastrophe models address this weakness by combining historical disaster information with current demographic, building, scientific and insurance data to determine the potential cost of catastrophes. Models are not perfect, but they are continually improving and are industry standard for use in hurricane rate filings and reinsurance purchases.



Above picture is a representation of stochastic event tracks in the model. RMS & AIR developed hurricane frequency base largely historical data, but accounts for the full spectrum of possible losses by taking into consideration hurricane paths and sizes that have not yet occurred, but could happen from a scientific/meteorological perspective.

Storm Surge

The TWIA policy covers wind-only and does not provide coverage for storm surge / flood related claims. We acknowledge the expert panel that has historically reported to TDI and TWIA on flood vs. wind claims and also acknowledge TWIA's underwriting requirement that an insured is responsible to purchase and provide a flood policy in certain FEMA zones.

Since TWIA policies are wind-only, **we recommend omitting storm surge loss cost from the TWIA rate filing**, **a new approach from prior rate filings.** This is consistent with most companies that offer wind coverage but exclude flood. In addition, it would correspond with the wind-only (ex. flood) modeled losses that guide the TWIA reinsurance purchases. The chart to the right outlines the current loss cost load in TWIA's most recent rate filing for storm surge (flood) related losses. TWIA will undoubtedly encounter flood vs. wind disputes in the future and TWIA may elect to add a non-modeled expense load, but an explicit flood loss cost should be omitted from the filing.

		Avg Load per policy for flood	
Policy	**Policy Count 12/31/19**	**AIR**	**RMS**
Residential	189,935	$ 3.45	$ 12.56
Commercial	8,674	$ 14.85	$ 61.14

The Texas statute does not prohibit TWIA from including a storm surge loss provision into the rate filings, and therefore TWIA may continue to include storm surge loss provisions. If that is the case, we offer the two below improvements in the methodology, with WTW's recommendation as item a) out of the two below options:

A. Run hurricane models with default assumptions for storm surge leakage, which essentially allows the model to determine a provision for storm surge losses on a policy that contractually only covers hurricane/wind/hail. For the TWIA portfolio, the inclusion of model <u>default</u> storm surge would add about 2.6% in AIR ($5M of AAL) and 10% in RMS ($16.3M to AAL) to the overall hurricane estimated losses (AAL).

B. Model TWIA's book assuming policies fully cover storm surge losses (100% storm surge) at county level for commercial and residential separately. Then apply a TWIA-specific provision judgmentally selected based on input from TWIA claims and legal experts to this 100% modeled storm surge losses to arrive at the incremental increase to hurricane losses due to storm surge leakage.

TWIA's current rate filing methodology is similar to option B above, but there are two fundamental errors with the current approach:

1. TWIA applies a 10% provision for storm surge leakage to a <u>modeled provision for storm surge leakage instead of applying it to the 100% storm surge</u> estimates from RMS and AIR. Since TWIA has taken the opinion to include a “flood leakage” in their historical rate filings, the approach has been inaccurate and resulted in significant underestimation of the storm surge loss provision from coverage leakage.
2. The storm surge factor in RMS and AIR has been applied across residential and commercial business as a bulk load across the entire portfolio. TWIA should apply any storm surge factor at county-level and different factors for residential vs. commercial.

Recommendation

Again, we recommend excluding storm surge cat expenses from future rate filings, however if the TWIA Board elects to maintain this expense provision, we recommend methodology A above. The financial impact would be as follows using our 75% RMS / 25% AIR weighting:

			Gross Modeled Losses								
	Critical	Return	HU xSS			HU w Default SS			Difference %		
Model	Probability	Period	Combined	Residential	Commercial	Combined	Residential	Commercial	Combined	Residential	Commercial
RMS only	1.00%	100	$2,775,782	$2,295,640	$498,113	$3,047,394	$2,488,342	$574,930	9.79%	8.39%	15.42%
RMS only	Average Annual Loss		$161,255	$131,916	$29,339	$177,590	$143,272	$34,318	10.13%	8.61%	16.97%
AIR only	1.00%	100	$3,826,594	$3,228,517	$589,596	$3,982,361	$3,371,393	$608,714	4.07%	4.43%	3.24%
AIR only	Average Annual Loss		$193,385	$162,169	$31,216	$198,360	$166,487	$31,873	2.57%	2.66%	2.10%
50% / 50%	1.00%	100	$3,301,188	$2,762,078	$543,855	$3,514,878	$2,929,867	$591,822	6.47%	6.07%	8.82%
50% / 50%	Average Annual Loss		$177,320	$147,043	$30,278	$187,975	$154,879	$33,095	6.01%	5.33%	9.31%
75% RMS / 25% AIR	1.00%	100	$3,038,485	$2,528,859	$520,984	$3,281,136	$2,709,105	$583,376	7.99%	7.13%	11.98%
75% RMS / 25% AIR	Average Annual Loss		$169,288	$139,479	$29,809	$182,782	$149,076	$33,707	7.97%	6.88%	13.08%

As you can see in the highlighted sections above, the AAL increases from $169.28M (no storm surge) to $182.78M, or $13.5 M by using model default storm surge assumptions. This $13.5M increase compares to the $1.52M that TWIA filed in the last rate filing, and while the impact by product and policy will vary, the overall portfolio average could be approximately a 3.3% increase in loss cost per policy.

Loss Adjustment Expense for the Reinsurance Provision

Given that the loss adjustment expense (LAE) for all expected loss in a year may differ from the LAE of hurricane events/catastrophic loss subject to reinsurance recovery, the approach for each scenario must be treated independently. By statute, TWIA must determine its 1-100 PML, and is permitted to establish a provision for LAE. As directed by TWIA, this section will focus on the LAE provision for reinsurance purposes and defining that PML. Please note that all LAE data in this section was provided by TWIA and in some cases will be split between “ALAE” (allocated loss adjustment expense) and ULAE (unallocated loss adjustment expense). It is our understanding from conversations with TWIA staff that LAE subject to reinsurance recover includes both ALAE and ULAE; therefore, while both will be evaluated separately, our recommendation will be the total of these two LAE components.

There are 2 widely used methodologies for determining the LAE load as respects a catastrophic event:
1. Add the LAE factor directly to the modeled event loss curve
2. A flat percentage LAE load as determined by the reinsurance buyer, which is TWIA’s current approach using 15%.

For items 1, instead of adding a fixed LAE factor on top of the PML, a carrier could load this factor directly across the entire event loss curves since LAE for a Cat 1 hurricane is different than a Cat 5 hurricane. This is our preferred method; however, it is very complex and given the nature of TWIA’s Board and stakeholders, we believe a more transparent, simplified approach is necessary.

Therefore, we recommend using item 2 above for the purposes of the TWIA PML determination. This is consistent with the current approach however; we believe refinements should be made in 2021. As you will see below, it should be first understood that a claim that is litigated does not necessarily produce a higher loss adjustment expense to indemnity ratio. Often, a litigated claim is settled for more than a non-litigated claim, and therefore the LAE ratio may be lower for a litigated claim vs a non-litigated claim.

TWIA has used 15% LAE since at least 2008. Below are TWIA's 2 largest cat events in recent years, Ike and Harvey, and the associated ALAE:

Event	Paid Loss	Paid ALAE	Indemnity Reserves	ALAE Reserves	Total Loss	ALAE / Indemnity
Hurricane Ike (2008)	2,259,462,856	182,674,241	1,500,000	436,547	2,444,073,645	**8.1%**
Hurricane Harvey (2017)	1,337,109,557	145,104,713	41,079,619	9,584,839	1,532,878,728	**11.2%**
Total	3,596,572,413	327,778,954	42,579,619	10,021,387	3,976,952,373	**9.3%**

source: TWIA, data as of August 20, 2020

As described above, TWIA incurred Indemnity loss and ALAE of $3.97B over these 2 events. For Hurricane Ike, the ALAE load was 8.1%, meaning that for each $1 of indemnity, TWIA incurred $0.08 of ALAE costs. This factor increased to 11.2% for Hurricane Harvey, and the simple average of these 2 cat events was 9.3%.

Each of these events was unique to TWIA. Hurricane Ike was pre-BH3 and it could be perceived that litigation expenses with the HB3 protections would defuse some lawsuits. Hurricane Harvey was unique with the flood ingredient, where TWIA incurred $18M of expense for claims that were closed without pay/indemnity which is generally associated with an insured needing a denial letter in order to recover insurance proceeds from the NFIP (National Flood Insurance Program).

As we look at Hurricane Ike (2008), it is important to review the LAE for claims that experienced litigation vs non-litigated claims:

Hurricane Ike	Paid Loss	Paid ALAE	Indemnity Reserves	ALAE Reserves	Total Loss	ALAE / Indemnity
No litigation	1,055,735,020	96,373,305	-	-	1,152,108,325	**9.1%**
Litigation	1,203,727,836	86,300,936	1,500,000	436,547	1,291,965,320	**7.2%**
Total	2,259,462,856	182,674,241	1,500,000	436,547	2,444,073,645	**8.1%**

source: TWIA, data as of August 20, 2020

A litigated claim doesn't always equate to a higher ALAE ratio since a litigated claim may incur a higher indemnity amount, and the balance between ALAE and indemnity can be distorted. While TWIA is more protected by HB-3 (effective 9/28/11) that may produce fewer litigated claims, it may not equate to a lower ALAE to indemnity ratio. Therefore, **we believe an ALAE ratio for Hurricane Ike of 8.5% - 9.1% is an adequate figure for future events.**

As we look at Hurricane Harvey (2017), it's important to consider the flood component as it relates to the NFIP claims handling process. An NFIP insured must obtain a denial letter from the windstorm insurance carrier in order to file a claim and obtain flood insurance recoveries. Therefore, TWIA incurred many LAE dollars in order to review the "flood" claim, possibly inspect the property, and ultimately deny the claim.

Hurricane Harvey	Paid Loss	Paid ALAE	Indemnity Reserves	ALAE Reserves	Total Loss	ALAE / Indemnity
Total ex CWOP	1,337,109,557	127,264,805	41,050,119	9,556,369	1,514,980,850	9.9%
Claims CWOP	-	17,839,908	29,500	28,471	17,897,879	60570.8%
All claims	1,337,109,557	145,104,713	41,079,619	9,584,839	1,532,878,728	11.2%

source: TWIA, data as of August 20, 2020

CWOP: "closed without pay" meaning TWIA opened a claim file, adjusted, and closed without an indemnity payment due to no coverage, the claim was below the deductible, or other reasons.

For reasons outlined above, TWIA incurred nearly $18M of ALAE for policies that did not receive an indemnity payment. If the CWOP is omitted given the uniqueness of this event, **TWIA's ALAE load for Hurricane Harvey was 10%**, meaning for each $1 of indemnity payment they paid $0.10 of LAE.

As it relates to ULAE for these events and in the case of Ike, ceded to reinsurers, we reference the August 2020 Board packet:

Hurricane (Year)	Loss	ULAE	ULAE Ratio
Ike (2008)	1,950,833,975	127,269,430	6.5%
Harvey (2017)	1,336,923,861	106,821,442	8.0%

Recommendation

LAE factors are typically determined by calculating the averages over multiple storms, however g**iven that we were only given LAE data for Hurricanes Ike and Harvey, we suggest using a factor of 17.2% loaded to the modeled losses for the PML determination. This figure is split 10.1% for ALAE + 7.1% for ULAE.**

Selection of Models for TWIA

WTW recommends that TWIA continue to utilize a multi-model approach; however, adjust the weighting from 50%/50% RMS/AIR to the below:

- Gross Modeled Hurricane Loss Ratio - **75%/25% RMS/AIR**
- Reinsurance Limit and PML determination - **75%/25% RMS/AIR**
- Modeled loss cost to reinsurance layer within rate filing - **50%/50% RMS/AIR**
  - This figure is used for the allocation of reinsurance cost, an amount determined by the reinsurance market. Since TWIA cannot control how a 3rd party reinsurer prices the reinsurance program, we believe a 50%/50% weight is a prudent long-term approach for this metric.

We believe the RMS model is a better fit for TWIA's Texas Tier I portfolio given its geographic and risk profile. For the purpose of rate filing and the 1-100 PML determination, we believe TWIA should continue to take into consideration AIR's view of risk, albeit with less weight. Although based on sound science and methodologies, there is still a high degree of uncertainty in modeled loss results from both models. Incorporating multiple views in risk management decision reduces uncertainties due to potential model change and provides a hedge against any potential unknown factors not considered in our analysis. Our recommendation is only valid when used in conjunction with our recommended use of long-term rates for hurricane modeling.

Our recommendations are based on thorough scientific and technical analysis of the models using a combination of available model documentation, direct discussions with model vendors, our comprehensive understanding of the models as the largest reinsurance broker in Texas, and our expertise and testing as discussed in the above sections. Key reasons for our selected model weights are summarized below:

- Frequency – comparison of historical hurricane frequency by cat size for Texas shows that RMS is closer to historic frequency than AIR overall.

- Severity – severity was reviewed in context of each model's method and assumptions for determining damage functions and how sensitive each model is to user input.

    - The development of vulnerability/damage function by region is more specific to Texas in RMS than AIR. While Texas is a region on its own and further categorized by inland vs. coastal in RMS, AIR vulnerability region groups Texas with Louisiana and Mississippi. This relatively more broad-brush approach also carries through in the vulnerability methodologies implemented for each of the five primary risk characteristics. For example, 93% of TWIA business residential business gets the same vulnerability treatment as it pertains to square footage. Another example, AIR does not consider number of stories for TWIA's residential business, which consist of 76%, 1-story, and 22% 2-stories (AIR does consider number of stories for commercial line).

- Overall loss validation through comparison of industry historical losses to modeled losses

    - Based on our validation of industry losses from RMS and AIR models against actual industry losses available from Property Claims Services (PCS), we found that for the eight events where comparisons to PCS loss estimates are available, the average of the difference between modeled losses to PCS is 17% for RMS and 31% for AIR. RMS is closer to PCS on an absolute basis on seven of these eight events. For 2008 hurricane Ike that made landfall in the Galveston region and had impact in Texas, RMS is approximately 10% lower while AIR is 19% higher than PCS loss. Due to limited historical hurricane to hit Texas directly, the historical losses are inclusive of other events outside of Texas region. **It is important to note that stochastic models should not be assessed purely based on the performance of a single historical event; rather it should be assessed based on a series of events.**

Given our analysis conclusion is a more favorable leaning towards RMS model for TWIA, we examined several options relative to model weightings and its impact on TWIA's 2020 view of a 50% / 50% model average. Below is the summary of the different options we looked at and its impact to the AAL, PML and ultimately indicated rate level and reinsurance cost for TWIA.

- **AAL Model Blend Variations and Impact on Rate Level**

  The gross AAL shown below for our impact analysis is from TWIA and is used in our rate indications work directly.

Hurricane Model Blend Variations and Impact on Rate Level Indications - Residential

Hurricane View	Model Blend	Gross AAL	Gross AAL + 17.2% LAE	Difference from Current Limit	Indicated Loss & LAE Ratio	Change from Current
Long Term	*50%/50% RMS/AIR*	*147,042,604*	*172,333,932*		55.6%	
Long Term	65%/35% RMS/AIR	142,504,563	*167,015,347*	(5,318,585)	53.8%	-3.2%
Long Term	75%/25% RMS/AIR	139,479,202	163,469,624	(8,864,308)	52.6%	-5.4%
Long Term	85%/15% RMS/AIR	136,453,841	*159,923,901*	(12,410,031)	51.4%	-7.6%
Long Term	100% RMS	131,915,799	*154,605,316*	(17,728,615)	49.7%	-10.6%

**TWIA currently add a 15% load for LAE to modeled result; our recommend load is 17.2%*

Hurricane Model Blend Variations and Impact on Rate Level Indications - Commercial

Hurricane View	Model Blend	Gross AAL	Gross AAL + LAE	Difference from Current Limit	Indicated Loss & LAE Ratio	Change from Current
Long Term	*50%/50% RMS/AIR*	*30,277,682*	*35,485,443*		62.6%	
Long Term	65%/35% RMS/AIR	29,996,222	*35,155,573*	(329,871)	61.8%	-1.3%
Long Term	75%/25% RMS/AIR	29,808,583	34,935,659	(549,785)	61.2%	-2.2%
Long Term	85%/15% RMS/AIR	29,620,943	*34,715,745*	(769,698)	60.6%	-3.2%
Long Term	100% RMS	29,339,483	*34,385,874*	(1,099,569)	59.8%	-4.5%

**TWIA currently add a 15% load for LAE to modeled result; our recommend load is 17.2%*

<u>The impact of this adjustment is a reduction of indicated loss & LAE ratio from current approach by approximately 5.4% for Residential and 2.2% for Commercial. Some of the reduction in gross AAL from our recommended weight mix is offset by our increase in the LAE provision.</u>

- **PML Model Blend Variations and Impact on Reinsurance Cost**

In this section we evaluate the impact of various model weights on the reinsurance limit and estimated corresponding spend as a portion of the fixed expenses section of the rate filing (Exhibit 11). Reinsurance is the single largest fixed expense item for TWIA and a notable component of the overall filing.

The modeled losses below are based on WTW independent modeling, which may be slightly different to results from TWIA's current broker. Our starting figure is about 1.5% less than what TWIA used for the 2020 reinsurance purchase due to our adjustment of building <u>limit</u> down to building <u>value</u> when the limit is higher than value; this adjustment was not done with recent Guy Carpenter modeling output. All depopulation policies were excluded.

Since the 2020 reinsurance program has already been purchased, our recommendations in this section is for the <u>2021 reinsurance program and rate indication</u>. The ultimate impact on the 2021 indications may differ from our analysis below since we were provided 2019 exposure data for modeling and are using "2019 earned premium at current rate levels". Any exposure or premium trend assumptions applied today would be less accurate than the exposure and premium trend ultimately used on updated figures for the 2021 filing. However, directionally this highlights how the reinsurance cost and resulting rate indication would change based on comparing the current 2019 methodology to our recommendations.

Please note that our engagement with TWIA for this proposal is for the hurricane peril, however in order to give TWIA a complete picture of the impact, we have included severe storm modeled loss results in figures below.

Below is an evaluation of both the current approach, 50%/50% RMS/AIR Near Term with a 15% LAE load vs the WTW revised approach of 75%/25% RMS/AIR Long Term with a 17.2% LAE load:

Current Funding Tower Limit	4,200,000,000
Reinsurance Spend[1]	102,066,436
2019 Earned Premium at Present Rates	384,669,667
Current Reinsurance Spend % Premium[2]	18.7%

Funding Tower Limit and Cost Implications for Rate Indication: Model Mix Variations

Term	AEP Hu + SCS Model Blend	1-100YR	1-100YR + 17.2% LAE[3]	Difference from Current Limit	Assumed ROL	Assumed Cost (Savings)	Revised Spend[4]	Layer AAL + 17.2% LAE[3]	Reinsurance Expense for Rate Indication	Revised % of Premium for Rate Indication	Difference from Current %
Near Term[5]	*50%/50% RMS/AIR*	*3,581,542,157*	*4,118,773,480*	*(81,226,520)*	*3.000%*	*(2,436,796)*	*99,629,640*	*31,031,745*	*68,597,896*	*17.8%*	*-0.9%*
Long Term	50%/50% RMS/AIR	3,420,698,016	*4,008,888,928*	(191,111,072)	3.250%	(6,211,110)	95,855,326	*25,663,175*	*70,192,151*	*18.2%*	-0.5%
Long Term	65%/35% RMS/AIR	3,363,518,285	*3,941,877,111*	(258,122,889)	3.400%	(8,776,178)	93,290,258	*25,143,202*	*68,147,056*	*17.7%*	-1.0%
Long Term	75%/25% RMS/AIR	3,185,707,687	*3,733,491,883*	(466,508,117)	3.600%	(16,794,292)	85,272,144	*23,246,449*	*62,025,694*	*16.1%*	-2.6%
Long Term	85%/15% RMS/AIR	3,080,485,623	*3,610,176,826*	(589,823,174)	3.700%	(21,823,457)	80,242,978	*22,079,505*	*58,163,473*	*15.1%*	-3.6%
Long Term	100% RMS	2,891,793,151	*3,389,038,580*	(810,961,420)	3.850%	(31,222,015)	70,844,421	*19,647,820*	*51,196,601*	*13.3%*	-5.4%

[1] Reinsurance spend is net of broker discount, depoulation policies and applicable commissions as stated in Indication Exhibit 11.2

[2] This figure represents the modeled AAL provided to WTW which used 50/50 RMS/AIR blend NT rates and 15% LAE load.

[3] TWIA current reinsurance is based on the modeled result + 15% load for LAE. WTW recommendation is to use 17.2% LAE.

[4] Revised spend assumes flat Broker Discount, Depopulation policies and Commissions vs Current

[5] Near Term 50/50 RMS/AIR uses the current TWIA strategy of 15% load for LAE as a baseline for comparison purposes

The impact of the WTW recommendation highlighted in grey is approximately $466M less reinsurance limit purchased, which reduces TWIA's reinsurance spend by approximately $16.8M based on our market pricing assumptions for 2021. This results in a reduction of total reinsurance expenses as a % of premium from 18.7% to 16.1%. A reduction in reinsurance cost is a direct decrease to the fixed expenses found in Indication Exhibit 11.

As previously stated, commercial policies represent 10% of the premium but 18% of the modeled average annual losses (AAL). WTW recommends that reinsurance cost should be allocated by line of business based on modeled AAL, resulting in a net reinsurance cost provision in Indication Exhibit 11.2 for Residential equal to 15.8% and Commercial equal to 17.9%. This compares to 18.7% that would be used for both lines of business under the current methodology.

Data Quality & Improvements for TWIA

Geocoding

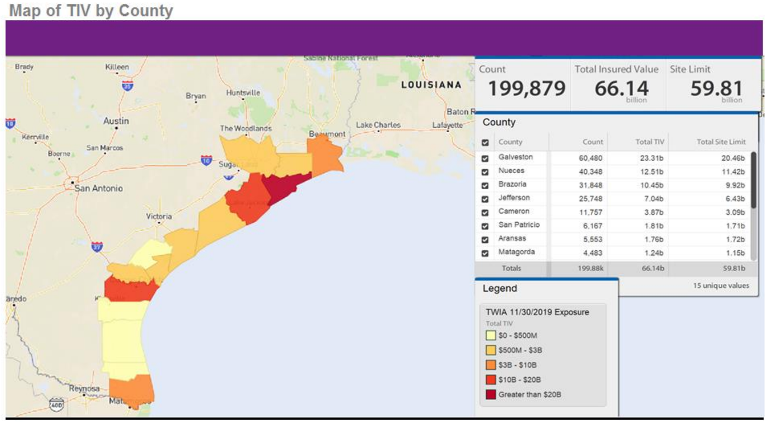
Geocoding for TWIA portfolio is approximately 89% at street level and 11% at postal code level. While the geocoding result is very good for the top four most concentrated counties (Galveston, Nueces, Brazoria, & Jefferson), there is room for improvement in counties such as Cameron, San Patricio where 100% of the risk are placed at the postal code centroid. These two counties make up 9% of total risk count. Both models assign over 15% of their respective total hurricane landfall frequency to Cameron county, so it is essential that TWIA makes effort to get street-level information for this region in order to improve the accuracy of modeled loss results. However, it should be noted that this data improvement would not likely improve TWIA's PML (modeled loss).

Figure 12: TWIA Geocoding Results and Map of Exposure by County

Geocoding Resolution by County

Reported County	Risk Count	Street Address	Postal code
Galveston	60,480	97.7%	2.3%
Nueces	40,348	98.9%	1.1%
Brazoria	31,848	99.3%	0.7%
Jefferson	25,748	99.0%	1.0%
Cameron	11,757	0.0%	100.0%
San Patricio	6,167	0.0%	100.0%
Aransas	5,553	96.7%	3.3%
Matagorda	4,483	91.8%	8.2%
Chambers	4,274	96.3%	3.7%
Calhoun	4,024	95.5%	4.5%
Harris	3,495	99.8%	0.2%
Kleberg	871	94.9%	5.1%
Willacy	405	93.1%	6.9%
Refugio	392	87.0%	13.0%
Kenedy	34	55.9%	44.1%
Grand Total	**199,879**	**89.3%**	**10.7%**

Map of TIV by County



Primary Risk Characteristics

The five primary risk characteristics considered by both models are: occupancy, year-built, construction, square footage, and number of stories. TWIA data captures all five of these characteristics. For the combined residential and commercial book, 96% of locations contain all five risk characteristics; the other 4% of the locations has a mix of known and unknown characteristics. From this perspective, TWIA data quality is very good compare to other insurance companies. However, we identified two areas captured under the reported occupancy field that can be improved within the realm of primary risk characteristics:

- **Manufactured Home Construction** – These manufactured homes (MH) can be identified in TWIA data under occupancy listed as “Manufactured Home” with construction type listed as “Not Applicable.” MH is actually classified by the models as a type of construction within the residential single family dwelling occupancy type. Therefore, it would be more technically accurate if TWIA identified MH as Residential under Occupancy, and Manufactured Home under construction. But more importantly, TWIA should explicitly differentiate whether each of the MH risk have tie-downs or no tie-downs. The difference in modeled loss results between a MH with tie-downs and a MH without tie-downs is signficant. Furthermore, the year-built for these MH was also not reported. When the presence of tie-down is not known, year-built can be used to infer whether the MH is tied-down or not based on state-level regulations. <u>MH represent just .1% of the Residential business, so this data quality issue is not going to make a big impact on TWIA PML. But if these items can be easily improved by TWIA without additional cost or much effort, it should be pursued.</u>

- **Commercial Business Occupancy** – TWIA currently capture these type of risk under the occupany field listed simply as “Commercial” and it was modeled as *General Commercial* in both models. But there are eight commercial subtypes in AIR and nine in RMS that can be modeled if there is more information about the nature of the commercial business. Below are the available options under RMS and AIR:

<u>RMS</u>	<u>AIR</u>
Temporary lodging	*Retail trade*
Retail stores and entertainment	*Wholesale trade*
Office buildings	*Personal and repair services*
Education	*Professional, technician and*
business	

Religion
Restaurants
Agricultural facilities
Gasoline service stations
Parking Garages
Health care services
Entertainment and recreation
Parking
Golf courses

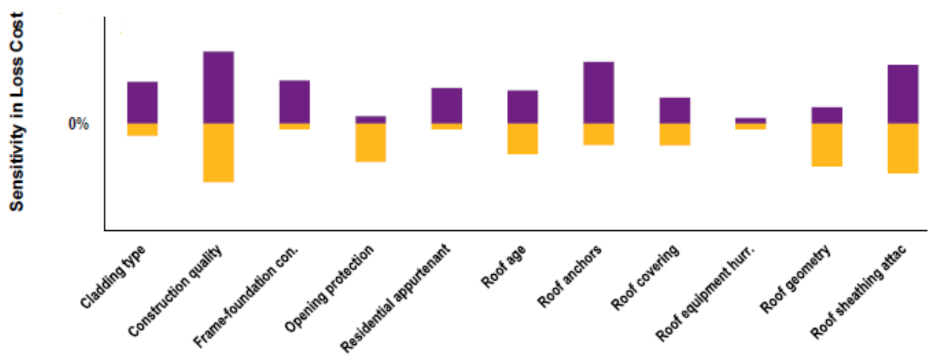
The types of business under Commercial category can be very different. For example, in RMS, the most vulnerable commercial subtype is gasoline stations, with the least being office buildings followed by parking garages. Modeled loss results would be more accurate for commercial business if TWIA can capture more detail information.

Secondary Risk Characteristics

TWIA data does not capture any secondary risk characteristics and therefore the catastrophe models assume "unknown". Secondary modifiers apply a credit or penalty to the mean damage ratio computed from a primary damage function for a particular combination of construction class, occupancy type, year built and number of stories. The magnitude of the credit or penalty is dependent on the wind speed during the event. Losses in different regions are governed by different wind speed ranges. Therefore, the same modifier could have different effects in different regions.

WTW has studied most of the secondary modifiers supported in the U.S. hurricane models from RMS and AIR in order to understand the sensitivity of losses around them. The sensitivity was calculated around the unknown characteristics of the modifier for RMS (Figure 8) and AIR (Figure 9).

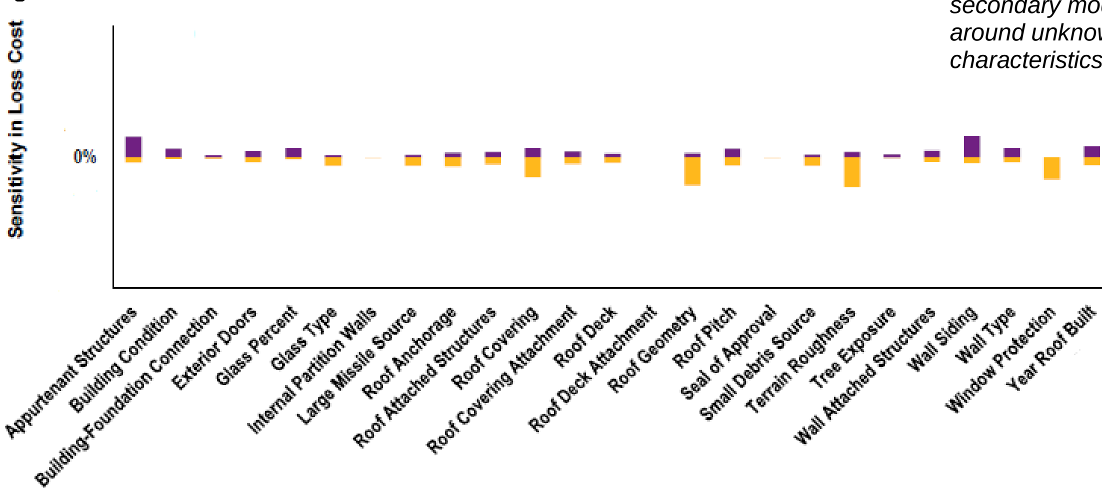
Figure 8



Sensitivity of different secondary modifiers around unknown risk characteristics in RMS

Figure 9

Sensitivity of different secondary modifiers around unknown risk characteristics in AIR



Based on the RMS and AIR charts above, it is clear that the impact on modeled losses from secondary risk characteristics is much less in AIR than in RMS. We modeled a few options for TWIA's book to understand the impact to gross modeled losses and results are discussed below. Our analysis for the *Construction Quality / Building Condition, Roof Geometry, and Roof Anchors* modifiers are meant to show the range of changes certain modifiers could cause to the loss cost, assuming all of the risk in the portfolio have that same modifier. In this regard, it is looking at the extreme end of loss increase or decrease. Our analysis for *Roof Age* and *Roof Cover* shows a more realistic assessment of potential changes to TWIA portfolio, as it considers different combination of options within the given modifier. <u>Note, TWIA as-is loss results do not reflect any TWIA data input for secondary modifiers, so the loss impact discussed here is around the model's default assumptions / weight given to different secondary modifiers when "unknown".</u>

- **Roof Age -** Roof age is a type of secondary risk characteristic that are often captured by insurance companies. The options to choose in RMS and AIR for roof age are listed as below:

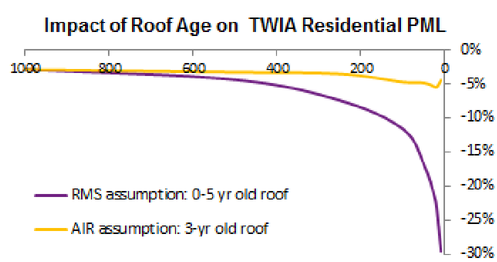
<u>RMS Roof Age</u>
- *0 - 5 years old*
- *6 - 10 years old*
needed
- *11 – 15 years old*
- *Obvious signs of duress and distress*

<u>AIR Roof Age</u>
- *AIR does not model roof age by band*
- *Actual year when roof was updated is*

We ran three scenarios on the TWIA residential portfolio for roof age to understand the sensitivity of the portfolio to roof age input and the results are summarized below:

<u>Scenario 1: Modeled all risks with roof age as *0 - 5 years* in RMS and 3-yrs old in AIR</u>

For RMS, this leads to gross AAL decrease of about 18%, with the 100-yr PML decreasing by about 12%. The magnitude of loss decrease is higher for less severe events than tail-end events, as depicted by the purple line on the right graph. This relationship recognizes that for very high severity events, the wind speed is so intense that it does not matter as much whether the roof is new or old.



Graph shows the relationship between decreases in modeled losses at different return periods

For AIR, this leads to gross AAL decrease of about 4%, with the 100-yr PML decreasing by about 5%. The magnitude of loss decrease is also higher for lower severity events than tail-end events although this relationship is significantly less pronounced than RMS, as depicted by orange line on the right graph.

Claims data from hurricane Harvey (2017) could determine which insured received a repaired / new roof which in turn would reduce TWIA's modeled loss for these locations.

<u>Scenario 2: Modeled all risks roof age as of *11 - 15 years* in RMS and 13-yrs old in AIR</u>

For RMS, this leads to gross AAL increase of about 6%, with the 100-yr PML increasing by about 3%. Similar to scenario 1 above, the magnitude of loss decrease is higher for less severe events than tail-end events in recognition that when wind speed is so intense, it matters less whether the roof is new or old.

For AIR, this leads to about 1% uniform decrease to gross AAL and all the return period losses.

At the very least, we know that 11.6% of the residential portfolio has a year built after hurricane Ike (2009 year-built in data). Again, claims data from hurricane Ike (2008, 12 yrs. ago) could determine which insureds received a repaired / new roof which in turn would increase or decrease TWIA's modelled loss for these locations (depending on the actual vs "unknown" in the model).

Scenario 3: Modeled risks with different roof age assumptions based on year-built

For this, we used the RMS assumed weights for roof age/condition when roof age is unknown and modeled based on this assumption in both RMS and AIR. The weights that RMS assigned depends on the year-built band that the location falls into; for example, more weight is assigned to roof age *11-15 years* if the construction is pre-1995 with no weights assigned to this roof age option if the year-built is post 2008. We did not use AIR assumed weight for unknown roof age because it was not made available by AIR.

For RMS, the impact to modeled losses is less than 1%, which is expected since we did used RMS default assumptions to determine the roof age for this scenario.

For AIR, this leads to about 2% uniform decrease to gross AAL, and all the return period losses.

Since we don't know the actual roof age for TWIA portfolio, the key take-away from this scenario is that a) RMS default assumptions for unknown risk characteristics are different than AIR and b) when roof age / or other secondary risk characteristics are not available, the models will still account for it by making assumptions on that "unknown" risk characteristic.

Roof Cover - Although we did not receive roof cover information from TWIA for this study, we did have access to TWIA's 2016 data (when WTW participated in TWIA RFP for reinsurance placement) which did include roof cover. This prior dataset shows that about 80-85% of TWIA has policies have asphalt shingles as roof cover. Based on this background information, we randomly assigned 80% of TWIA 2019's policies with this roof cover type, which in AIR is *Asphalt Shingles* and in RMS a comparable option of *Normal Shingle.*

This led to an overall gross loss increase of 2% in RMS and 3% in AIR. If the 80% asphalt shingles roof cover assumption still holds true in 2020, what this implies is that the underlying roof cover assumption in RMS and AIR is not too far off from TWIA portfolio.

- **Construction Quality / Building Condition -** We picked 3 options for each model to analyze this secondary modifier, but they are not directly comparable since the model options are different in RMS and AIR.

RMS Construction Quality Modifier	Gross Loss Impact
Obvious signs of deterioration or distress	60% increase
Fortified for Existing Homes, Bronze, Option 1	28% decrease
Certified design & construction	14% decrease

AIR Building Condition Modifier	Gross Loss Impact
Poor	5% increase
Average	0%
Good	1% decrease

RMS: There are nine options under this modifier to choose from in RMS that applies to wind-only losses. Six of these pertain to how the existing home was fortified. The option we show here, *Fortified for Existing Homes, Bronze, Option 1,* is defined by RMS as those with normal shingle (55 mph) roof covering and high wind nail schedule (10d nails). Other fortified options with may result in different loss impact but all fortified options lead to significant reduction to modeled losses. *Certified Design & construction* represent home designed by a certified professional engineer and inspected by certified building inspector, thus implying that the building is designed to a level that exceeds min building codes.

AIR: There are three options under this modifier to choose from in AIR and we modeled all three. The negligible change to existing portfolio results for the *Average* option indicates that this is AIR default assumption.

- **Roof Geometry -** We picked 3 options for each model to analyze this secondary modifier, but they are not directly comparable since the model options are different in RMS and AIR.

RMS Roof Geometry Modifier	Gross Loss Impact
Flat roof without parapets	13% increase
Hip roof with slope less than or equal to 6:12 (26.5 degrees)	29% decrease
Gable roof with slope less than or equal to 6:12 (26.5 degrees)	12% increase

AIR Roof Geometry Modifier	Gross Loss Impact
Flat roof	3% increase
Hip roof	19% decrease
Gable end with bracing	14% decrease

RMS: There are eight options under this modifier to choose from in RMS, all belonging to category of flat, hip, gable or braced gable roof. Hip roof is models most favorably, as seen by the large reduction to loss. The hip roof subtype we modeled here is *Hip roof with slope less than or equal to 6:12,* which is different from *Hip roof with slope greater than 6:12 (26.5 degrees).* This option would reduce loss by even more.

AIR: There are ten options under this modifier to choose from in AIR namely flat, gable, hip, complex, stepped, shed, mansard, gambrel and mansard (which in RMS would be classified as a type of flat roof without parapets). We modeled the three options that most resemble the option in RMS, but they are not directly comparable because RMS is more detailed on the type of flat, hip and gable roof.

- **Roof Anchors -** We picked 3 options for each model to analyze this secondary modifier, but they are not directly comparable since the model options are different in RMS and AIR.

RMS Roof Anchors Modifier	Gross Loss Impact
Clips	14% increase
Structural	16% decrease
Toe nailing / No anchorage	50% increase

AIR Roof Anchors Modifier	Gross Loss Impact
Clips	5% decrease
Structurally connected	7% decrease
Nails / Screws	3% increase

RMS: There are five options under this modifier to choose from in RMS; we modeled the three that most resemble the options under AIR. For example, clips and structurally anchors are comparable but nails/screws option in AIR is not comparable to RMS because RMS also group roof with no anchors with toe nailing.

AIR: There are seven options under this modifier to choose from in AIR. We modeled the three options that most resemble the option in RMS.

The result based on the TWIA portfolio again shows that impacts on modeled losses are much less in AIR than RMS. It should be noted that RMS does limit the impact of multiple secondary modifiers on the scaling of damage functions by setting a fixed percentage on losses can be reduced or increased.

Due to the unique descriptions and detailed nature of secondary risk characteristics across RMS and AIR, and the potential for a higher impact on modeled losses, we recommend modeling secondary risk characteristics as unknown unless there are clear information available about the type of risk and where to map them for modeling. Broad assumptions should be avoided.

In reviewing the options available from both models, it becomes apparent that most of the secondary modifiers are not captured by a typical insurance company. The challenges with trying to capture these types of information are that the options within a particular secondary risk characteristic are very detailed and beyond the understanding of most homeowners (unless they consult an expert) but also the options that can be modeled are not the same across the models. Two modifiers that are more commonly available from insurance companies are *Roof Age* and *Roof Cover*. Our analysis for these two modifiers, which offers an assessment of potential changes to TWIA losses based on reasonable assumptions (e.g., a mix of roof age for locations based on year-built), shows that TWIA modeled losses change by just 2 to 3% overall when modeling explicitly with these risk characteristics rather than allowing models to make default assumptions. Given that both models account for secondary characteristics using their default assumptions, we believe TWIA is not being overly penalized from a standard model view, but nonetheless, reinsurers may adjust client loss if “unknown” data is provided. However, as discussed in the next section of this document, the potential for a large portion of TWIA policies to have opening protections could favorably impact modeled loss. WTW was not given this information and therefore was unable to evaluate the potential impact. We believe the ability to capture more accurate and detailed data benefits most reinsurance buyers since reinsurers are obligated to avoid more punitive assumptions.

While the below section is outside the original scope of work, the TWIA Committee asked WTW to broadly review potential data quality initiatives.

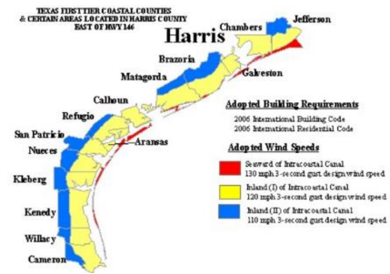
Data Quality & Wind Mitigation

Windows, doors, and other openings are all elements in maintaining the integrity of a building’s envelope and preventing losses during hurricanes; when openings fail, they allow wind and water to enter the building, creating an environment that increase the wind loads on risk elements such as the roof decking, which can lead to additional damage. According to RMS, the "weakest link" plays the key role in the performance of opening protections. The weak link, whether it is an unprotected door, window, or skylight will influence the amount of damage sustained by a building.

In order to better determine the financial impact to TWIA and its insureds, we look at the current modeling methodology by TWIA’s reinsurance broker and reinsurance partners. **TWIA staff confirmed that WPI8 and other details from an inspection report are not captured in the system (hail resistent roof, wind borne protections) and therefore, the PML is likely inflated due to this lack of data.** Further, absent this data, reinsurers likely used model “default” or “unknown” in the catastrophe models. In RMS for example, if a data field is “unknown” around opening protection, the model will assign 60% to ‘*no exterior openings have wind-born debris protection*’ and 40% to various other protections for single family dwelling built 2001 and prior. For those built post 2001, the assumption is 50%/50% respectively.

This is important because the TWIA underwriting manual, says that a property located in Seaward, Inland I, or Inland II is required to follow the 2006 IRC standards as updated by TDI and published on their website. Here is a summary of TDI’s revisions of the IRC building requirements intended to be tailored for Texas:

R301.2.1.2 Protection of openings (www.tdi.texas.gov).



- For structures located in the Inland II area as adopted by the Texas Department of Insurance, protection of exterior openings from windborne debris is not required.
- For structures located in the Inland I area, as adopted by the Texas Department of Insurance, buildings shall have glazed exterior openings protected from windborne debris.
- For structures located in the Seaward area as adopted by the Texas Department of Insurance, buildings shall have all exterior openings protected from windborne debris.

  Exterior openings shall include exterior windows, exterior doors, garage doors and skylights. Exterior opening protection for windborne debris shall meet the requirements of the Large Missile Test using either an approved impact resisting standard, ANSI/DASMA 115 or ASTM E 1996 and ASTM E 1886 referenced therein.

  There are some exception as noted by TDI, like structures located in Inland I, plywood panels are acceptable if they meet certain minimum standards (minimum thickness of 7/16 15/32 inch (12 mm) and a maximum span of 8 feet (2438 mm) shall be permitted for opening protection in one- and two-story buildings

More discussions with TWIA staff must occur, but it may be a reasonable assumption based on the TWIA underwriting requirements, that all properties located in Seaward and Inland I have some sort of windstorm protections and modeled in that manner.

It would require additional resources and time in order to properly assess the impact on TWIA's PML, but we believe **improved data or realistic assumptions on wind borne protections would reduce the PML by 15-25%**. Also, if TWIA is not currently giving this information to reinsurers, the cost of reinsurance could be artifically inflated since these wind borne protection would reduce the modeled loss cost vs using the model default view.

Claims Data

Based on our conversations with WTIA staff, It is our understanding that the current TWIA system does not connect claims information related to cat events with the policy administration system (exposure exposure database for modeling). Post event, an insurance payment is made and TWIA may not know whether that insured repaired or replaced the damaged property. As mentioned above, valuable information within the WPI compliance certificates are not captured within the policy management system. In the below example, we know the location passess the 2006 IRC standards and the Texas amendments, which examines that this location is required to carry wind borne protections for exterior openings. This type of information would decrease the loss cost for a given location, and overall would reduce TWIA's PML and reinsurance costs. On the claims side, we know this location had huricane damage from hurricane Ike (as noted) and received a new roof or repair. This is valuable information that may reduce the modeled loss for this location.

Application

Application ID	Application Date	Status	Location Code	Zone Type	Certification Date
577232	06-23-2009	Certified	Seaward	Residential	July 6, 2009

Building Standard	Building Information
SEAWARD - 2006 IRC Intl Residential Code	House

Commencement Date	Inspector type	Date of Revocation	Inspector of record
01-30-2009	Appointed Qualified Inspector		D Baggs

Inspection Type	Inspection Detail	Comments
Roof	Entire Re-Roof	DAMAGE DUE TO HURRICANE IKE.

Inspections Performed

Inspection Outcome	Design Standards	Dates of Inspection
SEAWARD - 2006 IRC Intl Residential Code		07/02/2009

The above is simply intended to offer an example of exposure and claims data issues. There are many **data extraction and artificial intelligence options** available in the market to quickly and efficiently assist TWIA in capturing additional claims and expsoure information. Willis Towers Watson already has preferred vendors identified for this project and willing to discuss solutions with TWIA at your direction.

Model References:

All WTW modeled loss references in this file used RMS RiskLink v18.1 and AIR Touchstone v7. Hurricane includes demand surge but exclude storm surge.

For AIR, *10K US AP (2019) Standard* and *10K US AP (2019) Warm SST Conditioned Hurricane* catalogs were used for losses referenced in the report as Long-Term and Near-Term respectively.

For RMS, *2019 Historical Event Rates* and *2019 Stochastic Event Rates* catalogs were used for losses referenced in the report as Long-Term and Near-Term respectively.

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Appendix I: Data Audit Report

See attached “TWIA 11-30-2019 Data Audit Report - v20200826” file.

Section 8: Future Enhancements

House Bill 3

House Bill 3 became effective September 28, 2011. This bill:

1. reduces the number of disputed claims by requiring that policyholders must request appraisal within 60 days of dispute,
2. tightens the time frame in which policyholders must report claims (one year) and TWIA must make claim determination (within 60 days),
3. removes the ability for policyholders to file lawsuits where coverage is fully accepted,
4. requires that policyholders must provide TWIA with time and information to respond and reconsider its position on the claim before instituting litigation when disputes over coverage arise,
5. provides an incentive for TWIA and policyholders to avoid further costs by implementing cost sharing provisions for appraisals or medications, and
6. limits the damages recoverable in court by policyholders.

For rate level indication purposes, this bill effectively:

1. speeds up the reporting of claims,
2. reduces the severities of average settlement, and
3. reduces LAE costs.

We have used 2010 through 2019 data to develop various LDF averages, and thus only the data for accident years 2010 and a portion of 2011 would not reflect this legislative change. To account for the changes above, we took the effective date of the bill into consideration and selected paid LDFs accordingly.

Additional Considerations

Due to either the condensed timeline associated with delivering TWIA our results or lack of data, we were unable to reflect certain immediate changes to the rate indication but present here some additional enhancements for future consideration:

1. Credibility

In the indications process, although loss volume appears relatively large for each accident year, we did not compute a credibility-weighted indicated change due to the lack of claim counts by accident year. A credibility-weighted indicated change using a claim count-based credibility standard could help improve the estimate of indicated rate need. This would affect commercial indications more than residential indications due to the smaller number of policies on the commercial side. A potential complement of credibility is the already-calculated industry loss ratios with TWIA data removed.

2. Loss Development Methods

Instead of using the chain-ladder method to develop loss development factors, alternative approaches could be considered. Due to the inception of House Bill 3 in 2011, we expect a speedup in claim reporting rates. To more accurately estimate the effect of the bill, a frequency-severity approach, which isolates the impact of the Bill to severity trends only, could be used. Only using the chain-ladder method while attempting to make use of accident year data prior to the inception of House Bill 3 may mask the true impact of the bill on loss development.

3. Capping of Non-Hurricane Large Losses

We believe that a non-hurricane loss capping procedure, combined with the introduction of a non-hurricane large loss load, would help ensure that infrequent large non-hurricane wind and hail property losses are not skewing the indication results. Removing large losses above a certain threshold and loading for them via a large loss provision could aid in producing a more accurate estimate of expected loss. This would require TWIA to produce more granular data.

Section 9: Conclusion

We believe the rate level indications included in the attached exhibits are calculated in accordance with Texas Statutes, all applicable Actuarial Standards of Practice published by the American Academy of Actuaries, and the Casualty Actuarial Society's Statement of Principles Regarding Property and Casualty Insurance Ratemaking.

The developers of the rate level indications are members of the American Academy of Actuaries and meet its qualification requirements to issue this statement of actuarial opinion.