Challenges in Achieving Hurricane Resiliency for Critical Infrastructure

Bill Read

Former Director, National Hurricane Center

Senior Fellow, Stephenson Disaster Management Institute

Introduction

The word “resiliency” has gotten a lot of usage of late, particularly when in reference to recovery from disaster. Resiliency means different things to different people. The Oxford Dictionary defines resiliency as:

1. The ability of a substance or object to spring back into shape; elasticity: ‘nylon is excellent in wearability and resiliency’

2. The capacity to recover quickly from difficulties; toughness: ‘the often remarkable resiliency of so many British institutions’

The Merriam-Webster Dictionary is similar:

1. ‘the ability of a body to regain its original size and shape after being compressed, bent, or stretched: ELASTICITY’

2. ‘the ability to recover from or adjust to misfortune or change’

The National Academy of Science (NAS) defines resilience as:

“One way to reduce the impacts of disasters on the nation and its communities is to invest in enhancing resilience--the ability to prepare and plan for, absorb, recover from and more successfully adapt to adverse events.” Disaster Resilience: A National Imperative, National Academies of Science, 2012

For the purposes of this paper, I will use the NAS definition.

Tropical meteorologists’ ability to provide forecasts and warnings in advance of land falling tropical cyclones has increased significantly since 1990. As the graph (Fig 1) shows, we currently provide a track forecast that is more accurate at 72 hours than it was at 24 hours in 1990. While forecasting the strength of hurricanes has not enjoyed the same level of success,
focused research is showing much promise for the coming decade. The impacts from tropical cyclones; storm surge, destructive winds, and flooding rains, are forecast with more accuracy now due to advances in computing technology and better observing platforms such as satellites and Doppler radar. In 1990 the communication of warning information was primarily through broadcast media while bandwidth of communication systems limited the amount of information that could be shared in real time. Today, thanks to exponential improvement in bandwidth, the internet, and new communication technologies, most people have access to the full complement of weather information needed to make an informed decision concerning their risk.

My concern is that in spite of the gains in forecasts and warning communication, the cost of hurricanes in terms of economic losses has risen exponentially (Fig 2). Further improvements in forecast and warning for hurricanes will likely improve response time for evacuation and preparation, which should continue to reduce the loss of life and injury from storms. However, I contend that these expected improvements in forecasting will do little or nothing to reduce the economic losses due to hurricanes. The resiliency issue, as I see it, is societal – a people problem. We insist on building in higher risk areas using methodologies not suited for the attendant risk.

The increasing losses due to hurricanes directly parallels societies’ shift to living near the coast. Census data shows the fastest growing counties are on the immediate coast or the next county inland. There are perhaps many reasons for this migration, jobs and retirement living being the two most significant. I myself have lived in and continue to live in a coastal location because of employment opportunities. Numerous demographic studies forecast this coastal migration to continue unabated as industry and the surge of retirees from us baby boomers lead the way.

Add to the growth in population the increasing size and value of homes, and therefore the possessions, and it is not surprising to see the almost exponential increase in decadal losses shown in the chart. The last factor, and one I’ll focus on, is the lack of resilience in our development along the coast. To be truly resilient, I would hope our land use and building practices would work to reduce the risk and loss caused by hurricanes.
Figure 1 Official verification of Tropical Cyclone track forecasts by NHC

Societal issues will become more complex

- Denial
- Population Growth
- Urbanization of coastal regions
- Land use and building code issues

Figure 2 Damage analysis since 1900
Lessons not learned

Since Columbus warned the Spanish Governor on Hispaniola in 1502 not to put the fleet to sea as he saw a hurricane approaching, a “lessons taught but not learned” mentality has reduced societies’ ability to deal with the storms. The Governor ignored Columbus’ warning, the fleet sailed - the fleet sank. Each storm that makes landfall provides insight as to what failed and what worked for the communities impacted. Bookshelves are filled with “lessons learned” studies written after a significant storm. While some of the lessons taught evolve into lessons learned, many are not, therefore are lessons not learned. A few recent examples illustrate the point.

Hurricane Hugo destroyed the barrier island communities on the South Carolina coast near Charleston. Local and state officials stated immediately after surveying the damage “we should not rebuild on the barrier islands.” That lasted less than a year and now the islands off SC are heavily developed, only this time with even more expensive property. I have seen this rush to rebuild before. Nearly everywhere the truly resilient action never happens after a big storm strikes. Communities nearly always rebuild in place and often more expensively. Hugo also taught that big growth requires more robust evacuation planning. While SC improved evacuation plans, subsequent storms like Opal, Katrina and Rita exposed how other communities don’t have robust evacuation plans.

Hurricane Andrew went through southern Miami-Dade County in 1992 destroying most structures in the path of the eye wall. After studying the damage, officials concluded “our building codes and enforcement are inadequate in hurricane risk areas.” Miami Dade County incorporated a robust high wind building code to become more resilient. Unfortunately, few communities in the rest of Florida or in other states have followed suit. Also, in spite of repeated efforts to educate people otherwise, many who went through the fringes of Andrew think they survived a Category 5 event. This false notion happens with most major landfalls and leads people into not taking enough precaution when the next “big one” comes.

Tropical Storm Allison stalled over the Houston area in June, 2001. The flooding from heavy rain was severe, ranging from about a 100 year event in the Medical Center area to a 500 year event over much of Harris County northeast of downtown Houston. The world class Texas Medical Center was flooded and came close to being unable to perform its mission. Waste water treatment plants, all built above the 100 year benchmark, were flooded, spewing sewage into the bayous and Galveston Bay. The lesson – use of the 100 year benchmark leaves critical infrastructure vulnerable to flooding at a higher risk than most people think. Planners addressing the issue recommended higher elevation standards for critical, must-have systems like hospitals, utilities, and hazardous material operations. While the medical center mitigated
the flood loss, the metropolitan area is still highly vulnerable to excessive but common tropical rainfall.

**Hurricane Rita** in September, 2005 exposed the flaws in evacuation plans and land use policy for the coastal areas of southeast Texas. The evacuation was the “disaster within the disaster” of the hurricane. Our highways could not handle rapid evacuation of millions of people, and they will not be able to for the foreseeable future. The lesson taught was that significant public infrastructure is not designed to handle the crisis of an evacuation. Nursing homes, assisted living communities and health care facilities should not be built in evacuation zones or be built to be safe and self-sufficient to allow the residents to remain rather than evacuate. While better evacuation plans are now in effect, building of these facilities in evacuation zones continues unabated. They are only built to existing code – and to the 100 year flood benchmark, therefore requiring evacuation. Evacuating a nursing home or hospital is extraordinarily complex. The more facilities there are in evacuation zones, the harder it will be to succeed in evacuating the residents. With the aging of baby boomers, this issue will only get more challenging with time.

**Hurricane Ike** –in September, 2008, brought significant storm surge to the Galveston Bay area. Given the historical surge events – 1900, 1915 and Carla, 1961, this area should have been resilient to Ike’s surge. However, other than the construction of the Galveston and Texas City sea walls, none of the lessons of the past were followed and tens of thousands of houses and businesses were flooded. Ike’s lesson is that it could have been much worse. If Ike had been only slightly stronger and made landfall just 20 miles west of where it did, the very critical port of Houston, the 250 ship channel petrochemical plants, the NASA Johnson Space Center and nearly 100,000 homes and small businesses would have suffered catastrophic flooding from surge. Houston area plants produce 40% of all base petrochemical products in the USA. Loss of petroleum products would have deeply aggravated the Great Recession, which began with the financial crisis the day after Ike. I was specifically asked by President Bush about Ike’s impacts to the Ship Channel industries the morning after landfall (FIG 3). While there has been considerable talk about building flood barriers, virtually nothing has changed in the six years since Ike to make the Galveston Bay area more resilient.
And lastly we had Sandy in 2012, destroying property all along the New Jersey and New York coast lines. Sandy exposed just how vulnerable coastal areas are, especially when the historical frequency of hurricane strikes is quite low. It is too soon to know if any lessons taught by Sandy are being followed. My guess is much of the shore communities will be rebuilt as they were, setting the table for the next big hurricane, which won’t be anything like Sandy.

**Status of Resilience for Hurricanes**

Looking at the last, and in my opinion, most important, part of the NAS definition of resilience, “more successfully adapt to adverse events”, the opportunities are almost limitless. Ideally, our coastal counties should limit placing critical infrastructure in storm surge risk areas. If we keep building to the 100 year event, the ability to meet the other aspects of resilience, prepare, plan, absorb, and recover from major hurricanes, will become increasingly costly and difficult, which is the opposite of our definition of resilience. Moving away from the 100 year risk benchmark toward, for example, a 500 year benchmark would protect for all but the most extreme events. The 500 year benchmark would lead to fewer people needing to evacuate, a safer environment for critical health care facilities, and lower risk to essential utilities and industries. Pre-existing properties should consider the economics of elevation increase to the 500 year event. However, because we are already heavily invested in using land in the 100-500 year flood risk areas, I see no willingness to retreat. An alternative step toward resilience would be to require flood insurance for mortgages on properties up to the 500-year event elevation. By extending
actuarial reasoning, the cost to homeowners in the 200-500 year risk areas would likely be reasonable, much like fire insurance is today.

Many states have insufficient building codes with respect to wind. The engineering profession knows how to economically build homes capable of withstanding winds in excess of 120 mph. By building to a standard equivalent to the risk, we can reduce the wind losses following a hurricane. Moreover, having housing stock that can survive a major hurricane provides a safe haven for the residents along with a quicker recovery. At a minimum, all coastal health care facilities, critical public safety facilities and hazardous material facilities need to be built to withstand a probable maximum wind.

Transportation systems are not keeping up with population growth in the coastal areas. This in turn increases the clearance time required for a successful evacuation. The evacuation clearance time for the Houston Galveston area was estimated to be around 24 hours for a major hurricane in 1990. Today it is likely more than 48 hours. Without taking action concerning land use, building codes, and transportation systems, the lead time will only get longer. At a certain point, we reach a lead time so far in advance that many if not most people will delay action, waiting for more certainty of the event happening to them before taking on the onerous task of evacuation.

There are many challenges to adopting resilience standards relative to the hurricane threat. Key leadership organizations, perhaps Chambers of Commerce, for the most part, resist any restrictions to growth or perceived cost increases to building. Elected officials tend to be unaware of just how much at risk their communities are unless, of course, they have been hit by a severe hurricane recently. Therefore, they tend to be skeptical about the need and resist taking action to make their community more resilient.

As a rule, the public resists taking responsibility for the risk they face. One factor for resilience is obtaining adequate insurance. Most coastal areas are struggling with the issue of windstorm insurance. Since people do not want to pay what is actuarially sound, and successfully lobby the state insurance commissions to hold down the rates, many private sector insurance companies have left the market. State run windstorm insurance then becomes the insurer of last resort and in most cases is underfunded. The true cost of the windstorm insurance can be seen as a measure of lack of resiliency. By adapting the resilience standards discussed earlier, communities can move the needle down on insurance and attract private insurance companies back to the marketplace.

Back to the National Flood Insurance Program (NFIP) mentioned above. The yes-no requirement for flood insurance pegged to the 100 year event is a major factor in non-resilience to flooding when it involves surge and rainwater flooding. Not only is it too risky a standard for
hurricane surge (A 100 year event in many Gulf coast and Florida locations is a Category 2 hurricane), by holding the prices way below actuarial, NFIP works against resilience. Congress attempted to correct this issue through the Biggert-Waters Act. This act tried to move rates closer to actuarial values. When the proposed rates were introduced, the coastal public whose rates would skyrocket screamed foul and pressured their congressmen to back down and keep the subsidized rates, which they did. While the act was flawed, the attempt to better delineate risk was correct.

The NFIP rule provides if your property is at an elevation below the 100 year benchmark, you must carry flood insurance if you carry a mortgage. If you are above it, say at the 200 year risk, you are not required to have it. This leads to a refrain heard after every big flood “I was not required to have flood insurance...why did I flood?” In order to meet the NAS definition of resilience, significant changes are needed in the NFIP program. As stated above, my preference would be requiring flood insurance for risk areas up to the 500-year event.

Houston-Galveston area

Finally, I want to convey my thoughts on activities related to resilience where I live in the Houston-Galveston (H-G) area. Three major events, Tropical Storm Allison in 2001, Hurricane Rita in 2005, and Hurricane Ike in 2008 exposed many areas needing improvement. Regarding preparation, planning response and to some extent recovery, H-G area officials have done a good job in adopting lessons learned. One factor, growth in the evacuation zones between Galveston and Houston, has been just short of extraordinary. In 1990, approximately 500,000 people lived in areas subject to storm surge. In 2014, the estimate is that more than 1,000,000 people live in surge risk areas.

In spite of the severe impact to hospitals, nursing homes and retirement facilities from these three storms, new construction of more critical health care facilities continues unabated in surge risk areas, some at elevations at risk from a category 2 storm surge. I am not the least bit optimistic that we will curtail growth of critical infrastructure given current policies and societal attitudes toward restrictions on development. In fact, I think this is the key obstacle to overcome in order to make a more resilient U.S. coastline.
The Houston area is host to the 2nd largest petrochemical complex in the world. It is the number 1 region for exports in the U.S. New York is second. Currently the GDP of the Houston area is on the order of $450 billion. We are also one of the fastest growing urban centers in the United States, currently 4th largest and will soon surpass number 3 Chicago. Perhaps surprising to some, the Galveston bay area represents the 7th largest estuary in the country. More seafood is harvested here than in the Chesapeake Bay. And much of the infrastructure is seriously vulnerable to catastrophic loss from a large major hurricane strike.

The size and nature of the industries, port and medical facilities in Houston makes it arguably the most significant concentration of critical infrastructure in the nation. Because we have built the bulk of industry and associated business and homes in areas at risk of surge and high winds from a hurricane, damage – perhaps catastrophic damage - to the complex from a major hurricane is a matter of when, not if. The impact of a major shutdown of the Houston petrochemical industry cannot be overstated.

From a resiliency perspective, an engineering solution, such as massive surge barriers, seem to be the only adaptive solution to our exposure. Not unlike the levee system for New Orleans, Louisiana, there are many concerns about how to best accomplish this protection. As of this writing, a major barrier extending along the barrier islands from the Bolivar peninsula to San Luis Pass on the west side of Galveston Bay is being given serious consideration by key local officials (Fig 5). It would include a huge flood gate across the entrance to Galveston Bay to the Gulf, much like gates used in the Netherlands. Estimates of cost range from $6B to $10B. Other possible smaller scale projects include a surge gate protecting the entrance to the Houston ship channel.
The Ike Dike strategy is to keep the ocean surge out of Galveston Bay by using a gated coastal barrier

Figure 5. Coastal Barrier system proposed by Texas A&M Galveston

The plan has big challenges. Local entities have not reached a consensus on a plan to move forward. The USACE would be the responsible agency to oversee building of the system. The Corps is backlogged now and facing budgetary pressures. Who pays for this project? Traditionally the federal government (aka taxpayers), share the cost with local communities who benefit. There is no guarantee that Congress will fund this because, among other reasons, if we fund the Galveston project, what about Beaumont-Port Arthur, Lake Charles, and any other area under threat of severe storm surge? Also, without a clear consensus coming from the Houston area leadership, the federal government will not start any project of this magnitude.

Why not take a different approach and fund this protection system locally? Those who live here along with the major industries figure to gain by having the protection and certainly have the financial resources. Also, most federal projects are tied to the 100 year event. I contend that if you do not protect to the probable maximum, you are not solving the resiliency problem. But do we have the will to do it?
Which brings us back to the societal issue, all along the Gulf and Atlantic coasts we developed ourselves into this dilemma by thinking we weren’t really at that much risk. If society is to work toward a more resilient future, we need to focus on how to make adaptive resilience a core value for industry and residents. Otherwise we will just continue reading about lessons taught but not learned.