

CHANGES IN U.S. EARTHQUAKE RISK

USGS 2014 NATIONAL SEISMIC HAZARD MAP DATA LAYERS FOR USE IN TOUCHSTONE'S GEOSPATIAL ANALYTICS MODULE

In July of this year, the U.S. Geological Survey (USGS) published an update to the United States National Seismic Hazard Maps. Updates to the maps occur on a 6-year cycle, with the last occurring in 2008. The process by which new maps are developed is open and consensus-building, with feedback on the methodology and inputs for the maps solicited from geoscientists and engineers at several regional workshops. AIR's scientists actively participated in some of the workshops leading up to the release of the 2014 maps.

In the next few months, AIR will publish an Issue Brief that will describe some of the research findings that have gone into the development of the new maps. In advance of that, however, AIR is making available three data layers for use in the Geospatial Analytics Module of Touchstone®. These layers can be analyzed against exposures to provide broad-brush insights into the directional changes of model results when the new maps are implemented in the AIR Earthquake Model for the United States. That release is currently scheduled for the summer of 2016.¹

This Issue Brief describes what the data layers represent, how to interpret them, and how they can be used in Touchstone. The data itself can be found on the USGS website at <http://earthquake.usgs.gov/hazards/products/contaminous/2014/data/>.

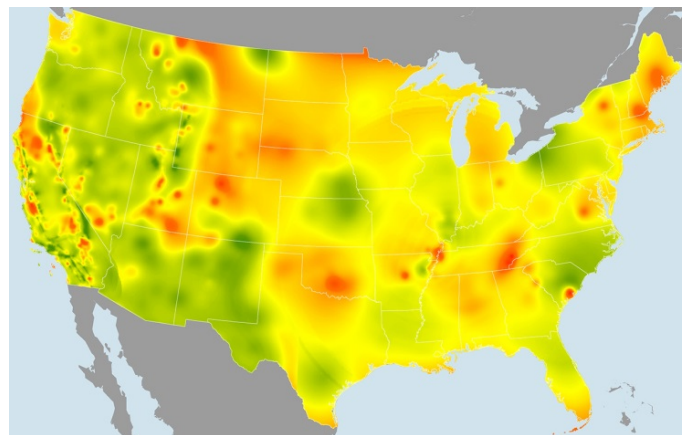
The three Touchstone-ready data layers AIR is providing are:

1. Gridded peak ground acceleration (PGA) from the newly updated (2014) maps, 475-year return period (10% in 50 years)
2. Percent change in 1.0 second spectral acceleration ($S_a[T=1.0s]$) from the 2008 seismic hazard maps, 475-year return period (10% in 50 years)
3. Percent change in 0.2 seconds spectral acceleration ($S_a[T=0.2s]$) from the 2008 seismic hazard maps, 475-year return period (10% in 50 years)

For those interested in generating their own layers, data for the 2008 maps can be found here:

<http://earthquake.usgs.gov/hazards/products/contaminous/index.php#2008>.

Again, it is important to note that comparisons between the newly released USGS hazard maps and the previous version (2008) will not directly correlate with changes in modeled loss estimates for various reasons, some of which are discussed here.



Percent change in $S_a[T=0.2s]$ (red areas show an increase and green a decrease in expected ground motions)

¹ This information is provided for information purposes only and may not be incorporated into any contract.

AT A GLANCE: THE 2014 UPDATE TO THE NATIONAL SEISMIC HAZARD MAPS

The 2014 U.S. National Seismic Hazard Maps display earthquake ground motions for given probability levels (rates of exceedance) across the conterminous United States.

The maps are important because they are applied in seismic provisions of building codes, insurance rate structures, risk assessments, and other public policy. As such, they also impact catastrophe models.

The new maps follow, in concept, the 2008 report, but put much greater emphasis on capturing the impacts of epistemic uncertainties surrounding regional hazard. The number of fault rupture scenarios in California, for example, has increased threefold and now includes extreme “black swan”-type scenarios.

In the New Madrid Seismic Zone of the Central U.S., recent findings on the geometry of seismic sources have been implemented and earthquake magnitudes from Mw 6.6 to 8.0 are considered. In the Pacific Northwest, new paleo-seismic and paleo-tsunami data are used to formulate an elaborate logic tree for the magnitudes and recurrence intervals of Cascadia subduction zone earthquakes.

The new maps also incorporate a number of recently published and region-specific ground motion prediction equations (GMPEs), weighting them with the GMPEs used in the 2008 maps.

The information here just skims the surface of the research that has gone into the development of the new maps and touches on only a few of the seismic sources that generate earthquake risk in the United States. Complete documentation can be found on the USGS website at <http://pubs.usgs.gov/of/2014/1091/>. AIR will be providing a more detailed Issue Brief in the future.

CAVEATS WHEN INTERPRETING GEOSPATIAL ANALYSIS RESULTS

It is important to note that the U.S. National Seismic Hazard Maps represent a *time-independent* view of earthquake occurrence. The time-dependent view of seismic risk for California (and the Cascadia subduction zone, which impacts California) is provided by the

Working Group on California Earthquake Probabilities and is separate from the maps. Their report is still in draft form (available at http://www.wgcep.org/U3_TimeDepPreview.)

It should also be noted that the maps and data layers provided by AIR for use in Touchstone assume ground motion on a uniform “firm rock” site condition. That is, they do not reflect local soils that may amplify or, in some cases, damp ground motion.

In addition, to fully understand changes in risk to portfolios of properties, events must be simulated that capture the *spatial correlation* in risk, which cannot be estimated from changes in hazard. When trying to translate the hazard changes reflected by the new maps to potential changes in modeled losses, users should also be aware that the AIR model implicitly takes into account the effects of site-to-site correlation of ground motion intensity measurements when estimating losses. This reflects the observation that if the ground motion is higher than expected at a particular site, it is more likely that a nearby site will also experience higher-than-expected ground motion. Addressing this correlation in the AIR model represents a departure from the USGS seismic hazard maps, which are designed to capture the hazard at any given single site; thus the USGS maps do not attempt to take ground motion correlation into account. However, such correlation has important implications for the *portfolios* of properties held by insurance providers and is thus essential to produce robust portfolio loss estimates.

The relationship between changes in hazard and losses are nonlinear as a result of complex interactions between parameters in both the hazard and vulnerability components of the model. While it is much too early to say how the AIR modeled losses will change as a result of implementing the new U.S. National Seismic Hazard Maps, the data layers being provided for use in Touchstone should offer valuable insight into broadly directional changes for different building types.

ASSESSING THE IMPACT OF THE NEW MAPS USING TOUCHSTONE’S GEOSPATIAL ANALYTICS MODULE

Considering the complex and nonlinear nature of buildings’ responses to earthquake ground motion, it is difficult to know how the ground motion changes in

USGS hazard maps will impact building damage and loss estimates without detailed analysis.

For instance, a 20% increase in the 500-year seismic ground motion intensity will not necessarily result in a 20% increase in the 500-year loss. Further, the USGS hazard maps are only available at specific return periods and will not provide complete insight into the entire exceedance probability (EP) curve—and consequently to average annual loss (AAL)—directly. Seismic hazard maps provide a “snapshot” of the overall earthquake hazard in terms of return period–based information.

Nevertheless, if the hazard significantly changes for a given location, it is expected that the risk—and losses—will also change.

CHANGES IN RISK FOR A SINGLE LOCATION

Generally speaking, it has been demonstrated that earthquake damage to low-rise buildings is more closely correlated to spectral acceleration at 0.2 seconds, Sa[T=0.2s] and that earthquake damage to high-rise buildings has a higher correlation to spectral acceleration at 1.0 seconds, Sa[T=1.0s].

The specific ground motion intensity measures used in the AIR U.S. earthquake model to predict building performance vary by construction type and height, as shown in the table below. Since the USGS hazard maps provide slightly different metrics than those considered in the AIR model, suggested equivalents are provided in the table.

Using the data layer that is most appropriate to the exposure being analyzed, the user can infer the general direction of the risk, and therefore losses, for the individual location.

Mapping of AIR construction types to USGS hazard map intensity measures

Construction Class	Height	Independent Variable	Similar Variable in the USGS Hazard Maps
Wood Frame	Low rise	Sa @ 0.3 seconds	Sa @ 0.2 seconds
Masonry	Low rise/mid rise	Sa @ 0.3 seconds	Sa @ 0.2 seconds
Masonry	High rise	Sa @ 1 second	Sa @ 1 second
Concrete	Low rise	Sa @ 0.3 seconds	Sa @ 0.2 seconds
Concrete	Mid rise	Sa @ 1 second	Sa @ 1 second
Concrete	High rise	Sa @ 3 seconds	Sa @ 1 second
Steel	Low rise/mid rise	Sa @ 1 second	Sa @ 1 second
Steel	High rise	Sa @ 3 seconds	Sa @ 1 second
Mobile Homes	N/A	PGA	PGA
Industrial Facilities	N/A	PGA	PGA
Infrastructure	N/A	PGA	PGA

(Continued)

CHANGES IN RISK FOR A PORTFOLIO

While the updated hazard maps can be used to anticipate changes in risk for a single asset at a given location, anticipating changes for a portfolio is much more difficult. For a single asset, the vulnerability is generally described with a single average damage function conditioned on the ground motion intensities at a single site, and the potential direction of the change in risk is more apparent.

For a portfolio, in which the vulnerability may be described by hundreds of different damage functions conditioned on ground motion intensities at hundreds of different sites, the potential direction of the change in risk is much more difficult to infer.

Nevertheless, it is recommended to consider spectral acceleration at 0.2 seconds, $Sa[T=0.2s]$, for homeowners portfolios and spectral acceleration at 1.0 seconds, $Sa[T=1.0s]$ for portfolios dominated by mid- and high-rise buildings as the ground motion metrics when assessing changes in risk.

Using the appropriate data layer, the user can overlay their exposure on the change in hazard to assess total insured value in areas where the hazard is increasing or decreasing. You can also leverage Touchstone's financial module to run a geospatial analysis based on exposed limits.

In general, based on changes in the USGS hazard maps at the 475-year return period (i.e., 10% in 50 years), we expect that the loss estimates in this range of the EP curve would tend to decrease in areas of eastern South Carolina and eastern North Carolina. An increase in loss estimates (in the same portion of the EP curve) is expected in parts of Oklahoma, the Northeast, east Tennessee, southern Utah, Colorado, Wyoming, the Seattle area, and northern California. In other areas, the changes in the new seismic hazard maps are more subtle or complex and it is therefore more difficult to predict the direction of changes in the loss estimates in these regions.

LIMITATIONS

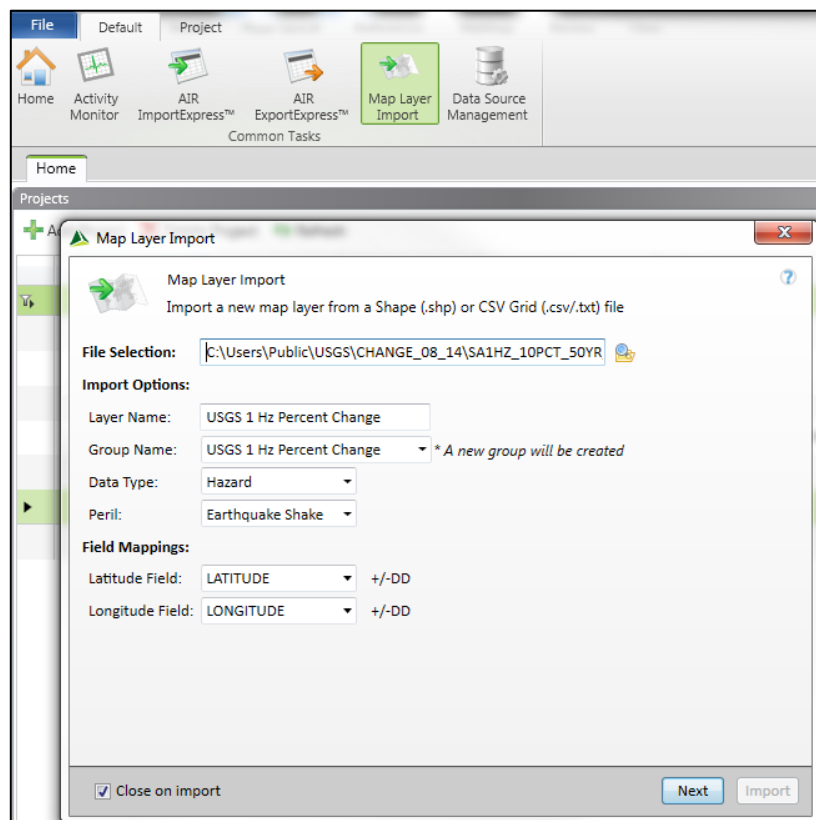
As noted above, there are several challenges in anticipating the change in risk while only considering the changes in the USGS hazard map. Model updates are subject to several refinements in addition to the consideration of updates to the general hazard—including possible new methods to calculate the local intensity, potential new data sets to characterize the site conditions, and more importantly, potential updates in the vulnerability relationships. Furthermore, the models undergo a rigorous calibration process after these refinements are included. Thus, the true change in the risk can only be assessed from the results of the updated model.

APPENDIX: USING THE USGS HAZARD MAP LAYERS IN TOUCHSTONE

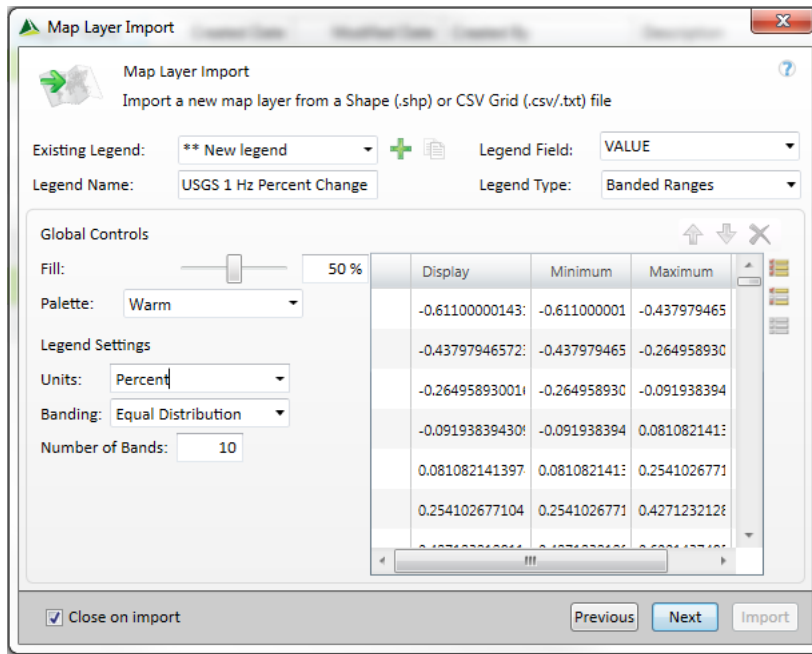
IMPORTING INTO TOUCHSTONE AND CONDUCTING A GEOSPATIAL ANALYSIS

1. Select Map Layer Import from the Default tab in Touchstone.
2. Under File Selection, change the file type to Comma Separated Grid File and navigate to the 1 Hz Percent Difference csv file. Specify a Layer Name and a Group Name unique to the layer. In this case, Group Name and Layer Name may be set to the same value.
3. Select Hazard for the Data Type and Earthquake Shake for the Peril. Set Latitude Field to "LATITUDE" and Longitude field to "LONGITUDE." Click Next.

NOTE: Because the percent difference maps are measuring the percent change from 2008 to 2014, this guide describes importing the layers with the Hazard Data Type, and Damage Ratios will be unavailable. While a 25% increase represents increased risk, it would not be meaningful to apply Damage Ratios uniformly based on the percent change, as a 25% change in acceleration for a low risk area represents less of an absolute change than a 25% change in a high risk area.



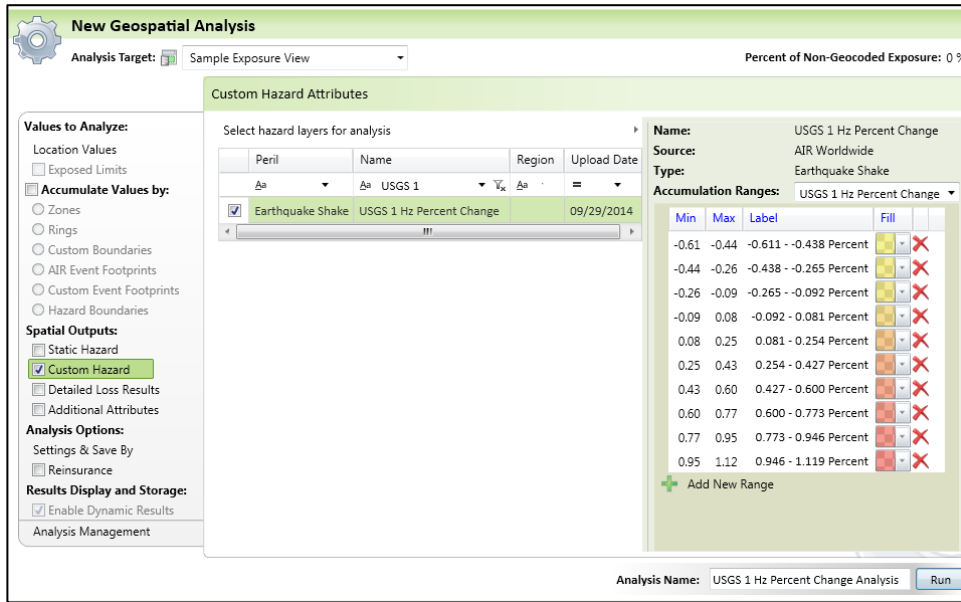
4. Create a new legend by clicking on the green "+." Set the Analysis Field to "VALUE," the field in the Comma Separated Grid File that corresponds to the percent change, and then set the Legend Type to Banded Ranges. The default option for segmenting Banded Ranges legends is Equal Distribution. This divides the range of attribute values into equal-width ranges based on Number of Bands.
5. For units, click inside the dropdown and type "Percent," accept the default values for Number of Bands and the Legend Display, Minimum, and Maximum values.



6. Click Next to review your import options and then click Import. To check the status of the import job, open or refresh the Activity Monitor. When the activity status is updated to “Complete,” navigate to your Project Data and click on the green refresh icon.

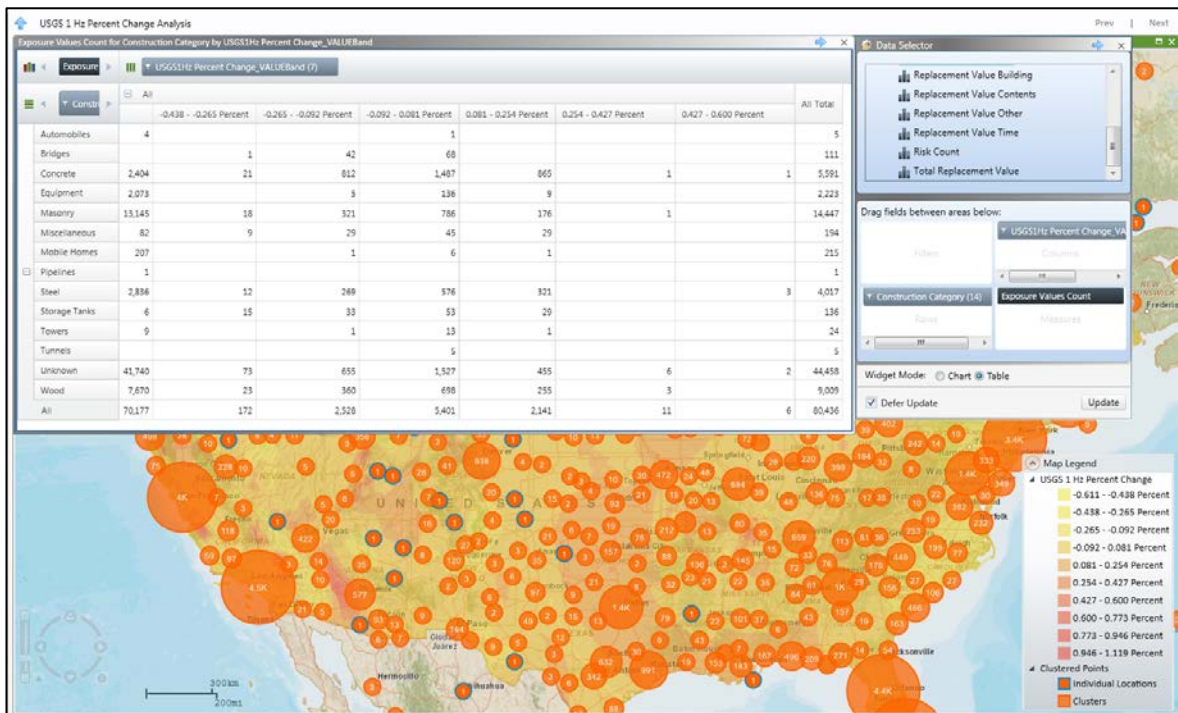
USING THE LAYER IN A GEOSPATIAL ANALYSIS

1. After refreshing your Project Data, highlight the desired Exposure View and under New Analysis select Geospatial.
2. Specify the parameters for your analysis. In this case, we are only using the new Hazard layer, so the box next to “Accumulate Values by” has been unchecked. This will disable some financial options that are not possible when no losses are generated and will turn on “Enable Dynamic Results” by default.
3. For this analysis, exposures will be summarized by the legend categories for the new Hazard layer, which is available under “Custom Hazard.” for the USGS Hazard layer. Check the box next to “Custom Hazard” and then check the box next to the new USGS Hazard layer. If multiple Hazard layers have been loaded, it is possible to include multiple Hazard layers in a single analysis. To quickly find a layer, it is possible to filter by each layer’s Peril, Name, Region, or Upload Date. It is also possible to combine a Spatial Output analysis with any of the options from “Accumulate Values by.”
4. Specify the database where your results will be saved and run the analysis.



- To check the status of the Geospatial Analysis, open or refresh the Activity Monitor. Once complete, navigate to your results to view the USGS Hazard layer in the Interactive Browser. Right click and select Advanced Table. In the Data Selector, you can choose the fields most relevant to your analysis. In this example, the legend categories are selected as columns with Construction Code values as rows. We can see the number of risks that fall within each band, broken down by Construction Code. Note that only legend categories containing risks are displayed in the table.

NOTE: When no “Accumulate Values by” options are selected, you will see the status “Completed with exceptions.” This message indicates that no losses were generated, because no exposures fell within a layer that had damage ratios applied. Spatial results, including the layer band into which each exposure fell, have still been generated.



OTHER ANALYSIS OPTIONS

Geospatial Analytics in Touchstone enables analysts to create unique, specialized, and varied views of their risk. This guide has demonstrated the use of USGS data as Hazard layers with the default 10 Band legend; however, these steps could be altered to enable even more analyses, for example:

1. For a more detailed analysis, repeat the import using more bands. If the default 10 bands are not providing the granularity, increasing the number of bands will cause the range of values in each legend category—and therefore in the analysis—to be smaller. You can also define your own classes by manually adding the number of bands and setting the desired class ranges.
2. For an overview analysis, import the percent change maps using only two bands, one with a maximum value of 0 and the next with a minimum value of 0. This would enable an analyst to quickly identify areas that have either increased or decreased in risk, and identify exposures that may need a more detailed investigation.
3. For the PGA Layer, import the data set using the Boundary Data Type. This will enable damage ratios by PGA band, allowing an analyst to accumulate losses by PGA band. In this case, when setting up a Geospatial Analysis, be sure to turn on “Enable Dynamic Results.”
4. NOTE: When using an Accumulation layer, double-check the options on the left make sure to Enable Dynamic Results is turned on to enable the Interactive Browser for accumulation results.
5. For a broader analysis, repeat the Geospatial Analysis and select other Geospatial Layers. This would enable an analyst to explore the spatial relationships between their exposure data, USGS Earthquake Hazards data sets, AIR Layers like Soil Type and Fault Lines, and any additional layers the analyst has loaded to Touchstone.
6. To explore results by a particular area, filter the analysis results, by exposure location, legend category, or by using the map drawing tools to draw spatial filters directly on the map.

For more information on setting up and working with the results of a geospatial analysis, please refer to the [Using Geospatial Analysis in Touchstone Version 2.0](#) guide on the AIR Client Portal.

ABOUT AIR WORLDWIDE

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