TWILLEY / LSU
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 5 PROGRESS REPORT
July 1, 2019 – June 30, 2020 (Updated 12/15/2020)

I. INTRODUCTION

Project Title: Integrating CERA-Planning Software to support DHS Modeling and Planning Efforts for more Resilient Communities

Principal Investigator Name/Institution: Robert R. Twilley, Louisiana Sea Grant/Oceanography & Coastal Science, LSU

Additional Research Participants/Partners:

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Short Project Description ("elevator speech"):

We propose to investigate how some of the skills developed within CERA-Planning can be integrated into some of the flood exposure and damage modeling techniques that have been developed to evaluate impact of natural hazards to improve planning. The approach is to test whether some of the skills that have been developed within CERA/ASGS and incorporated into CERA-Planning to describe flood exposure and impacts can contribute to the existing flood consequence modeling within FEMA and NIST.

II. PROJECT NARRATIVE

1. **Project overview:** We propose that the skills developed within CERA-Planning can be used to link CRC work developing high resolution flood hazard data and visualization through CERA/ASGS with the damage calculating abilities of FEMA's Hazus Flood and Wind models. Integrating reliable, high resolution flood hazard data into the Hazus models may be valuable in producing higher quality mitigative design and planning approaches that target areas of repetitive loss by making engineering and computer sciences advances easily accessible to other disciplines in the risk reduction field. Having better knowledge of where it is flooding and how much that flooding is costing a community, decision makers would more easily be able to protect the vulnerable areas of the community. This real-time knowledge is needed for disaster planning and response. The techniques developed are also useful for accurate post-event evaluation to make land use and redevelopment decisions in recovery, as well as shape disaster plans to avoid future loss by maximizing risk reduction.

   The program is focused on exchanging data from CERA with data from Hazus to create reliable maps fitting within the objectives of the NIST Community Resilience programs.

Having produced a technique to integrate CERA/ASGS hazard data into the Hazus flood model to produce building damage maps, the program plans to focus on the following in the future: (1) perfecting this technique and exploring others suggested by end-users, (2) create more types of loss maps using Hazus results, (3) integrate these maps into the existing CERA Planning tool prototype.

2. **Results:** In the past, our focus has been on presenting results to emergency managers and, more recently, promoting the use of other DHS tools through our results. In the 4th year of this project, we focused on promoting the use of the Hazus Wind and Flood Models by creating a technique that successfully processes CERA provided APS storm surge results into a format that can be used by Hazus. To properly compute storm surge damages in Hazus, the user must first complete a run through the Hazus Wind Model, followed by a run in the Hazus Flood Model. The results from these runs are combined by Hazus in a Combined Wind and Flood Direct Losses run to simulate the results of a storm surge. For a Combined Wind and Flood style run, the user can use a historic storm that is provided through Hazus, or through a user defined storm. The storms provided through Hazus are a simplified SLOSH model resulting in hazards that are a lower resolution than both SLOSH and APS model outputs. For this reason, an accurate user-defined storm for either the SLOSH or APS model would give a much more accurate Hazus hazard scenario.

   Having previously established that APS is more accurate than SLOSH, this group focused on creating a user-defined scenario from APS outputs. This task has been previously complicated by the file format, netCDF, of APS outputs since this file format is not able to be read in the Hazus Flood Model. Furthermore, once the data in the netCDF file is accessed, it is difficult to process in ArcGis into an acceptable depth grid for Hazus, as APS meshes do not easily transfer to the Hazus required raster. However, it is possible and relatively simple using CERA/ASGS. The hazard outputs visualized in CERA are done automatically for each storm advisory produced by NHC. An output available for download on the CERA website is the inundation point shapefile for a storm. The shapefile can be loaded into ArcGis and interpolated into a raster which depicts the flood inundation levels. This raster is the ideal input for a user-defined storm in Hazus.

   Since our group has developed this method to easily and accurately integrate the APS results into Hazus, we are able to create Hazus scenarios with APS results that produce risk in dollars that are comparable to the historic losses for Hurricane Isaac in 2012. This type of Hazus run could be done in real time to predict the losses as a storm approached or during recovery and planning.

   We use this data to create maps that depict the risk associated with that high-resolution hazard data to aid in post-storm land-use planning. The map we have worked on shows simulated building damages in dollars per census tract. Variations of this map include damages due to wind, flood and combined. We plan to develop these maps further using other outputs of Hazus. This would make it possible to overlay these risks and identify the census tracts in a study region most susceptible to loss. Comparing these types of maps of multiple storms hitting the same study region would work well to identify the census tracts repeatedly effected by storm surges.

The team has also started to work on a CERA Planning prototype. This features the same mapping visualization available on CERA with inventory data added. The inventory data is provided by SDMI, as it is more accurate than the Hazus data and organized according to NIST guidelines. Right now, this is only available for Hurricane Isaac 2012 water levels, but could be useful in the future when a storm is approaching to determine what essential facilities are at risk of flooding.

3. **End users: FEMA** Hazus Program under the Risk Management Directorate of FEMA and the Risk Analysis Program of FEMA Hazus.

   During the annual CRC meeting in Chapel Hill, our team connected with FEMA Hazus Program including Risk Analysis Program Manager, Hazus Program Manager, Hazus Development Lead and several software engineers to discuss techniques and tools within the ADCIRC Prediction System (APS), including CERA-Planning that could support Hazus development. This led to discussion via email and zoom meeting with the FEMA Hazus Program team. The Hazus Program team found our technique to be a reasonable solution. However, the team would like to see more techniques using a netCDF to raster approach to hopefully cut down on processing time. While there is an experimental process for this, it is only for the state of North Carolina and has proved very difficult to process. We are looking into seeing how much a direct netCDF to raster approach is possible at a national scale, and, if it is possible, would it actually be more computationally efficient.

4. **Transition:** A member of the CERA Planning team learned how to use to use Hazus Flood and Wind Models.

   The team discussed and tested methods to process CERA outputs into a raster to successfully integrate the data into Hazus. In more recent months, this discussion has included members of the Hazus development team to try to better fit the technique into their needs.

5. **Project Impact:** Contact with Hazus development team to make the APS integration into Hazus technique widely available.

6. **Unanticipated Problems:** The original workplan for the CERA-Planning tool had three strategies: develop local team of regional planners to develop CERA-Planning tool to assist in mitigating repetitive losses in coastal Louisiana; work with NIST to modify CERA-planning tool that would support community resilience guidelines to coastal communities; develop CERA-Planning tools that would support Hazus damage assessment tools. As program evolved, the project focused primarily on working directly with FEMA Hazus Program team to incorporate APS tools into Hazus software. The CERA/Hazus planning was initiated in June 2019 with a follow up discussion remotely with FEMA Hazus Program team in January 2020. Follow up with Hazus developers at the March 2020 CRC all hands meeting initiated the planning for an in-person workshop as anniversary to our June 2019 meeting. COVID-19 prevented us from planning the follow up workshop to be held at FEMA in Washington DC. We have changed that strategy to inviting Hazus developers to participate on selected biweekly research team meetings of the CERA/Hazus group at LSU. We will continue to hold those remote discussions with the Hazus development team with the

LSU CERA/Hazus team in the next several months to compare results with different data transfer techniques.

7. Student Involvement and Awards:

- Katherine Jones is a graduate student funded by the CRC as a research assistant in the Department of Civil and Environmental Engineering. Her work is focused on the CERA Planning project, and she plans to complete all requirements for a Masters of Science in Civil and Environmental Engineering in May 2021.

8. Interactions with CRC education projects:

N/A

III. RESEARCH ACTIVITIES AND TRANSITION MILESTONES

1. Year 5 Research Activities and Milestone Achievements:

Year 5 Research Activities and Milestones: Status as of 6/30/2020			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Link CERA-Planning with Hazus FLOOD analysis to investigate what skills from CERA/ASGS flood exposure and communication capabilities would support FEMA consequence modeling	Dec. 2019	100%	
Research Milestone			
CERA-Planning simulations based on scenarios from Hurricane Isaac are implemented as data source used by Hazus FLOOD analysis with significant improvements based on hindcasting.	4/30/2020	100%	

2. **Year 5 Transition Activities and Milestone Achievements**:

Year 5 Transition Activities and Milestones: Status as of 6/30/2020			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Develop a working group to develop ways that CERA Planning can augment technical capabilities of FEMA Hazus-FLOOD	Dec. 2019	100%	
Hold technical workshop with Hazus-FLOOD modelers and developers to identify how CERA-Planning tool can provide additional high-resolution input data on flood conditions during an event.	June 2020	80%	Smaller working group sessions have been held remotely with FEMA Hazus Program developers due to COVID-19 restrictions on travel and in person consultation.
Transition Milestone			
Incorporate output identified in the CERA-Planning/Hazus FLOOD workshop results into a simulation test of the Hazus FLOOD model.	March 2020	100%	
Compare Hazus-FLOOD model capabilities with and without the higher resolution input data on flood exposure	June 2020	80%	Smaller working group sessions have been held remotely with FEMA Hazus Program developers due to COVID-19 restrictions on travel and in person consultation.
Provide DHS a report and presentation on the method and findings resulting from this project that would enable them to be used/applied in practice.	June 2020	75%	Smaller working group sessions have been held remotely with FEMA Hazus Program developers due to COVID-19 restrictions on travel and in person consultation.

3. **Research Project Product Delivery.**
N/A

IV. PUBLICATIONS AND METRICS

1. Publications: N/A

2. Performance Metrics

Twilley: Performance Metrics

Metric	Year 1 (1/1/16 – 6/30/16)	Year 2 (7/1/16 – 6/30/17)	Year 3 (7/1/17-6/30/18)	Year 4 (7/1/18-6/30/19)	Year 5 (7/1/19-6/30/20)
HS-related internships (number)					
Undergraduates provided tuition/fee support (number)					
Undergraduate students provided stipends (number)	1	1	1	0	0
Graduate students provided tuition/fee support (number)	1	1	1	1	1
Graduate students provided stipends (number)	1	1	1	1	1
Undergraduates who received HS-related degrees (number)					
Graduate students who received HS-related degrees (number)					
Graduates who obtained HS-related employment (number)					
SUMREX program students hosted (number)					
Lectures/presentations/seminars at Center partners (number)	1	2	3	3	0
DHS MSI Summer Research Teams hosted (number)					
Journal articles submitted (number)					
Journal articles published (number)					
Conference presentations made (number)	5	3	3	4	1
Other presentations, interviews, etc. (number)	6	2	3	2	2
Patent applications filed (number)					
Patents awarded (number)					
Trademarks/copyrights filed (number)					
Requests for assistance/advice from DHS agencies (number)	7	6	11	18	
Requests for assistance/advice from other Federal agencies or state/local governments (number)	5	4	3	55,000*	3
Dollar amount of external funding	$650,243	$800,243	$575,243	$575,243	$575,243
Total milestones for reporting period (number)	8				
Accomplished fully (number)	3				
Accomplished partially (number)	5				
Not accomplished (number)	0				

* CERA users during 2018 hurricane season