Evaluation of the Effectiveness of the Central Region Impact-Based Warning Demonstration Conducted by Weather for Emergency Management Decision Support

Submitted to the NWS Central Region Headquarters

March 1, 2013

Ken Galluppi, PI – Arizona State University
galluppi@asu.edu

Jessica Losego, co-PI – University of North Carolina
jlosego@unc.edu

Burrell Montz, co-PI – East Carolina University
montzb@ecu.edu

Table of Contents

1. Introduction

From service assessments of large impacting tornadoes in 2011, the National Weather Service (NWS) inferred that emergency managers and media decision makers wanted a better sense of the potential impacts from storms so that they could make better response and business decisions. In response to this challenge, the Central Region Headquarters (CRH), in collaboration with a number of internal entities, devised a prototype of a modified severe weather and tornado warning message in hopes of improving the urgent and correct decision making. The message, called the Impact Based Warning (IBW), was planned to convey a sense of severity of the potential impact of storms, thus giving decision makers more information to base decisions. A pilot demonstration project was developed to test the message utility in five Weather Forecast Offices (WFO) for the severe weather season starting April 2, 2013. The goal was to see if by changing the message to emphasize tiers of impact severity, emergency management and media decision-making could be enhanced. The CRH team focused on the message structure that could convey some additional information while staying within current warning system. Prior to using the warnings, the team created tiers of impact wording for the IBW, and trained WFO personnel to develop consistency of use. The question was left open, how to evaluate the effectiveness of the IBW in achieving its limited goal of providing improved information.

The Weather for Emergency Management Decision Support (WxEM) team, in collaboration with the NWS Office of Science and Technology, was developing methods to better understand how to improve weather products and services from the emergency management point of view. The WxEM project had previously explored the development and testing of agile development for winter weather and tropical weather. The methods employed enabled a rapid assessment of critical emergency management needs for information and prototyped development to meet those needs. The success and promise of the WxEM approach seemed appropriate to assist CRH in evaluating its IBW pilot. It was mutually agreed upon by OST, CRH, and WxEM that a collaboration could be defined where the WxEM team, who had nothing to do with the design of the IBW or pilot, could serve to independently evaluate effectiveness from the customer point of view.

This final report details the overall plan and background, the methods used, the quantitative and quality evaluation of IBW, and lists findings and recommendations that can be used by NWS to improve IBW and other warnings.

2. Summary

The evaluation of the IBW experiment revealed many details about how EMs actually use NWS warnings, the gaps that emerge between what NWS provides and what EMs need, and ideas for improving NWS products to better serve the EM community. Many of these findings were not only useful in the evaluation of IBW, but are applicable beyond the scope of IBW to other NWS products and services.

The evaluation plan consisted of completing several iterative and reoccurring steps beginning in February 2012. The background and methodology of these steps are discussed in Section 3. A total of 17 iterations (see Section 6) were completed to accomplish these steps:

- Define clear IBW goals.
- Assess the outreach coverage to customers to set the stage to identify bias.
- Develop a baseline of intent and practices to compare effectiveness against.
- Observe current practices in real weather scenarios.
- Develop findings (hypotheses) by assessing what changes in decision processes were made and can be attributed to IBW.
- Establish a framework and criteria to evaluate effectiveness of warning messages.
- Through prototyping, develop the ideal knowledge message and how it could be conveyed.
- Evaluate the IBW compared to the criteria and ideal message.
- Emphasize findings for follow up or make recommendations concerning the IBW.

Overall, we found that EMs feel that the use of IBWs is a step forward in providing more useful information to the EM community. Many EMs like IBW because it gives them more insight into what the forecaster is thinking. Given that EMs are always looking for a forecaster's easy-to-understand "best guess," the additional information in IBWs begins to get at this and can help build the confidence of the EM. We found no evidence that EMs think that IBW does or would do any harm in informing the public of a threat.

IBW is a small step forward in providing the necessary information to EMs. The information that EMs are really looking for – what we've termed the "six critical elements" to operational decision making – we feel is beyond the scope of IBW as a simple text product. Keeping in mind the EMs manage risks, and not just hazards, these critical elements include: 1) what is the hazard/how big is it; 2) timing; 3) location; 4) duration; 5) history; 6) forecaster confidence. To get at this information, a mix of improved graphical and text products is needed. Without knowing these six critical elements, EMs cannot fully manage risk because they cannot complete a full vulnerability assessment. NWS and EMs need to work together to address this gap in the vulnerability assessment.

3. Methodology and Background

This section provides an overview of the background and methodology that serve as the foundation of all research conducted by WxEM, including the evaluation of IBW. The four main components of this background and methodology include:

- *Emergency management community background*: WxEM studies all public decision makers in the community, not only the county EM director, to understand their responsibilities, decision points, and use of weather information.
- *Risk Paradigm*: WxEM uses the Risk Paradigm to connect the NWS to EM through a common desire to manage risk.
- *4-Step iterative process:* Using this process allows WxEM to understand the EM community's responsibilities and decision points; establish gaps between what EMs need and what NWS provides; prototype ideas for EM feedback; validate that EMs use the prototype in operations.
- *Methods for gathering information:* WxEM uses various standard social science methods, such as focus groups, semi-structured interviews, and surveys to gather information.

Details on each of these components are included in the next four sub-sections.

Emergency Management Community Background

A major principle of WxEM is our broad definition of emergency management. The EM community is dynamic and diverse, and it includes more than the traditional county EM director that many people think of at first. Each EM has their own responsibilities, decisions, and need for weather information.

The community can be described by Emergency Support Functions (ESFs) as laid out in FEMA's National Response Framework (NRF 2008). ESFs are groupings, by functional area, of resources and capabilities that are most frequently needed in a disaster response. Examples of ESFs include firefighting, public health, medical services, and public works. ESFs are used at the local, state, and federal level for disaster response. A complete list of ESFs is shown in Table 1.

Table 1: Emergency Support Functions from FEMA's National Response Framework (2008).

#1: Transportation	#9: Search and Rescue
#2: Communications	#10: Oil and HazMat Response
#3: Public Works and Engineering	#11: Ag and Natural Resources
#4: Firefighting	#12: Energy
#5: Emergency Management	#13: Public Safety and Security
#6: Mass Care, Emergency Assistance, Housing, and Human Services	#14: Long-Term Community Recovery
#7: Logistics Mgmt and Resource Support	#15: External Affairs
#8: Public Health and Medical Svc	

As we can see, “Emergency Management” is ESF #5, verifying that it is only one part of the larger community. A common misperception about a local emergency manager (EM, ESF #5) is that he is the one that arrives at an incident, directs everyone on what to do, and is the leader of a response. In reality, during an incident, an EM helps manage the application of resources to other ESF leads that can be considered “emergency response managers” (FEMA IS-1). These emergency response managers, such as a fire or police chief, a public works director, or a hospital coordinator, control their resources; the EM helps them apply their resources sensibly and in a coordinated way.

Many times, NWS considers the local EM as the only customer in this community. However, only considering this function does not allow for a complete understanding of the needs of the community. Although the EM often serves as a main weather information collector and distributer, it is insufficient to only consider this one support function when discussing decision support for weather. Often the available information doesn’t communicate what the EFS needs, and they do their best to interpret it for their use.

Depending on the incident type, various ESFs are involved, and they are all working on different problems with varying time scales. Each may need a different bit of weather information at different times as their decision process unfolds. For example, in advance of a winter storm a power company needs to know how much ice is predicted so that they can start bringing in extra manpower 48 hours in advance of the storm; a transportation official needs to know if rain is forecasted to fall before the storm so he can decide if preventative brine should be applied to the roads a day before frozen precipitation falls; a school official is interested in the forecast, but will ride the roads the morning of a storm to see precipitation on the ground to make a school closing or delay decision.

Risk Paradigm

Another major principle of WxEM is the risk paradigm, which links the weather community (NWS, broadcast meteorologists, private sector) with the EM community (Figure 1). EMs manage risk, but in order to do so, they must know what the risk is in terms of potential impacts on their areas of concern and in terminology that makes it possible for them to understand and communicate the risk to others. There are three main components to the risk paradigm: risk characterization, risk communication, and risk management.

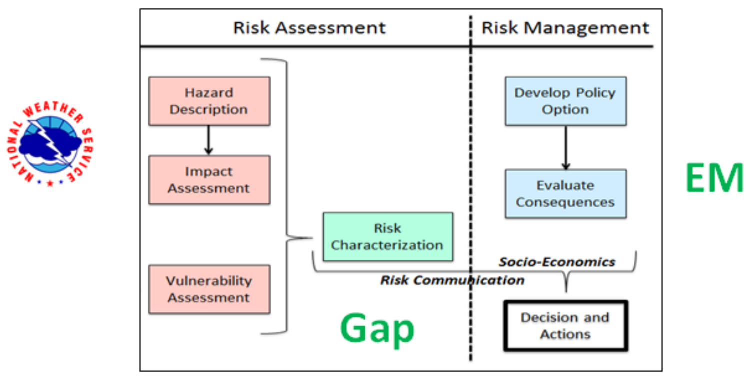

Figure 1: Risk paradigm adapted from the NRC (1983 and 2009).

Risk Characterization

In the IBW evaluation, the risk characterization evaluation will focus on the NWS’s ability to assemble and describe the critical risk knowledge of a convective storm that will be conveyed to the partner communities. Decisions and actions concerning safety (risk management) are not based on impact potential but the risk, or perceived risk, to specific lives or property. To this end, it is critical to assess how well hazard information or impacts are connected to specific risk-triggered decisions and preventive actions. This evaluation will focus on three subcomponents needed to effectively characterize risk:

- *Hazard description*: From the forecaster perspective, how effective is the forecaster at communicating what the hazard is? Effectiveness may deal with forecaster confidence, availability of options in WarnGen, or how parts of the warning message may vary across offices.
- *Impact assessment*: From the forecaster perspective, how effective is the forecaster at communicating the impacts of the hazard?
- *Vulnerability assessment*: From the forecaster and EM perspective, what information can be provided to help the EM assess vulnerability? Vulnerability builds on impacts, but it is more specific in timing, location, and type of

damage. For example, impact tells you that trees will blow down. Vulnerability tells you what trees will be affected, how many will fall down, and at what time.

Risk Communications

The essence of communicating storm risk is the conveyance of the knowledge about the risk such that it creates a mutual understanding of the situation. Situational "awareness" may be insufficient to lead to proper decisions. These communications need to address the NWS packaging and delivery of the risk message such that the partner receiving the message has the same understanding as that intended by the creator.

- *Message packaging/receiving*: From the NWS side, examine the intent of the message and options that exist to package and convey the message. From the EM side, examine how EMs receive warning messages, what they do with that information, and what the warning tells them.
- *Message delivery*: Examine how effective the delivery mechanisms are in getting the message to EMs, other options to deliver the message and how they compare in effectiveness in receipt and understanding (forecaster and EM perspective).
- *Operational considerations:* Assess how easily and consistently NWS can develop and disseminate IBWs, determine if other options for delivering the warning are operationally possible.
- *Confidence, competence, comfort:* Assess how comfortable partners were in using IBWs, examine the capabilities and competence of the intended audience when using warning info, and determine how the personal confidence of the deliverer and receiver influence the effectiveness of messaging.

Risk Management

Risk management involves the decisions and actions by the partners to protect lives and property given the understanding of the risk, other societal factors, and resource availability. Decisions and actions are undertaken both by the partners and by individuals. Ultimately it is the actions of individuals to protect themselves and others around them that matter. However, it is the decisions and actions of the partners that influence individual actions and therefore, whatever NWS does must also facilitate and enhance their risk communications. To this extent, a strong conveyance of risk to the partners can have a major influence on their messaging to individuals. Ambiguity in the NWS risk characterization or risk communications can lead to misinterpretation and misunderstanding that, in turn, leads to undesired actions by the partners and individuals. This part of the evaluation will assess the partner decision processes and the knowledge needed to drive decisions, and how well the proposed warning message meets those needs.

- *Risk Perception:* Examine how risk is perceived by the EMs when reading an IBW, if IBW allowed EMs to infer the appropriate level of risk to make proper decisions, and how effective IBWs are in conveying risk.
- *Decision-Making:* Examine what decisions EMs are making during a severe weather event and on what timeline, what knowledge is needed to make these decisions, evaluate if and how IBW changed EM decisions, what other information is needed by EMs in decision making.
- *Safety Actions:* Determine what actions by partners are desired by conveying risk information, assess if and how the warning intent reaches and influences behavior, assess what factors detract from the message intent on influencing actions.

The use of the risk paradigm and how to evaluate its components advanced over the course of WxEM. During the first two case studies (winter and tropical), various components of the risk paradigm were examined. In the final use case, the IBW demonstration, the effectiveness of all components were formally evaluated against six critical elements needed for decision making as defined by EMs over the course of WxEM.

Four Step Iterative Process

In order to meet the needs of the EM community, it is necessary to understand what information they need, what they use, where they get it, and how it is used. It is also necessary to understand that there is a difference between *information* and *knowledge*. Information can foster knowledge, but information can also require knowledge, sometimes rather sophisticated knowledge when it comes to weather forecasts.

Once the processes and needs of the EM community are understood, it is then possible to work together to fill any gaps and develop products and services that can help them better carry out their duties. This can be accomplished through a process of four iterative steps, each of which is described in more detail below:

1. Establish the base case
2. Determine current practices to identify gaps
3. Generate ideas as prototypes to fill gaps
4. Validate results

The iterative nature of these steps means steps will be revisited periodically, as the process is worked through. What you learn in one step will send you back to previous steps because you may have discovered, for instance, that you didn't fully understand the base case or that there are more gaps to identify than you had initially considered, so you continue to build on each step (Figure 2). This does not mean that you never complete what you set out to do, but rather that you must allow for flexibility in the process. As you will see below, it becomes clear when you have enough information to move ahead and when you need to go back to a previous step.

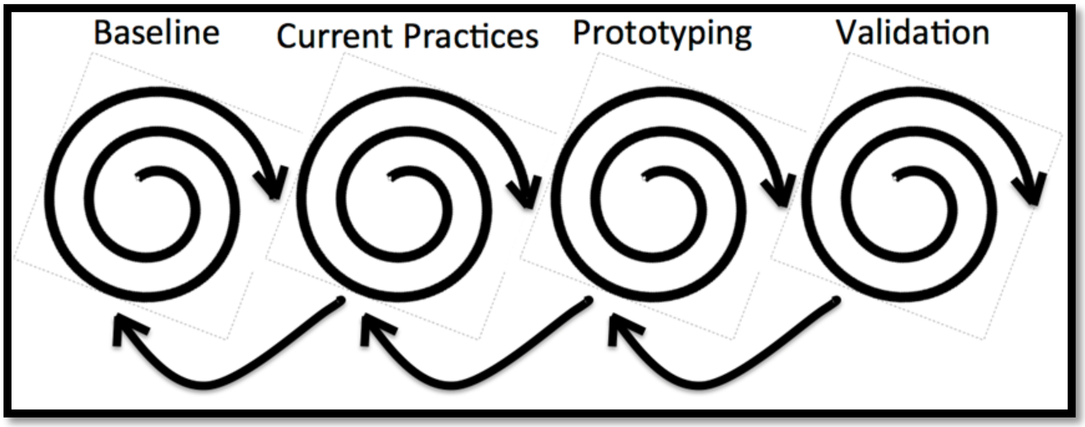

Figure 2: Four Step Iterative Process

Establish the base case

Establishing the base case is the first step in the iterative information gathering process. It is the foundation for understanding the thinking, reasoning, and decision processes of EMs and will guide the other iterative steps. Although the overarching goal is more effective, useful weather products for the EM community, this should not be the focus of this discussion. Instead we want to understand the processes different EMs go through as they learn of impending severe weather as well as the information they need to make the decisions they must make at various points in time. Using a series of scenarios starting from the first indication that severe weather may be affecting an area, we asked EMs questions such as:

A. What decisions need to be made?
B. On what timeline are these decisions made?
C. Who is involved in making these decisions?
D. What knowledge do you need to know to make the decision?

Information gathering techniques for establishing the base case include focus groups using some organizational methodology such as CRC cards, interviews, and surveys. As is presented later, focus groups and interviews provide in depth information with a small group or an individual, while surveys permit a larger cross-section of participants but with less depth. As a result, a mix of methods is useful.

By understanding what the EM thinks about and why, we can begin to identify gaps between what is needed and what is provided, and between what is intended in a product and what is understood.

Determine current practices to identify gaps

In this second iterative step we examined the current practices of both the EM community and the NWS.

Current Practices – EM Community

While collecting information to establish the base case, we often also began collecting information for this step since the two are linked. In this step we are determining when, how, and where EMs collect and receive information to make their decisions. In so doing, we also learned if they really understand the products. As a result, this step required much more discussion on weather and products, and sometimes took more than one discussion with members of the EM community to understand. Sample questions we considered are:

A. From where is information obtained to make a decision?
B. Who gathers this information?
C. When is this information gathered?
D. What knowledge does the EM have about the information?
E. How does the EM use the information?
F. After showing an example of a product, what does this product tell you?

G. How will you or how do you use this information to make your decision?

Current Practices – NWS

In order to identify gaps in the next iterative step between what EMs need and what NWS provides, we also examined the current practice of forecasters. Sample questions we considered are:

A. Who do you think is the audience for the information you provide?
B. What knowledge are you trying to disseminate?
C. Once you become aware of possible severe weather, when do you provide information that you think the EM community needs?
D. What knowledge are you expecting the EMs to get from what you provide?
E. Through what means are you conveying this knowledge?
F. How do you know that is the most effective way to convey it?

Identify gaps

Once current practices are delineated, it is now possible to identify gaps between the two sets of practices and processes. Two types of gaps can exist:

A. There is something EMs need, but NWS does not provide it. Example: school transportation directors need a map of hazardous road conditions during a winter weather event, but NWS does not produce this product.
B. NWS provides something that EMs need, but it is not effective, for any number of possible reasons. Example: EMs need hourly data that is available on the Hourly Weather Graph, but many cannot find it on the web page, so it is not used.

GENERATE IDEAS AS PROTOTYPES TO FILL GAPS

The third iterative step in the information gathering process centers on filling the gaps that have been identified, or said differently, exploring ways to improve NWS products and service. Those gaps that were most critical to EM operations, as determined in establishing the base case, are those that took highest priority.

In generating ideas, several options were created to fill the gaps. These options were shown via mock-up graphics and/or text. These ideas were not always something that NWS was currently capable of producing, nor did they have to be something that NWS will necessarily end up providing. The point of generating the ideas is to get feedback from EMs and better understand their needs. As an example, work in North Carolina showed that county EMs make evacuation decisions based on the forecast onset time of tropical storm force winds. NWS does not have such a product, but a prototype was developed by an NWS office, which was then shown to EMs. It is unknown when or even if this product will be available to EMs from the NWS, but its usefulness to EMs illustrates one way to fill a serious gap. More examples of prototypes will be discussed in the case study section of this report.

Once prototypes were available, we verified them by again working with members of the EM community. There are various ways to do this, but structured interviews worked best at the outset. Our goal was to determine if the prototype was available to them, would it fill the gap? This is too broad a question to ask, however, so while showing them the prototype, various questions were asked such as:

A. What does this graphic tell you?
B. What do you think of this graphic?
C. Under what circumstances would you use it?
D. How might you want it modified and why?

Verification for IBW was done through interviews, surveys, presentations at meetings, and other venues where members of the EM community come together.

VALIDATE RESULTS

Validating results means that prototypes are tested in a real situation, if possible, rather than just in a survey or interview setting. Incorporating the prototypes into a real event will allow for an indication of how the prototype would likely be used as well as how it would affect decisions and actions. Observation during an event or rapid follow-up after the event is required to document the usefulness and effectiveness of the prototype. Validation can be difficult to carry out depending on resources and event occurrences. In WxEM, validation only occurred in the IBW project because of that project's rapid development, i.e., the prototype was already developed and planned for testing in the field before the other steps were complete. The other steps were carried out as rapidly as possible before validation began.

Methods for Gathering Information

There are several methods that have been effective in carrying out the iterative methodology described above. These methods go beyond the more traditional route of presenting information and asking if there are questions, which can be useful under many circumstances. However, the qualitative and quantitative methods described here have been shown to provide very useful information on the needs of NWS partners and customers. The qualitative methods presented here are focus groups and interviews; the quantitative methods are surveys. Each has its own advantages and disadvantages, but together they provide a very useful approach to working through the four step iterative methodology.

Focus Groups

Focus groups are really facilitated group interviews or group discussions. The discussions, statements, and comments made during focus groups provide the "data". However, instead of numbers that would be obtained from a structured survey, focus groups provide insight into the topic of concern and allow for an understanding of relationships and perspectives. As a result, focus groups provide a depth and richness of information that cannot be obtained from a survey. The most effective focus groups are comprised of a relatively small number of participants (say 4-10) and are guided, but not directed, by a moderator. The moderator needs to keep the participants focused while at the same time allowing the conversation to flow naturally.

Unlike surveys and structured interviews, focus groups do not have specific protocols. However, the moderator should have a design comprised of questions that provide focus to the discussion but that also help participants feel comfortable. The questions should not come across as a phone interview or a survey. Brainstorming, with some scenarios or questions to start the conversation, is one way to carry out a focus group. A method that has been used effectively with the EM community is CRC (Class Responsibility Collaboration) Cards, described below. Focus group discussions for IBW and other case studies were audio recorded and then transcribed in order to provide for a full record. Many times, insights are gained from the recordings that may not have been captured in note-taking.

Although focus groups should be rather free-flowing, they do need to be moderated. For the purposes of this project, one useful technique to use during a focus group is an adapted form of the Class, Responsibility, and Collaboration (CRC) Card methodology (Beck and Cunningham, 1989). Originally used for object-oriented software design, CRC cards are an easy, consistent way to collect information across multiple focus groups and keep the facilitator focused on the goal of the focus group. Participants write their job title, responsibilities, and collaborators on an index card in response to a series of scenarios, and then each participant reads this information to the group (see Figure 3 for an example). This generates discussion and questions amongst the participants and facilitator, providing an immense amount of information to establish a baseline understanding and generating discussion about the responsibilities, collaborations, timelines, decisions, and concerns of partners.

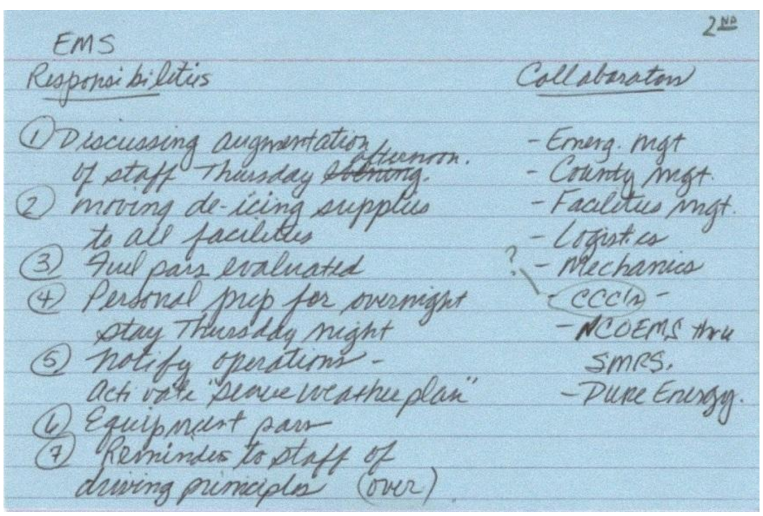

Figure 3: A sample CRC card from a focus group conducted in North Carolina for a winter weather scenario. The participant's job title is written on the top line ("EMS"), responsibilities along the left side of the card, and collaborators along the right side of the card. Extra information can be written on the back of the card.

Focus groups in general, and CRC cards specifically, allow us to see who talks with whom in the EM community and learn what type of information they are passing and why. An example of a network is shown in Figure 4 and shows who is talking with whom in one county two days before a winter storm. It shows much of the communication stemming from the county EM director. The network is complicated, and it is easy to see how information can be miscommunicated or lacking within this network.

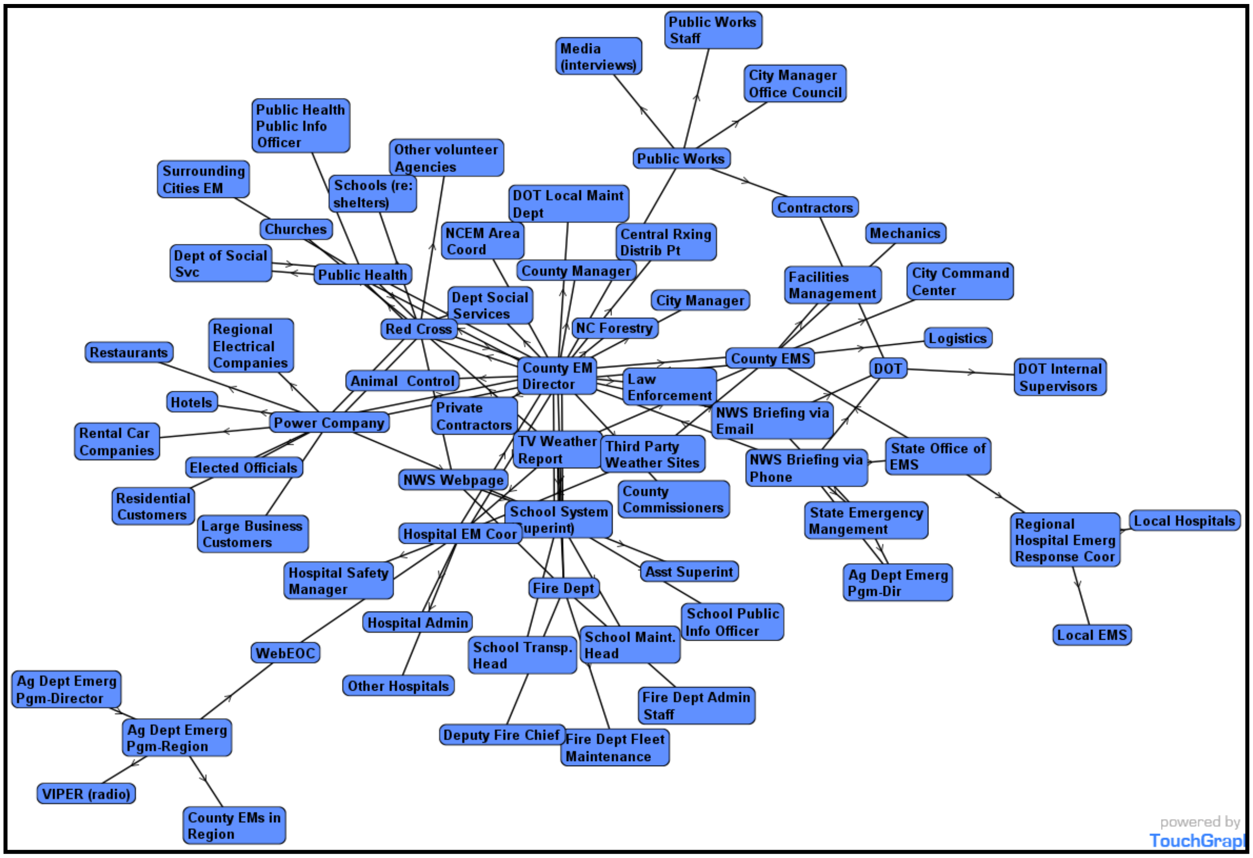

Figure 4: Flow of information two days before a winter storm event.

Semi-structured Interviews

Following the IBW focus groups in which we obtained information with respect to the base case and current practices, and therefore identified some gaps, we explored specific topics or discussed prototypes in an even more focused and in depth context. Semi-structured interviews (SSI) provided this opportunity for such data collection. The main goal of SSIs is to encourage the interviewee to talk freely and openly so that we can learn more about current practices by probing various topics and issues that were brought up during the focus groups. This also allowed us to continue to build on our base case.

In a SSI, the interviewer develops a list of open-ended, unbiased questions and topics that need to be addressed during the interview (i.e., interview guide), but allows for discussion that may stray from the planned topics. In addition to the planned questions, the interviewer asks the majority of the questions “on the fly” as the discussion proceeds. This allows the interviewer to probe new information and form a better understanding of the customer needs. It also allows the interviewees to express their views from their perspective. The interviews are conversational and allow for flexibility.

A particular benefit of using SSI is that it can be used by multiple interviewers at different sessions because the interview guide developed beforehand lays out instructions and questions. An example of SSI results for a winter event is shown in Figure 5.

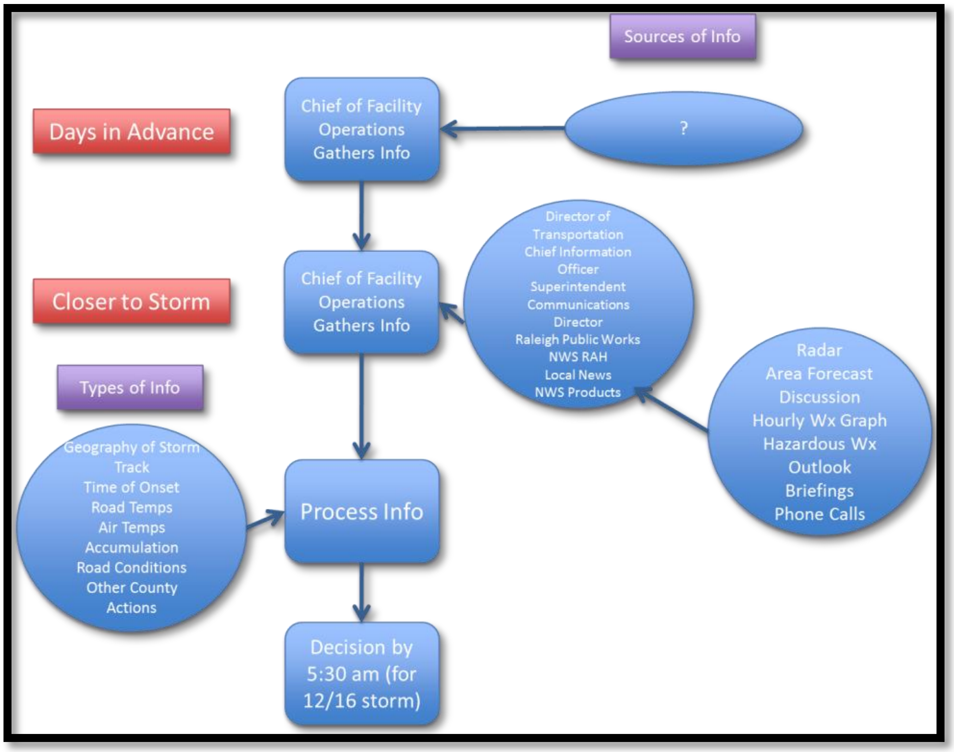

Figure 5: Documentation of results from semi-structured interview

SURVEYS

Surveys have two characteristics that differ from focus groups and interviews. First, they can readily be administered to a large number of people, so the results provide a more broad-based view than do the other methods. Second, the responses can be tallied and, assuming the sample size is sufficient, analyzed using statistical tests. Even without statistical tests, the results provide quantitative evidence of trends. At the same time, surveys do not allow for the depth of a focus group or interview.

Surveys can be undertaken at any point in a given project. They might be used first, before the focus groups, to identify areas of general concern or misunderstanding. They might be used after the focus groups to determine how widely some of the findings are shared. They might be used after the interviews, again to see how widely the findings are shared. And they might be used to present prototypes of graphic and text products, after the interviews, to determine how effective or useful respondents believe them to be. Because of these opportunities, it is very important to decide early in the process when surveys are most appropriate. It is also necessary to determine who should receive the surveys. Depending on the goals of the survey, some may be sent to all ESFs, while others may be directed only to one group, such as county or city EM.

The three methods for data collection discussed here – focus groups, semi-structured interviews (in person and via phone), and surveys – were the main methods used during IBW to gather information. Each of these methods is useful at one time or another for talking with and better understanding partners' responsibilities, decision points, and processes.

4. IBW Iterations and Evaluation

There were 17 iterations conducted during the evaluation of IBW. A list of these iterations is included in Table 3 on the following page. Iterations ranged from phone interviews and focus groups with EMs before the experiment started, to follow-up interviews of forecasters and EMs after events, to surveys of EMs and forecasters in five non-IBW offices in CR, to the actual evaluation of IBW within the risk paradigm. A summary of each iteration is available in Appendix I in Section 6. Many of the iterations were conducted by the WxEM team in collaboration with CRH personnel.

The evaluation of IBW was conducted using a matrix that scored the effectiveness of each of the six critical elements identified by EMs as being critical to decision making - 1) what is the hazard/how big is it; 2) timing; 3) location; 4) duration; 5) history; 6) forecaster confidence - against the components of the risk paradigm (Tables 4-6). The scoring criteria are listed in Table 2. Each member of the WxEM team and CRH personnel scored each component of the matrix independently. To finalize the numbers, we discussed the rankings given by everyone and their reasoning, and settled on a consensus ranking. Lower ranking components indicate which NWS should focus on improving. The ranking of each cell in the matrix is discussed in detail below its respective table.

Table 2: Ranking scale used in evaluation

5	Extremely Effective: Covers all elements appropriately and as accurately as possible; clearly meets needs of all parties
4	Very Effective: Covers all or almost all elements well; meets needs of all but a few parties
3	Effective: Covers almost all element; meets needs of most parties but variable
2	Somewhat Effective: Covers some elements but not all; meets some needs but not all, and not necessarily well
1	Not Effective: Doesn't meet needs; missing critical elements
0	Don't know enough

Findings and recommendations are shown in in Section 5 in Table 7. These findings are based on all the data collected throughout all iterations and the matrix evaluation. Some are outside the scope of what is possible for a text warning like IBW, but we felt they were important to include because they indicate where NWS can make improvements in decision support.

Table 3: List of iterations completed from March 2012-November 2012 by the WxEM and CR IBW team to evaluate the effectiveness of IBW. Iterations numbers will be used as points of reference within the evaluation. See Appendix I for iteration summaries.

#	Iteration Name	Iteration Description
1	Pre-IBW March EM Focus Groups	One EM focus group was conducted in each of the five IBW areas in mid-late March before IBW warnings were operational. The focus groups were conducted by WFO staff with guidance from the WxEM team. The goal of the focus groups was to establish a baseline understanding of EMs' decisions, processes, and usage of weather information before they began using IBWs.
2	Pre-IBW March EM Phone Spot Check	93 EM and media partners in the IBW test area were contacted via phone by WxEM team members to determine if the outreach for IBW was effective, i.e., did partners know about IBW and if so, what did they know.
3	Pre-IBW Missouri EMA Conference	A paper survey (77 completed) and multiple instant response surveys (119) during breakout sessions were administered at the Missouri EM conference April 4-5. Informal interviews (10) were also conducted at the NWS booth. The goal was to establish a baseline understanding of EMs decisions, processes, and thoughts on IBW before any IBWs were issued.
4	Pre-IBW Forecaster Interviews	Forecasters at three of the five IBW offices were interviewed in early April before any IBWs were issued. The goal was to establish a baseline understanding of forecaster processes and gather initial thoughts on IBW.
5	April 14 EM Interviews	Shortly after the April 14 tornado outbreak in Kansas, EMs were interviewed in person (17) and via phone (8) to learn about the processes of EMs during the outbreak in general and if and how IBWs were used for the event.
6	April 14 Media Interviews	Shortly after the April 14 tornado outbreak in Kansas, eight media partners (TV and radio) were interviewed in person to learn about media processes during the outbreak in general and if and how IBWs were used for the event.
7	April 14 Forecaster Interviews	Shortly after the April 14 tornado outbreak in Kansas, forecasters at the WFOs in Topeka and Wichita were interviewed to learn about the warning process and how IBWs were used and if they impacted forecaster decisions.
8	April 27 EM Interviews	At least two brief and weak tornadoes occurred on April 27 in the Topeka CWA. Nine EM partners – some had tornado warnings issued for their county, others didn't – were contacted to see if and how they used IBWs.
9	May 19 EM Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. EMs from two counties that were affected were interviewed to see if and how they used IBWs.
10	May 19 Media Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. Two TV media partners were interviewed to see if and how they used IBWs.
11	May 19 Forecaster Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. The warning forecaster for NWS Wichita was interviewed to learn about his warning process and use of IBWs.
12	August Forecaster Survey	A forecaster survey was administered to IBW offices in August to gauge forecasters' opinion and comfort level on various gaps identified in early iterations. 51 responses were received. Preliminary results were used to inform focus groups conducted later in the month.
13	August EM Focus Groups	One EM focus group was conducted at each of the five IBW offices in late August. The goal was to address gaps that were identified in early iterations and to discuss ideas for prototypes to address these gaps.
14	August Forecaster Focus Groups	One forecaster focus group was conducted at each of the five IBW offices in late August. The goal was to address gaps that were identified in early iterations and to discuss ideas for prototypes to address these gaps.
15	KEMA EM Survey	Paper surveys were administered at the Kansas EM conference in mid-September. The goal was to gather feedback from EMs on gaps identified in earlier iterations to help inform prototype development.
16	Non-IBW EM Survey	A survey for EMs in five non-IBW areas in Central Region was administered in late September. The goal was to gather feedback on IBW, various gaps identified in earlier iterations, and the warning system in general from a new group of EMs to use as comparison to EMs involved in IBW. 252 responses were received.
17	Non-IBW Forecaster Survey	A survey for forecasters in five non-IBW offices in Central Region was administered in late September. The goal was to gauge non-IBW forecaster feedback on gaps that were identified in earlier iterations. This survey matched the one given to IBW forecasters in early August. 28 responses were received.

Table 4: Evaluation of effectiveness within the risk characterization component of the Risk Paradigm.

		A	B	C
		Risk Characterization		
		Hazard Description	Impact Assessment	Vulnerability Assessment
1	Threat and its magnitude	4	3	1
2	Timing	2	2	1
3	Location	2	2	1
4	Duration	2	2	1
5	History	2	2	1
6	Confidence	3	3	1

Risk Characterization – Explanation of Rankings

Risk Characterization: ability of the NWS to assemble and describe the critical risk knowledge of an event that will be conveyed to partners. Three subcomponents make up risk characterization: hazard description, impact assessment, vulnerability assessment.

Hazard Description – From the forecaster perspective, how effective is the forecaster at communicating what the hazard is? Effectiveness may deal with forecaster confidence, availability of options in WarnGen, or how parts of the warning message may vary across offices. This section does not reflect how warnings are perceived by EMs. Note that there is a wide range of perceptions and opinions from forecasters on what EMs actually do, their role in the time leading up to the event, and how NWS should serve the EM community.

<u>Cell 1A (threat and its magnitude)</u>: Rank 4 – IBW is very effective at communicating the threat, or hazard, that the forecaster is trying to convey. This is accomplished by the "Hazard" section of IBW warnings, which clearly state what the forecaster is expecting or what has been reported, e.g., damaging tornado, ping pong size hail, 60 mph wind gusts, developing tornado.

IBW is very effective at allowing the forecaster to convey the magnitude of the threat via damage threat tags (significant, catastrophic), and forecasters like having the ability to convey this information. 76% of IBW forecasters thought that the damage threat tags conveyed the threat's magnitude "well" or "very well." Until now it was difficult to clearly state how severe the forecaster thought the damage threat was, so all tornado warnings sounded the same regardless of how severe. The predefined terminology for damage threat tags and formatting of IBW give forecasters a way to express their concern and more effectively communicates this information. Terminology, such as the damage threat tag "significant" should be improved. [Iterations 4, 12, 14]

<u>Cell 2A (timing)</u>: Rank 2 – From the forecaster perspective of characterizing risk using timing, IBW is ranked somewhat effective. IBW itself did not change or improve upon how timing information is communicated when compared to standard warnings, so this ranking of 2 applies to the standard warning as well. Timing information is provided in warnings in phrasing such as "At 630 PM CDT…A confirmed large and extremely dangerous tornado…", but the forecaster is not being specific on what time it will affect specific locations.

Pathcasts were a major point of discussion with forecasters, as EMs said that specific timing information is a critical missing element to current warnings. Even though the use of pathcasts is an option in WarnGen, no IBW offices use it. In a survey, 64% of IBW forecasters said that they were only "somewhat comfortable" or "not at all comfortable" using WarnGen storm motion to provide time of arrival to specific locations, while 90% said "no" or they were "not sure" that pathcast should be provided in warnings. These numbers can be misleading however, without taking into consideration focus group discussion about IBW forecaster feelings on pathcasts. During discussion, most forecasters were comfortable and willing to use pathcasts if they could build in location and timing fuzziness to the pathcast. For example, instead of saying that the tornado will arrive in Salina at 6:45 PM they would be more comfortable saying that the tornado will be around the Salina area or near Salina at 6:40-6:50 PM. Forecaster survey indicated that pathcasts should be valid for 15-30 minutes.

Interestingly, during a survey of non-IBW forecasters that *do* use pathcasts, only 15% (compared to 64% of IBW forecasters) said that they were "somewhat comfortable" or "not at all comfortable" using WarnGen storm motion to provide time of arrival to specific locations, while only 26% of non-IBW forecasters (compared to 90% of IBW forecasters) said "no" or they were "not sure" that pathcast should be provided in warnings. [Iterations 12, 14, 17]

Cell 3A (location): Rank 2 – From the forecaster perspective of characterizing risk using location, IBW is ranked somewhat effective. Like timing, IBW itself did not change or improve upon how location information is communicated when compared to standard warnings, so this ranking of 2 applies to the standard warning as well. Location information is provided in warnings in the "Locations impacted include…" section of the warning. Warnings also indicate where the storm or tornado was located shortly before the warning is issued and a direction of movement.

The location information is closely linked to the timing and pathcast discussion in the previous section. EMs need to know at what location and time a storm will occur; neither of these is currently specific enough to be very effective in helping EMs. [Iterations 12, 14, 17]

Cell 4A (duration): Rank 2 – From the forecaster perspective of characterizing risk using duration, IBW is ranked somewhat effective. Like timing and location, IBW itself did not change or improve upon how duration information is communicated when compared to standard warnings, so this ranking of 2 applies to the standard warning as well. Duration of an event can be implied from the expiration time of the warning. However, this information is not localized to an EM's area, but rather for a larger area of warning. [Iteration 14]

Cell 5A (history): Rank 2 – From the forecaster perspective of characterizing risk using history, IBW is ranked somewhat effective because some information on history can be included in the "Source" bullet (e.g., Spotter confirmed large tornado) and the timing and location line (e.g.,…dangerous tornado was located just south of Argonia…). However, forecasters commented during focus groups that the ability to add a spotter report was removed for IBW, making IBW less effective than a standard warning. Forecasters were in favor of adding a bullet into IBW to allow them to add spotter reports to the warning. [Iteration 14]

Cell 6A (confidence): Rank 3 – From the forecaster perspective of characterizing risk using confidence, IBW is ranked very effective. The damage threat tags options that forecasters can assign – none, significant, or catastrophic – allows forecasters to express their confidence of the threat's magnitude in the warning. This confidence is implied and not state directly, however, and is only for threat and magnitude and none of the other critical elements.

In IBW severe thunderstorm warnings, the phrase "Tornado…Possible" is an available option, but forecasters have varied opinions on when, why, and how it should be used. Some say they use it when they have low confidence that a tornado may occur, while others think of it for use in describing a time frame (imminent or in 30 minutes). Others think it should be used if the tornado will be weak (e.g., QLCS situation). Some forecasters think that usage of the phrase is confusing to EMs, yet 72% of IBW forecasters said they would use it in a warning. [Iterations 4, 5, 12, 14, 17]

Impact Assessment – From the forecaster perspective, how effective is the forecaster at communicating the impacts of the hazard?

Cell 1B (threat and its magnitude): Rank 3 – From the forecaster perspective of using the threat and its magnitude to assess impact, IBW is effective. Through IBW, the forecaster has the ability to relate what will be impacted, such as houses, cars, and power, by the threat. However, forecasters noted during focus groups and surveys that they felt that the impact statements weren't as well aligned as they could be with the damage threat tags and the actual impacts the storm would cause. For example, many thought that the impact statement for the base tornado warning (where no damage threat tag is used) was too severe sounding. Using that wording for weak tornadoes, and cold air funnels specifically, forecasters felt was not reflective of potential damage. Several forecasters mentioned that they did not think the hail damage impacts and damaged tree branch sizes were accurate either. Some forecasters also wondered what effect using the same impact statements over and over would have on their effectiveness. [Iterations 4, 5, 7, 11, 12, 14, 17]

Cell 2B-5B: Rank 2 – From the forecaster perspective of using timing, location, duration, and history to assess impact, IBW is somewhat effective. As noted in the previous section, IBW did not change how any of these critical elements were characterized, so the ranking of 2 applies to the standard warning as well. Without more specific timing, location, duration, and history information it is difficult for forecasters to give provide less generic impact information.

Cell 6B (confidence): Rank 3 – Forecasters were somewhat confident in using the current impact statements, so they are ranked as effective. Impact statements need to be adjusted as discussed in the threat and magnitude section. [Iterations 4, 5, 7, 11, 12, 14, 17]

Vulnerability Assessment – From the forecaster and EM perspective how effective is the assessment of vulnerability? Vulnerability builds on impacts, but it is more specific in timing, location, and type of damage. For example, impact tells you that trees will blow down. Vulnerability tells you what trees will be affected, how many will fall down, and at what time. Vulnerability assessment is not exclusively NWS's job, but NWS needs to give EMs the right information for them to be able to evaluate vulnerability.

Cells 1C-6C: Rank 1 – IBW is not at all effective in communicating vulnerability across any of the critical elements because the warnings do not provide guidance on exactly where and when the threat will happen. Assessing vulnerability is not only NWS's job, but the warnings as they are do not help EMs assess vulnerability.

Table 5: Evaluation of effectiveness within the risk communication component of the Risk Paradigm.

		D	E	F	G
		Risk Communication			
		Message Package/Receiving	Message Delivery	Operational Considerations	Confidence, Competence, Comfort
1	Threat and its magnitude	3	3	2	4
2	Timing	2	2	2	2
3	Location	2	2	2	2
4	Duration	2	2	2	2
5	History	2	2	2	2
6	Confidence	3	2	2	4

Risk Communication – Explanation of Rankings

Risk communication: The risk communication part of the risk paradigm is where NWS and EM come together and information is being handed off from NWS to EM. The goal is to convey risk knowledge about the event so that it creates a mutual understanding of the situation.

Message Packaging/Receiving – From the NWS side, examine the intent of the message and options that exist to package and convey the message. From the EM side, examine how EMs receive warning messages, what they do with that information, and what the warning tells them.

Cell 1D (threat and its magnitude): Rank 3 – From the NWS perspective, threat and its magnitude are effectively communicated through the IBW messaging packaging. IBW provides text in a format that uses spacing to differentiate various headings. This formatting allows the intent of the message, including the threat (hazard) and its magnitude (damage threat tag), to be conveyed in a way that is easier to find than in a block of text. Overall, forecasters seemed satisfied with the mechanism to select threat and magnitude information within WarnGen.

From the EM perspective, threat and its magnitude are effectively communicated through the IBW messaging receiving. EMs are able to identify the threat and its magnitude in various sections of the warning, although improvements should be made to move the section at the bottom of the warning that includes whether the tornado is observed or radar indicated, the tornado damage threat, and hail tags closer to the top of the page. The NWS's intent with this section is to convey important information, but since it's at the bottom it can go unnoticed or unread due to time restrictions. [Iterations 4, 5, 7, 11, 12, 14, 17]

Cell 2D (timing): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, timing information is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. From the NWS side, options exist that would allow forecasters to better convey timing information if the pathcast option in WarnGen is used.

From the EM perspective, timing information is critical. EMs take the warning message, and along with other tools such as radar, try to deduce their own time of arrival of the storm to their location. This indicates a major gap between what EMs need and what NWS provides. [All iterations]

Cell 3D (location): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, location information is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. From the NWS perspective, not many options exist to improve upon conveying location information within IBW since it is a text product. A graphical product would be ideal for conveying this information. In the meantime, it would be helpful if the way in which location information is listed across WFOs was consistent. Currently, WFOs may list many cities, or a few, and they may list them in the order that they are affected or in alphabetical order. In a survey, about 75% of forecasters thought that cities/towns should be listed by expected time of arrival. [All iterations]

From the EM perspective, timing information is critical. EMs take the warning message, and along with other tools such as radar, try to deduce their own time of arrival of the storm to their location. This indicates a major gap between what EMs need and what NWS provides.

Cell 4D (duration): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, duration information is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. Is there an option within WarnGen to list duration? [All EM iterations]

From the EM perspective, duration is important so EMs know when they will be able to go out and assess damage safely. They currently have to infer this information from information in the warnings and their interpretation of radar.

Cell 5D (history): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, information about storm history is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. Forecasters noted that in the standard warnings before IBW they were able to add a bullet with storm spotter information, and they would like to have this option available to them for IBW warnings. As with location, few options exist within a text product to effectively convey history information. [All EM iterations]

From the EM perspective, the history of the storm provides EMs with a better feel for what may impact them and increases their confidence. Many EMs get storm history from NWSChat or the SPC storm reports page, but some users of warnings (e.g., 911 dispatchers) depend solely on text products.

Cell 6D (confidence): Rank 3 – NWS could more clearly convey their confidence level in IBW, although there are not many options within WarnGen to do so. IBW allows forecasters to convey and implied confidence in several parts of the warnings (e.g., source, damage threat, observed/radar indicated).

From the EM perspective, EMs are searching for confidence levels from forecasters. They may be able to get this through other means such as NWSChat, but IBW does not directly provide this information. Terms that EMs are using to imply confidence, such as the damage threat tags, are open to interpretation.

Message Delivery – Examine how effective the delivery mechanisms are in getting the message to EMs, other options to deliver the message and how they compare in effectiveness in receipt and understanding (forecaster and EM perspective).

Cell 1E (threat and its magnitude): Rank 3 – The delivery mechanism for IBW is text pushed out to users through methods such as iNWS, NWSChat, EMWIN, etc. Using text to communicate the threat and its magnitude is effective, however this information could also be communicated effectively through graphics.

Cells 2E-6E: Rank 2 – The delivery mechanism for IBW is text pushed out to users through methods such as iNWS, NWSChat, EMWIN, etc. Using text to communicate timing, location, duration, history, and confidence is somewhat effective, but not ideal. It is very difficult to visualize much of this data after reading it in text, so a graphical product needs to be developed to convey this information.

Operational Considerations – Assess how easily and consistently NWS can develop and disseminate IBWs, determine if other options for delivering the warning are operationally possible.

Cells 1F-6F: Rank 2 – Both NWS and EMs have operational considerations to think about when issuing and receiving IBWs. From the NWS perspective, we did not hear any forecasters say that clicking the added options in WarnGen caused delay in issuing the warning. Some stated that having to think about which damage threat tag to use, and its associate impact statement, did cause them to stop and think for a few moments about what they were about to communicate was aligned with what they thought the storm would produce. This was especially true when deciding to use the catastrophic damage threat tag instead of significant.

From the EM perspective, we found that quite a few EMs do not actually read tornado warnings (IBW or standard), so this contributed to the somewhat effective ranking. Some EMs said that they do not read the warnings because they are out in their trucks spotting and don't stop to read warnings. Others said that just knowing a tornado warning was issued was enough for them, and they are busy enough doing other things to stop and read the warning. A remaining question is whether more EMs would make the effort to read the warnings if they contained more useful information, such as pathcasts, or were in a graphical format that better catered to providing information on the six critical elements.

Another operational is issues is the use of "Tornado…Possible" in IBW severe thunderstorm warnings. EMs first indicated that this was an issue in interviews and surveys before IBW became operational because some EMs must activate sirens any time "tornado" is mentioned in a warning. Interpretation of what the phrase meant was varied amongst EMs, and how and when it should be used varied amongst forecasters. This phrasing needs to be addressed.

Confidence, Competence, Comfort – Assess how comfortable partners were in using IBWs, examine the capabilities and competence of the intended audience when using warning info, determine how the personal confidence of the deliverer and receiver influence the effectiveness of messaging.

Cell 1G (threat and its magnitude): Rank 4 – Based on the limited number of events for IBW, EMs that read the warnings were comfortable using the IBW information to receive threat and magnitude information.

Cells 2G-5G: Rank 2 – IBW did not change how any of these parameters were conveyed, so the warning is somewhat effective at conveying this information as it relates to EM confidence, competence, and comfort.

Cell 6G: Rank 4 – As discussed in other sections, EM confidence increased when NWS used the damage threat tags because forecasters were giving EMs some idea of potential severity. Forecasters overall seemed confident in their decisions to use the damage threat tags, as the warning forecaster had an open discussion with other forecasters when using the significant or catastrophic tags.

Table 6: Evaluation of effectiveness within the risk management component of the Risk Paradigm.

		H	I	J
		Risk Management		
		Risk Perception	Decision-Making	Safety Actions
1	Threat and its magnitude	3	3	0
2	Timing	2	1	0
3	Location	2	1	0
4	Duration	2	1	0
5	History	2	2	0
6	Confidence	3	3	0

Risk Management – Explanation of Rankings

Risk Management: decisions and actions taken by EMs to protect lives and property based on their understanding of risk, societal factors, and resource availability. The understanding of risk is based on the risk characterization and communication by NWS.

Risk Perception: Examine how risk is perceived by the EMs when reading an IBW, if IBW allowed EMs to infer the appropriate level of risk to make proper decisions, and how effective IBWs are in conveying risk.

Cell 1H (threat and its magnitude): Rank 3 – IBW is effective at conveying the risk of the threat, as the damage threat tags and hazard sections of the warning give EMs a sense of the threat's magnitude unlike standard warnings. However, some interpretation by EM is still going on (e.g., what does "significant" really mean?), so there is room for improvement in communicating the risk of the threat. According to the surveys conducted at the Kansas EM conference, ~75% of EMs think damage tags will convey urgency (note: not necessarily risk) to the public. EMs say this is helpful to EM because people may take action that they otherwise would not have. [All EM iterations]

Cells 2H-5H: Rank 2 – IBW did not change how timing, location, duration, or history is communicated in warnings. These critical elements are not being well communicated, so they are only somewhat effective in communicating risk to EM. [All EM iterations]

Cell 6H (confidence): Rank 3 – To EMs, damage threat tags are an indicator of confidence of the forecasters, so an EM's confidence also increases. When significant and catastrophic damage threat tags are used they are effective indicators of risk to EMs. In a survey conducted before IBWs were operational, EMs said that the primary way IBWs will help is that they will give EMs a better sense of forecaster confidence, which in turn increases EM confidence. [All EM iterations]

Decision-Making: Examine what decisions EMs are making during a severe weather event and on what timeline, what knowledge is needed to make these decisions, evaluate if and how IBW changed EM decisions, what other information is needed by EMs in decision making.

Cell 1I (threat and its magnitude): Rank 3 – IBW is effective in providing threat and magnitude information for decision-making, but improvements to the warning, such as the wording for the damage threat tags could be improved. We had a limited number of cases in which to evaluate how IBW contributed to decision making, but we did find one decision made by an EM due to the catastrophic damage threat tag: an EM director had his fire department move all of their trucks out of the path of the approaching storm so that if the town got hit they could still respond. [All EM iterations]

Cells 2I-4I: Rank 1 – IBW did not change how timing, location, or duration is communicated in warnings. These critical elements are not being well communicated, so they are not at all effective in helping EM decision-making. [All EM iterations]

Cell 5I (History): Rank 2 – IBW provides some information on history to EM via the Source and the opening time/location/hazard sentence. However, this history is limited since it only talks about the most recent spotting or radar indication of the storm. Also, it can be hard to visualize this information from text information. [All EM iterations]

Cell 6I (Confidence): Rank 3 – IBW damage threat tags increase the confidence of EMs for decision making because EMs feel that tags are an indicator of forecaster confidence. The more confidence a forecaster conveys, the more confidence an EM has in their own decision making.

Safety Actions: Determine what actions by partners are desired by conveying risk information, assess if and how the warning intent reaches and influences behavior, assess what factors detract from the message intent on influencing actions.

All Cells: Rank 0 – Do not know enough to make evaluation. Due to the limited number of cases in 2012, we do not feel that we have enough information to really know if safety actions were influenced by IBW. Were any actions changed due to IBW?

5. Findings and Recommendations

In this section, we define "findings" as an educated assertion, or a hypothesis, based on what we hear numerous times from EMs. A recommendation is made when an action can be taken from a finding that will lead to improvement. In Table 7 you can see that we have findings and recommendations broken out by the components of the risk paradigm. A major finding comes from the vulnerability component, which received some of the lowest scores (all 1 rankings) in the matrix evaluation. This is because NWS is not yet consistently providing the information needed by EMs, specifically the six critical elements, for EMs to carry out a thorough vulnerability assessment for the purpose of managing risk.

Other important findings come in the operational considerations and comfort, confidence, and comfort components. For example, we learned that many EMs don't even read text warnings themselves because they are out spotting and instead depend on a 911 dispatcher to read the warning. This changes our perception of what information they may be receiving and possibly how we should be communicating it. In the comfort, confidence, and comfort component we heard from many EMs about informal cues, perceived or real, they receive from NWS. An example from one EM was that when he was told by a forecaster that they had a call with SPC later in the day he took that to mean that the situation was more severe. In reality, the call the forecaster was referring to was a standard update call with SPC that is held regardless of the severity of the event.

Table 7: Findings and recommendations for each component of the risk paradigm.

Risk Paradigm Component	Finding	Recommendation
Hazard	a. There are 6 critical elements that EMs need to know to understand risk and make decisions. EMs currently do not receive all of this information. If they do receive it, it can be difficult to interpret and apply to operations. 1. Threat/magnitude 2. Timing 3. Location 4. Duration 5. History 6. Forecaster confidence b. IBW gives forecasters a way to express their confidence and anticipated severity, which a standard warning does not allow.	a. Time, location, duration have a significant impact on EMs understanding of risk and therefore their preparedness and response. These parameters are not addressed in IBW. These need to be addressed as the next level of priority. Example: Forecasters should use pathcasts in warnings or develop another tool to communicated time, location, and location. Issuing discrete timing and location information is not necessary; issuing approximate timing and location information is acceptable.
Impact	a. In the limited number of events in 2012, many forecasters stated that they thought the impact statements should be examined and adjusted. Many were not sure if all of the impacts described were commensurate with the potential of the storm, especially on the low end (base and significant) impact statements. b. EMs think that the impact statements are more useful for the public than they are for EMs, as currently written. EMs like the impact statements for the purpose of informing the public. c. EMs prefer to get a "best guess" from NWS and then a qualitative description of the uncertainty.	a. Impact statements need to be more thoroughly examined to make operationally useful for EM and forecasters
Vulnerability	a. Vulnerability is not explicitly addressed by	a. For effectiveness EMs and NWS need

	NWS so EMs can have difficultly connecting the information NWS does provide to vulnerability and risk. b. There is disagreement amongst personnel on where NWS's job in describing vulnerability ends and the EMs job begins. c. Data sets to assess vulnerability or risk are not readily available to EM or NWS (e.g., population and critical infrastructure)	to dialog on how to connect specifics to vulnerability to determine risk. Hazard and impacts need to be characterized better to get to vulnerability.
Message Packaging/Receiving	a. Forecasters like the new IBW template, but there are parts of the old templates, such as the ability to type in information that is not canned, that they'd like to see in the IBW template. b. Forecasters had some hesitancy in deciding when to elevate a warning from base to significant and from significant to catastrophic. This was due in part to the newness of IBW and forecaster consideration in making the impact match what they thought was going to happen. c. Forecasters like having the ability to express severity through a tiered system. d. EMs feel that the word "significant" is overused in NWS products, so it doesn't have much of an impression on them anymore.	a. From EM perspective, tiering conveys better levels of risk and confidence, though its total effectiveness is uncertain due to lack of events. R: Continue exploring the use of IBW tiering. b. Word "significant" is overused – another word needs to be used. c. Move tags at bottom to the top of the warnings d. Clarify with forecasters and EMs the difference between "Radar indicated" vs. "Radar confirmed" e. Reformat warning for clarify and emphasis
Message Delivery	a. EMs are starting to use social media such as Facebook. b. EMs rely heavily on NWSChat to understand the message itself as well as the tone of message.	a. Warnings need to be communicated in other modes (iNWS, NWSChat, Facebook) than a text message.
Operational Considerations	a. Many county EM directors do not read a warning message because they are out spotting, so IBWs don't influence them much unless they listen to a dispatcher read it over the radio. b. EMs that do read the warning message can have trouble finding the information they need amongst the other details, such as preparedness statements and impact statements, that while useful for the public, can make the message long. c. EMs say something is needed between a watch and a warning because there is normally several hours between the two, so when a warning is issued it can happen suddenly.	a. Consideration of creating something that goes between a watch and a warning is warranted to enable EMs to better prepare in time and space rather than just waiting for the warning to happen. b. Consider breaking message into two pieces: short part with most important details first, then go to second part for details. iNWS is on the right track, but also needs to be done for other modes of communication.
Competence, Comfort, Confidence	a. The level of competence, comfort, and confidence in using IBW could have been higher with more outreach. Many in the EM community that use warnings, such as dispatchers, were not aware of IBW. b. EMs take cues, correct or not, from NWS actions. For example, if a phone briefing	a. Improve outreach, such as developing a better web page to explain IBW and increasing distribution of information, to EM community to increase competence and understanding. b. Consideration of formalizing the

	is going to be held versus a briefing that is only emailed then EMs' sense of severity immediately increases. c. Every county has their own siren policy. These range from activating sirens when a severe thunderstorm warning includes "Tornado…Possible" to only activating when a tornado is observed, regardless of whether a warning is issued or not.	informal conveyance of confidence and increase in risk. EMs currently take cues from differences in action by NWS (e.g., phone briefings vs. emailed briefings). c. If one doesn't exist already, develop inventory each county's tornado siren policy and what triggers (criteria and who turns it on) siren. Know how the warning message is reaching the person that activates the siren. Example: "Tornado…Possible" tag and how jurisdictions use this information: do they activate their sirens for this tag?
Risk Perception	a. EMs indicate that they are missing vital pieces of information to truly assess risk. They are interpreting the information as best they can, but would prefer to get an easy-to-understand "best guess" from NWS.	- No recommendation for NWS. Taking into consideration the previous recommendations will help improve risk perception by EM.
Decision-Making	a. We did not have enough events in 2012 to fully assess whether IBW made a difference in EM decision making. However, one example of a decision that was taken as a direct result of IBW was on April 14 when a county EM director moved all the fire trucks and ambulances in one of his cities to an area out of the potential path of a tornado because the "catastrophic" damage threat tag was used for the county to his west. The tornado lifted before reaching his county, but the tag caught his attention, told him it was a serious situation, and lead to the decision. b. Many factors can go into an EM's decision making process beside weather information, including politics and past experience.	- No recommendation for NWS. Taking into consideration the previous recommendations will help improve decision-making by EM.
Safety Actions	a. With very few events in 2012, we were not able to fully assess safety actions taken as a result of IBW.	- No recommendation for NWS. Taking into consideration the previous recommendations will help improve safety actions by EM.

6. Appendix I: Iterations Summaries

#	Iteration Name	Iteration Description and Summary
1	Pre-IBW March EM Focus Groups	One EM focus group was conducted in each of the five IBW areas in mid-late March before IBW warnings were operational. The focus groups were conducted by WFO staff with guidance from the WxEM team. The goal of the focus groups was to establish a baseline understanding of EMs' decisions, processes, and usage of weather information before they began using IBWs.
		Summary: First started hearing about the critical elements EMs need to make decisions (six elements were eventually identified). Verified that EMs are using many tools – NWS and non-NWS – to figure out what they need to know because they cannot get everything they need from one place. Some EMs stated they were very dependent on TV mets because social media information is broadcast, which is information many EMs don't have access to. First indication that some EMs do not actually read warning text because of operational considerations. First indication that something is needed between a watch and a warning. EMs use the level of briefing (email vs. conference call) to cue them in on how severe the event will be.
2	Pre-IBW March EM Phone Spot Check	93 EM and media partners in the IBW test area were contacted via phone by WxEM team members to determine if the outreach for IBW was effective, i.e., did partners know about IBW and if so, what did they know?
		Summary: Outreach about IBW needs to be improved since ~40% of partners we contacted hadn't heard about IBW. It was assumed the EM directors had passed IBW information on to others in their community, but this often did not happen. Feedback in general was that partners thought it would be helpful for the public, not necessarily for the EM and media themselves.
3	Pre-IBW Missouri EMA Conference	A paper survey (77 completed) and multiple instant response surveys (119) during breakout sessions were administered at the Missouri EM conference April 4-5. Informal interviews (10) were also conducted at the NWS booth. The goal was to establish a baseline understanding of EMs' decisions, processes, and thoughts on IBW before any IBWs were issued.
		Summary: Surveys indicated that the primary way that IBW will be helpful to EMs is that it (specifically damage threat tags) will give them more confidence in the forecast. Hazard and impact information are more useful than source information. First indication that there is an issue with the usage of "Tornado…Possible" in severe thunderstorm warnings. First indication that EMs think that the number of warnings issued is appropriate, i.e., NWS does not overwarn. Those interviewed thought IBW is a good idea because it gives them more information as to what NWS is thinking. EMs are desperate to know NWS "gut feeling".
4	Pre-IBW Forecaster Interviews	Forecasters at three of the five IBW offices were interviewed in early April before any IBWs were issued. The goal was to establish a baseline understanding of forecaster processes and gather initial thoughts on IBW.
		Summary: There is a wide range of opinions among forecasters as to what EMs do and who they are. Forecasters generally felt that trying IBW was a good idea because something needs to be done to differentiate between storms, and were interested in seeing how it would work in a real event. Providing enhanced wording indicating that something is different is key to getting people's attention. Some concern as to NWS speculating on impacts. Some believe that IBW will have no effect on EMs and that its primary benefit is to media – hopefully media will use the stronger language to instill in people that it's not a normal situation. Some concern that people won't respond to warning unless it's sig or cat.
5	April 14 EM Interviews	Shortly after the April 14 tornado outbreak in Kansas, EMs were interviewed in person (17) and via phone (8) to learn about the processes of EMs during the outbreak in general and if and how IBWs were used for the event.
		Summary: All EMs were aware of IBW. Public and EM awareness of severity of event was due to days of advanced notice from media, SPC, local office outreach. One EM in Wichita's area said that people told EM they took the warnings seriously because of the enhanced language, but this could also be attributed to increased sensitivity after Joplin. Dispatcher liked format, easier to read. Overall, IBW did not have much of a direct impact on EM actions, but EMs like getting this information. The actions of one EM were

		changed when he saw catastrophic in the warning – emptied fire and EMS stations so they could still respond if the town was hit. Whether the tornado is radar indicated or observed makes a difference in people's minds. Font formatting could be changed to highlight important sections.
6	April 14 Media Interviews	Shortly after the April 14 tornado outbreak in Kansas, eight media partners (TV and radio) were interviewed in person to learn about media processes during the outbreak in general and if and how IBWs were used for the event.
		Summary: Overall, positive about IBW, but hope it's only the first step. Did not change anything TV media did on April 14 b/c they were already doing much of what IBW does. Build up in the days leading up to April 14 saved the most lives, not IBW. Worried about complacency using the same phrasing repeatedly. Will help radio stations because they don't have meteorologists. Many media don't use SVS because they're just polygon updates, so need to issue any upgrade in damage threat in a new TOR. Some impact statements seem over the top. Need to make important parts of message stand out, maybe bold. Would like pathcast information because the warning can quickly become old and past a location. TV suggests pathcast of 15 min. NWSChat is critical to TV mets. Radio stations don't seem as engaged as expected with NWS, TV mets, and weather info in general.
7	April 14 Forecaster Interviews	Shortly after the April 14 tornado outbreak in Kansas, forecasters at the WFOs in Topeka and Wichita were interviewed to learn about the warning process and how IBWs were used and if they impacted forecaster decisions.
		Summary: Decisions to use catastrophic were made after discussion with other forecasters. Still a question on when to use catastrophic – how big does a town need to be to meet threshold? Radar confirmed vs. radar indicated option in WarnGen – some confusion.
8	April 27 EM Interviews	At least two brief and weak tornadoes occurred on April 27 in the Topeka CWA. Nine EM partners – some had tornado warnings issued for their county, others didn't – were contacted to see if and how they used IBWs.
		Summary: EM for one county didn't use IBW warning – his spotting reports to NWS are what caused the warning to be issued. Likes IBW though because having harsher language in warnings for the public helps him. Dispatcher for his county did read IBW word for word, although he hadn't heard of IBW before. Would like better, easier to read formatting. Another EM said that she did not read the warning because she was out spotting, but dispatchers did. A third EM said that he doesn't normally read warning because he just takes action (activates siren), but once he was told about IBW and read one issued for his county he stated that he may begin reading the warnings because they are more useful and easier to read than past warnings.
9	May 19 EM Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. EMs from two counties that were affected were interviewed to see if and how they used IBWs.
		Summary: Severity of storms surprised EM, sheriff, and dispatcher. Did not use warning because they were the trigger for the warning. Tornadoes were supposed to be very weak (landspouts), but they were more severe. EM was reporting that they were "true" tornadoes, but media and NWS were not accepting this and their reports were not making it into warnings.
10	May 19 Media Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. Two TV media partners (from the same station) were interviewed to see if and how they used IBWs.
		Summary: Not completely surprised to get warning, but more surprised that tornadoes continued. Paid more attention to IBW for this event than on April 14 because TV met was more used to IBW. Has heard from public that they took it more seriously because the TV mets have been talking about it more.
11	May 19 Forecaster Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. The warning forecaster for NWS Wichita was interviewed to learn about his warning process and use of IBWs.
		Summary: Used "Tornado…Possible" because expecting landspout situation. Once he received reports of observed tornadoes issued TOR. Contemplated issuing significant damage threat tag for one cell because saw debris signature on dual pol, but it weakened quickly. At first thought the impact for the base tornado warning was overkill, so he added "rope" to downplay.
12	August Forecaster Survey	A forecaster survey was administered to IBW offices in August to gauge forecasters' opinion and comfort level on various gaps identified in early iterations. 51 responses were received. Preliminary results were used to inform focus groups conducted later in the month.

		Summary: About 75% of forecasters feel that the damage threat tags communicate threat "very well" or "well" and most feel that the impact statements are aligned with the damage threat tags "to a great extent," although some work is needed to tone down some of the language (base impact statement especially). About half of forecasters said that the wording of the impact statements affects their choice of damage threat tags because it makes them think about whether the impact statement is really the message they want to send to people and their confidence level of whether the tornado is on the ground and causing widespread damage. The comfort level of IBW forecasters was medium to low when asked about providing pathcast information using WarnGen, and only 10% of forecasters thought pathcasts should be provided in warnings).
13	August EM Focus Groups	One EM focus group was conducted at each of the five IBW offices in late August. The goal was to address gaps that were identified in early iterations and to discuss ideas for prototypes to address these gaps.
		Summary: The six critical elements of information that EMs need to make decisions were verified (had heard about these frequently in previous iterations): hazard/how big, timing, location, duration, history, and forecaster confidence. When asked to describe the perfect product for decision making, all EM focus groups (as well as forecaster focus groups) came up with the same idea: a graphical tornado warning overlaid on a map that includes the six critical elements. Although there are operational considerations to using a graphical warning (e.g., looking at it while driving and spotting), EMs felt that this type of product would provide the information they need and that it would be worth their time to stop and look at it.
14	August Forecaster Focus Groups	One forecaster focus group was conducted at each of the five IBW offices in late August. The goal was to address gaps that were identified in early iterations and to discuss ideas for prototypes to address these gaps.
		Summary: Ideas for prototypes that were brought forth (unprompted) were very similar to those discussed at the EM focus groups, i.e., a graphical tornado warning that conveys timing, location, duration, history, and forecaster confidence. Forecasters also said that impact statements need to be adjusted, such as damage caused by hail and 1" branches. Forecasters were comfortable using pathcasts if they could include fuzziness in the time, shorten the time duration of the pathcast.
15	KEMA EM Survey	Paper surveys were administered at the Kansas EM conference in mid-September. The goal was to gather feedback from EMs on gaps identified in earlier iterations to help inform prototype development. 53 responses were received.
		Summary: Three-quarters of EMs agree or agree completely that damage threat tags convey urgency to the public and 70% disagree or are neutral that the public will become complacent after hearing a number of warnings with tags. About half of EMs agree that people will only take notice of a tornado warning when the damage threat tag is significant or catastrophic. Verified past finding that EMs find the number of warnings issued by NWS to be appropriate and that a false alarm will not likely influence future decision-making.
16	Non-IBW EM Survey	A survey for EMs in five non-IBW areas in Central Region was administered in late September. The goal was to gather feedback on IBW, various gaps identified in earlier iterations, and the warning system in general from a new group of EMs to use as comparison to EMs involved in IBW. 252 responses were received.
		Summary: 81% of EMs agree or agree completely that damage threat tags convey urgency to the public. EMs are divided with 50% agreeing or agreeing completely and 50% neutral or disagreeing that people will become complacent after hearing a number of warning with tags. There was a similar split on whether people will only take notice of warnings when there is a damage threat tag. The results verified past finding that EMs find the number of warnings issued by NWS to be appropriate.
17	Non-IBW Forecaster Survey	A survey for forecasters in five non-IBW offices in Central Region was administered in late September. The goal was to gauge non-IBW forecaster feedback on gaps that were identified in earlier iterations. This survey matched the one given to IBW forecasters in early August. 28 responses were received.
		Summary: Non-IBW forecaster results were especially interesting when compared to IBW forecaster results for questions dealing with pathcasts, as the majority of non-IBW forecasters were in favor of using pathcasts and were comfortable doing so. Almost 79% responded that severity will not be communicated sufficiently without a tag and 57% said urgency will not be communicated sufficiently without ta tag. Also, 64% of non-IBW forecasters thought that the damage threat tags communicate threat "very well" or "extremely well" compared to 37% of IBW forecasters.

7. References

Beck, K., and W. Cunningham, 1989: A laboratory for teaching object-oriented thinking. *Conference on Object-Oriented Programming: Systems, Languages, and Applications*, New Orleans, LA. [Available at http://c2.com/doc/oopsla89/paper.html]

Federal Emergency Management Agency (FEMA), 2008: National Response Framework. Accessed at http://www.fema.gov/emergency/nrf/ .

Federal Emergency Management Agency (FEMA): IS-1 Emergency Manager: An Orientation to the Position. Accessed at http://training.fema.gov/emiweb/is/is1lst.asp

National Research Council Committee on Improving Risk Analysis Approaches Used by the U.S. EPA, National Research Council. "Front Matter." *Science and Decisions: Advancing Risk Assessment*. Washington, DC: The National Academies Press, 2009.

National Research Council Committee on the Institutional Means for Assessment of Risks to Public Health. "Front Matter." *Risk Assessment in the Federal Government: Managing the Process*. Washington, DC: The National Academies Press, 1983.