Data: Notional DoD installations and potential system failures

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Outline

- Background
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Background

- Military installation resilience: capability of a military installation to avoid , prepare for, minimize the effect of, adapt to, and recover from extreme weather, and environmental conditions.

- Mapping failure and recovery pathways during extreme and compound events and examining the system functionality and resilience of military installations is essential for mission assurance and decision support.

- Data on notional military installations and simulated test cases of potential system failures can offer critical information on system functionality and resilience.

Objective

- Model notional military installations and potential system (and compound) failures to investigate energy resilience in military installations

E.g., Fort Wainwright military installation

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Method

- Build out scenarios and data sets of notional military installations, power/energy use and potential impacts under compound extreme events (e.g., tornado, wildfire, etc.).
  - E.g., compound extremes for an artic installation that might experience acute and chronic events, with potential features such as coping with permafrost thaw (chronic) and wildfires (acute), coupled perhaps with a cyber-attack (acute) and on-going pandemic (chronic)

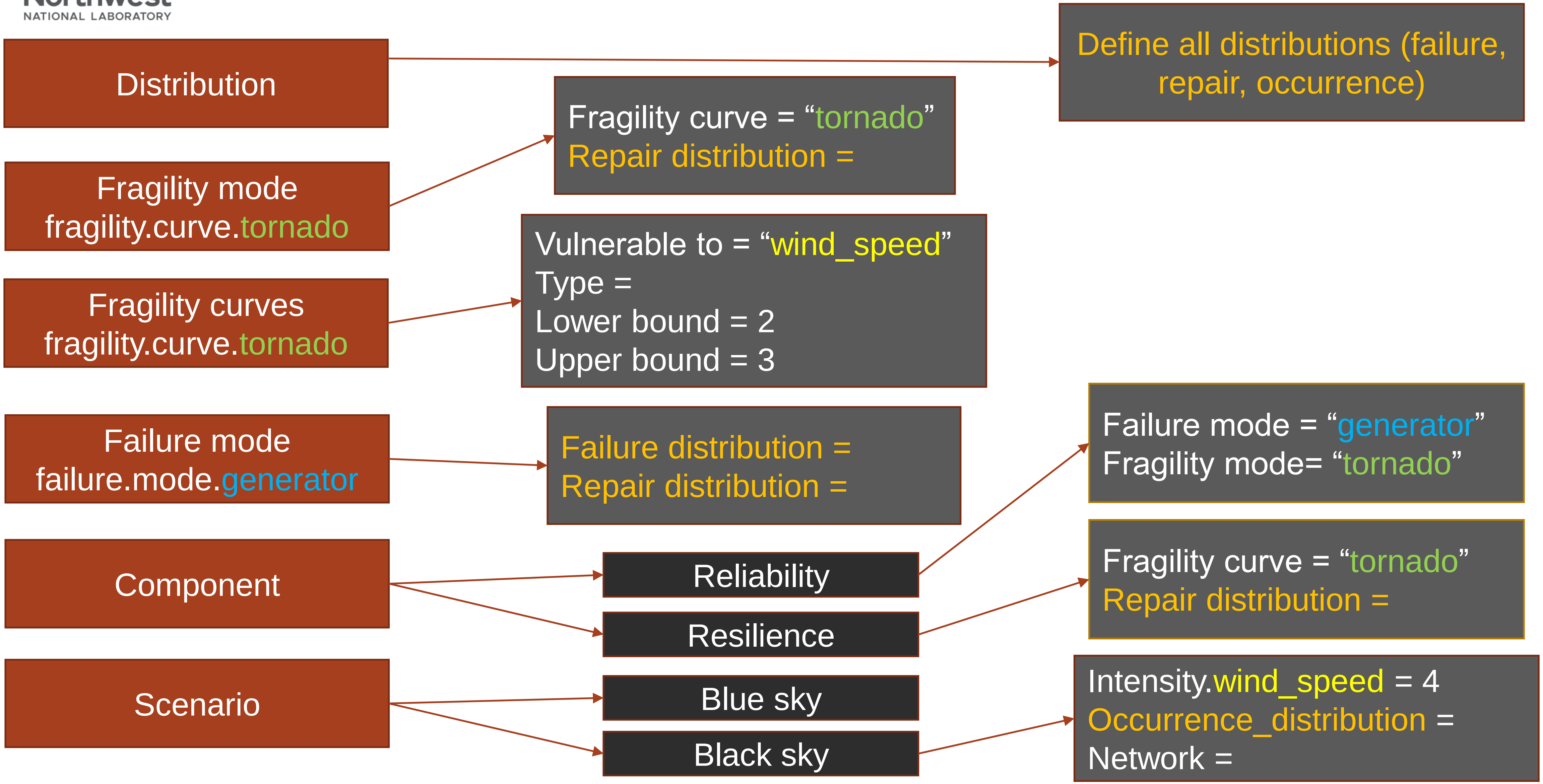
Acute	Chronic	
	C1 (Permafrost Thaw)	C2 (On-going Pandemic)
A1 (Wildfire)	Wildfire / Permafrost Thaw	Wildfire / On-going Pandemic
A2 (Cyber-attack)	Cyber-attack / Permafrost Thaw	Cyber-attack / On-going Pandemic

Method

- Use of ERIN (Energy Resilience of Interacting Networks) tool
  - A resilience calculation tool used by DoD to simulate energy flows through interacting network of components in military installation systems
  - The tool accounts for both reliability (failure and repair) as well as resilience to various scenarios while providing key energy usage, resilience, and reliability metrics

- Define scenarios as inputs to the ERIN tool and simulate energy flows though the network of components at Ft. Illinois military base

ERIN Framework



ERIN Execution

The simulation engine is a command-line program.

The input file format is written using the TOML, a plain-text input file format.

The file contains entries for loads (.csv file for each component), component attributes, fragility modes, distributions, failure modes, scenarios, etc.

Use the command prompt to run the application file erin_multi.exe using the TOML file as the input.

```
[loads.load_id_1]
...
[loads.load_id_2]
...
[components.comp_id_1]
...
[components.comp_id_2]
...
[fragility.fragility_id_1]
...
[dist.dist_id_1]
...
[failure_mode.fm_id_1]
...
[networks.nw_id_1]
...
[scenarios.scen_id_1]
...
```

Setup (Ft. Illinois military base)

- ~60 different buildings/components each including subcomponents such as chilled water, electricity, steam, generator outflow/inflow, etc.

- Simulate data under various adverse events which are categorized into two groups, blue-sky (more ideal events) and black-sky (compound extreme events)
  - Our focus is majorly on black sky events (i.e., tornado with different wind intensities). The events are defined using a set of input specifications (e.g., duration of the scenario, the occurrence distribution, and the damage intensities).

- Define notional specifications for the system (e.g., the network of components, component physical characteristics, component failure modes, component fragility, and how components are connected to each other)

Results

- Output includes energy demand (chilled water, electricity, steam, water and the corresponding energy availability under the simulated blue-sky and black-sky events
  - Energy availability
  - Maximum downtime
  - How much energy was requested but not achieved

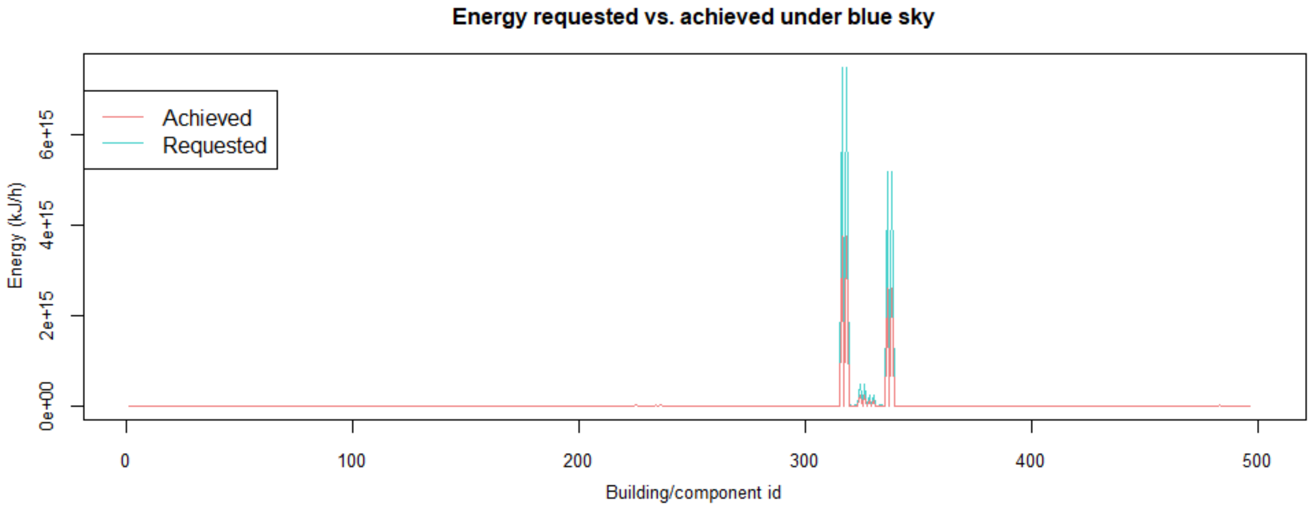
Results (a simulated “tornado” event at Ft. Illinois.)

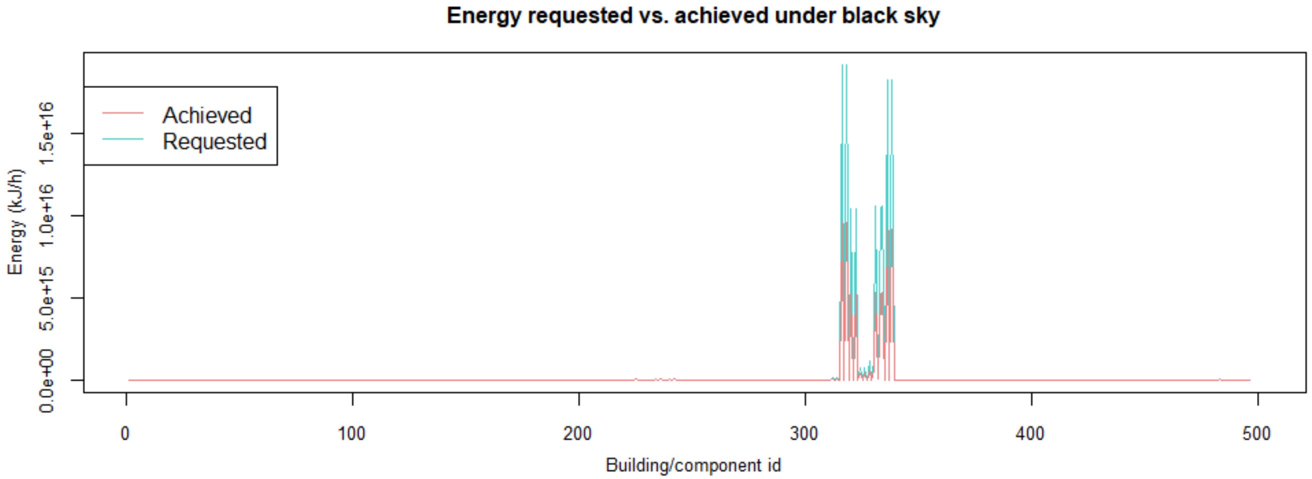
- Setup: "Tornado" scenario with different wind intensities
  - Duration = 14 days
  - Max number of occurrences = 10
  - Intensity of the wind speed (mph) = 155.0
  - Intensity inundation depth (ft) = 6.0

- We defined the scenario's damage intensity and the chance that a given component would fail under the scenario.

- Output: energy demand (chilled water, electricity, steam, water and the corresponding energy availability) for 8,760 hours (i.e., a full year)

Results (a simulated “tornado” event at Ft. Illinois.)





The energy availability (requested energy and achieved energy) in each building/component in the network under blue-sky (more ideal events) and black-sky (tornado) scenario.

Black sky

- Energy not served (kJ/h): 6.555905×10^{16}
- Energy requested (kJ/h): 1.311441×10^{17}

Blue sky

- Energy not served (kJ/h): 2.161557×10^{16}
- Energy requested (kJ/h): 4.341693×10^{16}

Future work

- Explore, identify, and define attributes for compound events (e.g., wind speed, inundation depth, etc.) to simulate scenarios that emulate real world compound extremes.
- Explore, identify, and define failure and fragility attributes for the components in the network (e.g., muxer, storage, converter, etc.) to emulate real world scenarios.
- Explore the use of ERIN for simulating larger installations/networks and more complex compound extreme events for NICE applications
- Data-driven learning from the simulation output
- Explore access to other potential real world DoD installation data

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Thank you !