# APPLICATION OF THE EF-SCALE IN DAMAGE SURVEYS

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## I. INTRODUCTION

On 01 February 2007, the National Weather Service in the USA implemented the Enhanced Fujita Scale (hereafter known as the EF-Scale) as the main tool to estimate tornado intensity. The transition from the F- to the EF-Scale serves two functions: 1) adjust the wind speed estimates closer to our best understanding and 2) to provide more guidance for surveyors in the form of more Damage Indicators (DIs) (McDonald and Mehta, 2006). The EF-Scale is designed to accommodate new DIs. The greater number of DIs provides both an opportunity and a challenge to surveyors. The challenge is to effectively conduct a survey with a more complicated tool without suffering from increased workload. The opportunity is greater precision in damage surveys when the EF-Scale is combined with GIS-based surveying techniques. In this presentation, we describe how the challenge is addressed in both training and implementation of the EF-Scale in addition to sharing some experiences of damage surveying with this new scale.

## II. A BRIEF DESCRIPTION OF THE EF-SCALE

The EF-Scale contains 28 DIs including a wide variety of artificial structures (e.g., houses, retail stores, office buildings, transmission line towers, schools), and two vegetation categories (softwood and hardwood trees). For each DI, Degrees of Damage (DODs) describe the damage and the associated range of wind speed estimates. Typically the lowest DOD indicates the level at which damage begins whereas the highest DOD corresponds to a wind estimate in the EF5 range, or the DI has been completely destroyed at lower wind speeds. Most increasing DODs correspond to a higher estimated wind speed; however some adjacent DODs simply describe different types of damage to a DI without a significant increase in wind speed estimates (Fig 1).

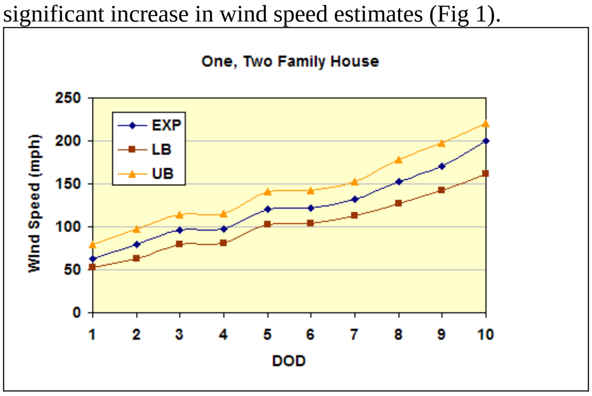


FIG 1. DODs for a One- and Two Family House vs. Lower Bound (LB) wind speed, Expected wind speed (EXP), and Upper Bound wind speed (UB).

A surveyor would identify the DI, match the DOD to the scene, and then estimate the wind speed between the lower- and upper-bounds for the given DOD depending on the quality of construction. For example, a poorly constructed house may exhibit a DOD corresponding to a lower bound wind speed. A final step for rating a DI would be to match the wind speed estimate to an EF-Scale rating. Figure 2 shows the EF-Scale wind speed ranges for each rating. Surveyors continue to rate the entire tornado event by picking the highest accurately rated DI.

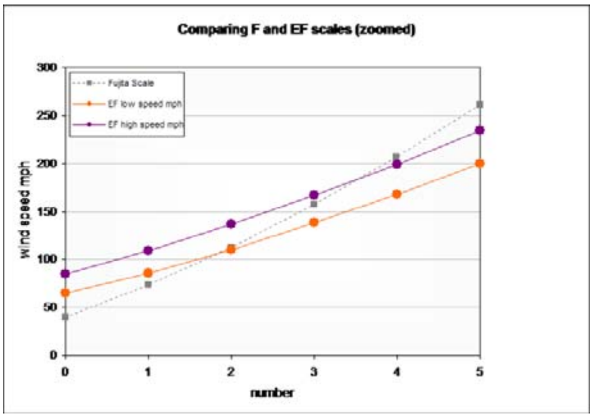


FIG. 2: Lower- and upper-bound wind speed vs. rating for the EF-Scale in solid lines. The lower bound wind speed vs. rating is indicated for the F-Scale in a dotted line.

The EF-Scale is designed for flexibility. There is the capability to add new DIs as needed (e.g., standard housing types for different regions worldwide). Following an established methodology (e.g., McDonald and Mehta, 2006) in creating a new DI, this scale has the capability to be adaptable to diverse construction types and building codes. Wind speed estimates vs. DODs are also subject to modification should better guidance suggest a change.

## III. SOLUTIONS TO THE CHALLENGES OF THE EF-SCALE

The EF-Scale confronts surveyors with an order of magnitude more complexity than the F-Scale. How to educate a surveyor in its use required a need for a blended training approach with two online asynchronous lessons, a PC-based toolkit called the EFkit, and an online forum (LaDue and Mahoney, 2006). The asynchronous lessons provide an introduction to the EF-Scale along with proper surveying techniques. The EFkit provides a surveyor with a dual purpose tool to use during the online training and during an actual survey. The online forum serves as continuous training through the sharing of ideas and lessons learned after surveys. The training resources are available online at http://www.wdtb.noaa.gov/courses/ef-scale/ .

The EFkit is designed to help a surveyor quickly navigate to the correct DI, then the correct DOD, estimate the wind speed, and then rate the structure Where possible the EFkit allows the user to peruse several examples of a particular DOD. Several surveyors have let the authors know that the EFkit has been very useful in cutting down the time of rating structures in the field. The alternative is to spend more time paging through a thick manual for each structure that a surveyor investigates. The current version of the EFkit works with a laptop running Windows-XP. For more portability, there is a beta version of the EFkit designed to work on a Windows CE based VGA PDA with a 480 X 640 pixel screen.

## IV. OPPORTUNITIES FOR ADVANCED DAMAGE SURVEYING

Numerous DIs with the EF-Scale allow a surveyor to create more detailed analysis, especially when equipped with the ability to tag images with precise latitude and longitude location (termed geotagging images). The first author had the opportunity to test the EF-Scale's ability to geotag and analyze numerous structures while on several surveys including the 02 February 2007 Florida tornado, and the Enterprise, Alabama tornado of 01 March 2007. The author carried: 1) a laptop equipped with Delorme Street Atlas™ with GPS, 2) a VGA PDA equipped with a Bluetooth GPS, GPS logger, and the EFkit, and 3) a digital camera time synched to the GPS time. The GPS log can be used to geotag each image taken on the scene (an example GPS log is shown in figure 3. With aerial photographs geotagged, each structure within the image can be easily located with referenced aerial imagery often found in applications such as Google Earth™ or available from government sources. Surface-based photographs can be associated with rated structures and geotagged and combined with the aerial imagery in order to create a GIS-based map of damage for which more sophisticated analysis of tornado damage can be done at a later date.

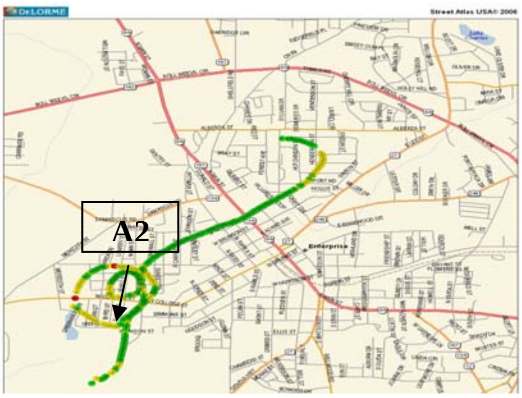


FIG 3: A GPS track of one segment of an aerial survey of the Enterprise, AL tornado. The arrow labeled A2 shows the location of the photograph in figure 6.

As an example of such a damage survey, the author used the GPS track of an aerial survey of the Enterprise, AL tornado (Fig. 3) to geotag aerial photographs (e.g., Fig. 4) in order to create a GIS-based overview of damaged structures along the path of the tornado as it passed through Enterprise. Such a database can be used to more precisely map the tornado path with respect to other meteorological data. In figure 5, the damage path has been overlaid onto 0.5 degree reflectivity image from the Ft. Rucker WSR-88D in order to show the relative size of the debris ball signature with respect to the actual damage path.

FIG 4: Aerial photograph marked A2 in figure 5 showing two one- and two- family residences destroyed by the tornado.

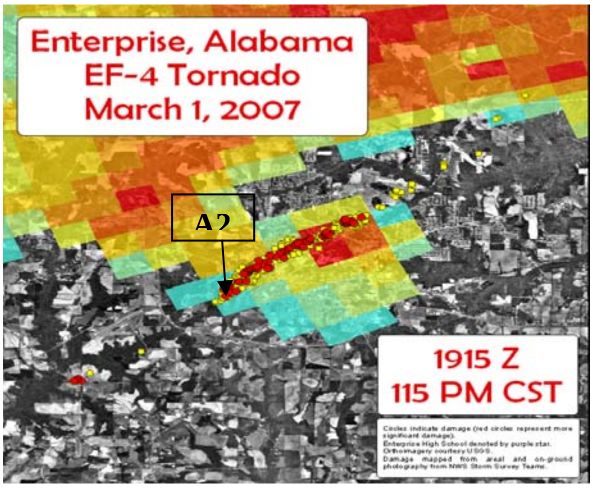


FIG 5: The damage track of the Enterprise, AL tornado superimposed on the 0.5 degree reflectivity product from the Tallahassee, FL WSR-88D. The yellow (red) circles represent EF0-1 (> EF1) damage. The label A2 represents the destroyed houses in figure 4. Map courtesy of Parks Camp, WFO TLH.

## V. AKNOWLEDGMENTS

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## VI. REFERENCES

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