Possibilities for Improvements to the EF Scale

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Remote-Sensing Wind Damage Surveys

- Womble (2005) created RS Scale to categorize remote-sensing damage states

Damage Rating	Most Severe Physical Damage
RS-A	No apparent damage.
RS-B	Shingles/tiles removed, leaving decking exposed.
RS-C	Decking removed, leaving roof structure exposed.
RS-D	Roof structure collapsed or removed. Walls may have collapsed. (Oblique imagery may be needed to determine wall condition.)

- Improved resolution—up to 3 in. spatial resolution for aerial photographs commercially
- Major events commonly flown
- Georeferenced

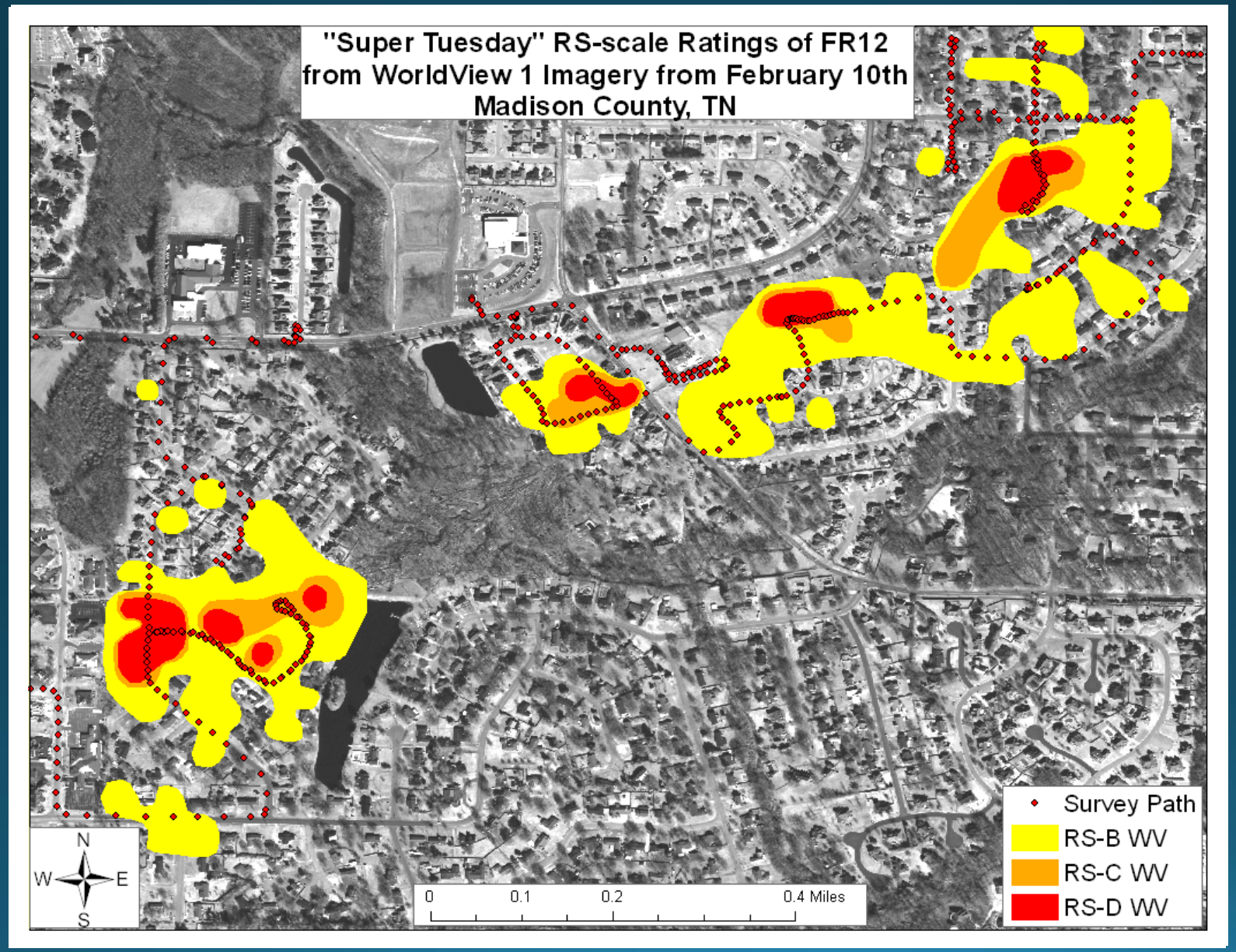
Remote-Sensing Wind Damage Surveys

Images Courtesy of DigitalGlobe Inc.

Remote-Sensing Wind Damage Surveys

Images Courtesy of Pictometry Inc. and NOAA

Remote-Sensing Wind Damage Surveys



Remote-Sensing Wind Damage Surveys

- 144 statistical models developed
- Best model from Brown et al. 2012:
  - $DOD = 0.1656 * RS^2 + 1.070 * RS + 0.2654$
  - $R^2 = 0.6795$
- Dataset does not include any EF4 or EF5 damage

Need New DIs

- Not many objects in rural areas to determine damage
- Other items commonly damaged—including non-buildings

Courtesy of Jim LaDue

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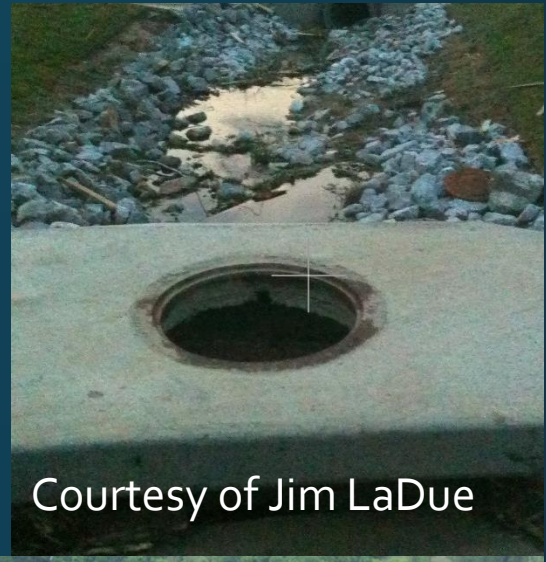
Need New DIs

- Possibilities:
  - Parking stops
  - Manhole covers
  - Rail cars
  - Grain bins
  - Bridge collapse
  - Vehicles
  - Irrigation systems
  - Churches
  - Vegetation scouring
  - Pavement scouring—Noda et al. 2013
  - Canadian Dis: transmission lines, heritage churches, solid masonry houses, sheds/fences/lawn furniture


Courtesy of Jim LaDue

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Need New DIs & DODs

- Need more DODs for existing DIs to increase consistency of ratings
  - 15-20+ mph gaps between DODs for one- or two-family residences (FR12), apartment/condos/townhouses (ACT), many others
  - 65+ mph gap between DOD 9 & 10 for mid-rise and high-rise buildings (MRB, HRB)

2. ONE-AND TWO-FAMILY RESIDENCES (FR12)
(1000 – 5000 sq. ft.)

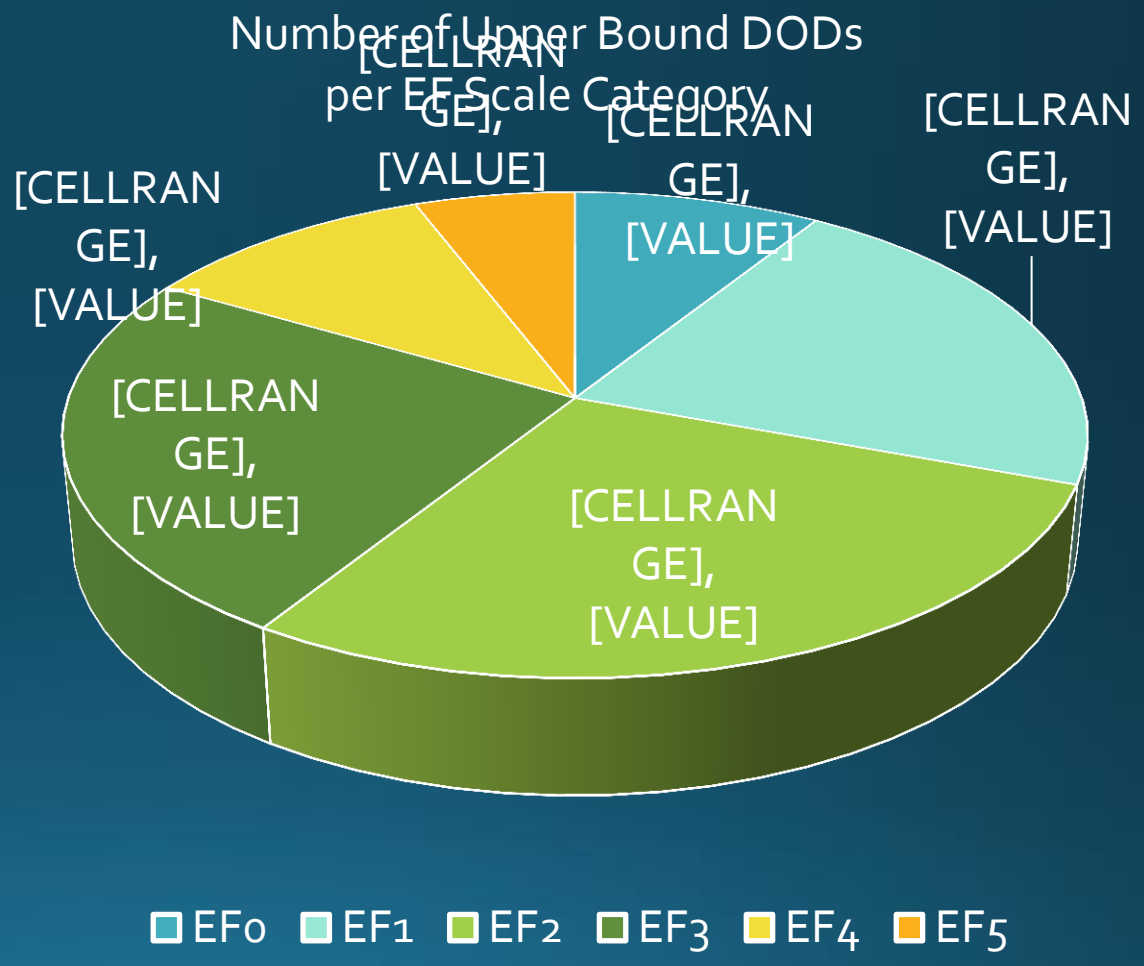
Typical Construction

- Asphalt shingles, tile, slate or metal roof covering
- Flat, gable, hip, mansard or mono-sloped roof or combinations thereof
- Plywood/OSB or wood plank roof deck
- Prefabricated wood trusses or wood joist and rafter construction
- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete panels
- Attached single or double garage

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

Need New DIs & DODs

- Need more DIs or more DODs for existing DIs that extend to higher wind speeds—not completely destroyed at EF1-EF3 level??
  - Only 13 / 222 total DODs can be used to obtain an EF5 rating (max DOD for respective DI)
- Need more DIs or more DODs for existing DIs that include lower wind speeds??
  - Only 20 / 222 total DODs can be used to obtain an EF0 rating



New DIs & DODs caution!

- Must have a way to determine or estimate wind speed-damage relationship!!!
  - Engineering calculations
    - Must be normalized to 3-second peak gust
    - 33ft (10m) above ground
    - Exposure C (open terrain)
    - Relate to building code wind speeds (wind pressures from ASCE 7)
  - Measurements—in-situ or remotely-sensed
  - Laboratory testing

Forensics

- Determining wind speeds from engineering load analysis
- Can be used for damaged objects with known material and connection load capacities

Courtesy of Jim LaDue