Using Multiple Modeling Techniques to Estimate First Floor Height

Objectives

- Attendees will be able to identify an expert model and understand when to use one.
- Attendees will learn techniques to slice data and determine weights for blending of models
- Attendees will learn techniques to align model results to calibrate the final model.

First Floor Height Case Study

What is first floor height?

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Background / FEMA

- FEMA & NFIP (*) offer subsidized flood insurance to individuals residing within Special Flood Hazard Area's (SFHA's ("FEMA 100 year flood plain")
- FEMA and the NFIP have endeavored to create a risk rating and flood risk insurance policy pricing system that aligns to current risk rating/risk pricing methodologies for all other perils (wind/hail/fire, etc.): "Risk Rating 2.0"

* FEMA: The Federal Emergency Management Agency (FEMA)

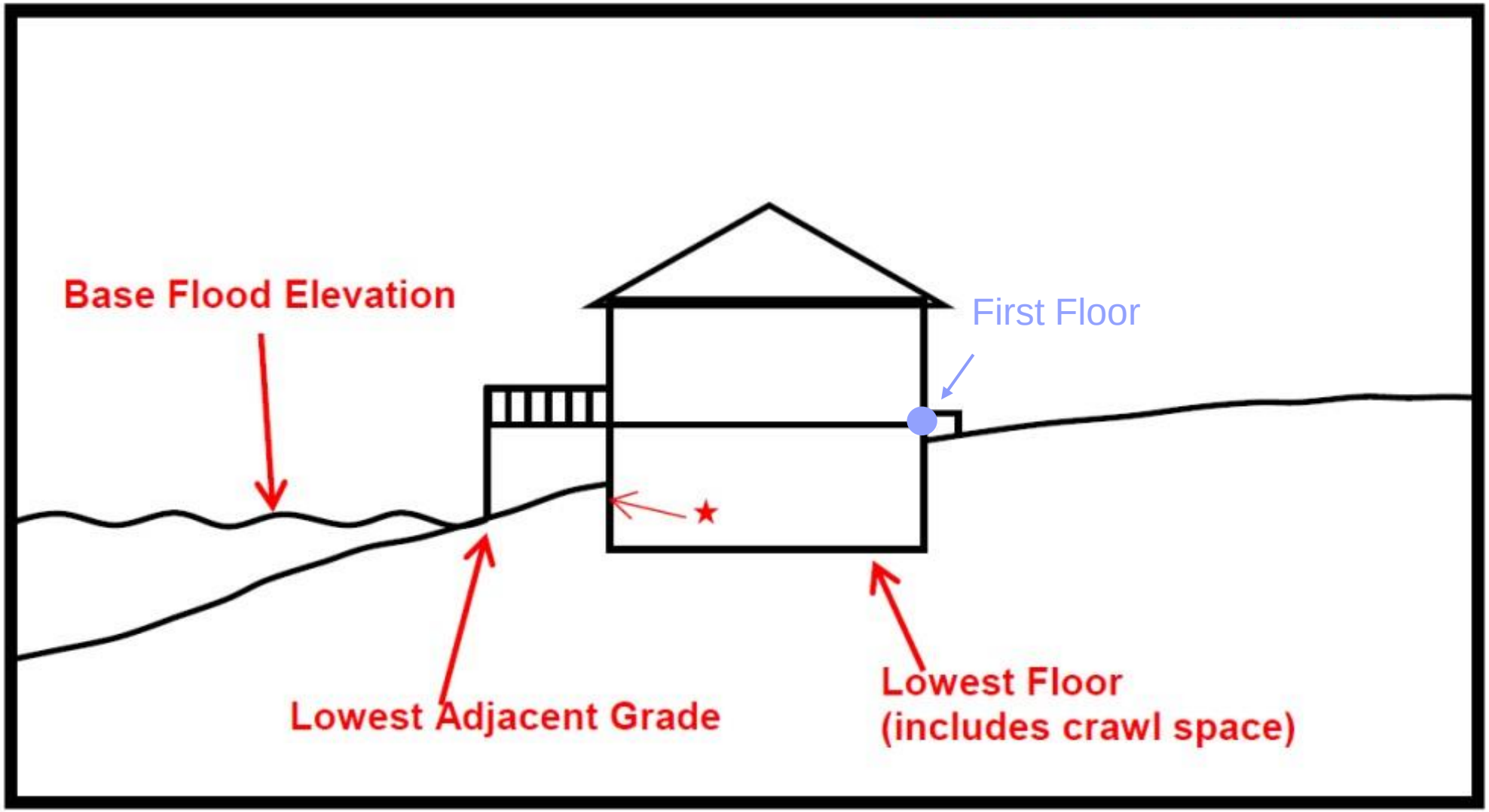
NFIP: National Flood Insurance Program

Problem Statement / The First Floor Height of a house

- CoreLogic provided data, tools and services integral to Risk Rating 2.0's development.

- Based on the above, FEMA/NFIP undertook the unusual process to sole source several key deliverables required in the Risk Rating 2.0 algorithm and deliverable to CoreLogic, including:
  - Reconstruction Cost Values
  - Geocoding (inc. building structure footprints)
  - Spatial Flood mapping
  - Specific building structure characteristics relevant to flood issues
  - Parcel boundary data
  - **First floor height, inclusive of highest adjacent grade and lowest adjacent grade details.**

The First Floor Height problem in one picture



Flooding

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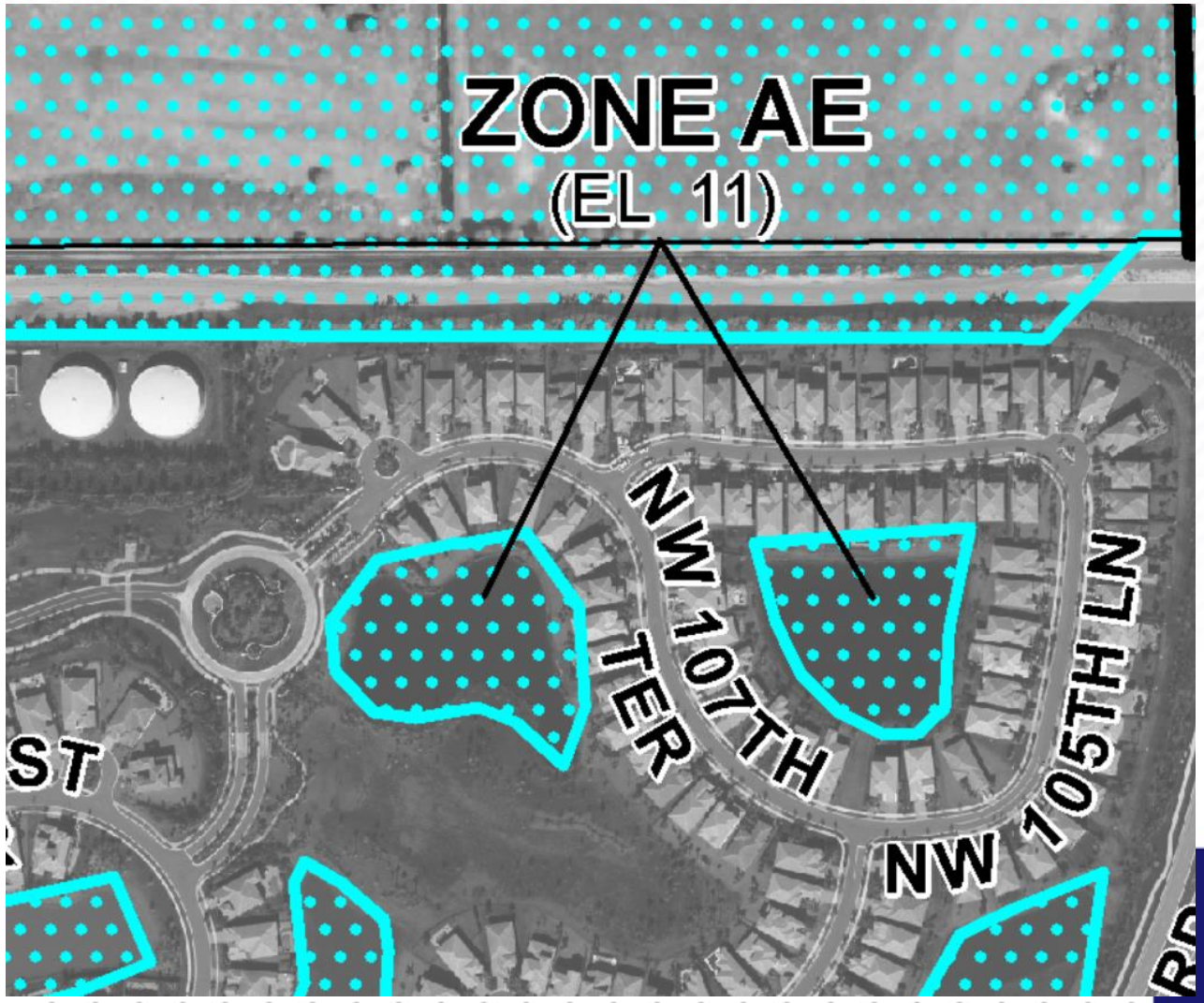
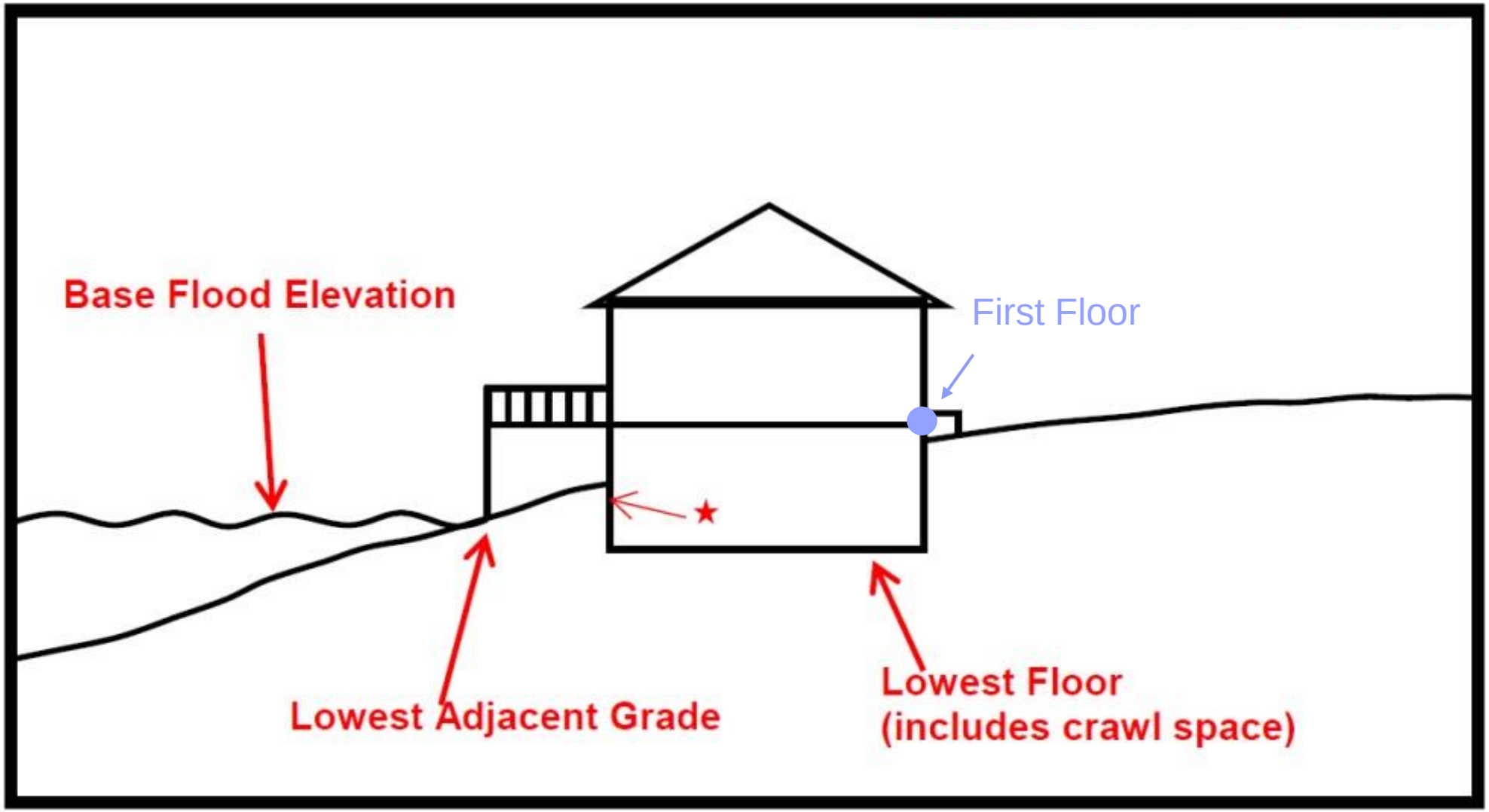
Flood Zones

- Flood Maps are drawn based on expected annual flooding chances.
- A common zone is the 100 year (AE to the right)
- If the house is elevated, flooding on the ground does not directly equate to flooding of the house.



First Floor Height Definition



Sample EC

C1. Building elevations are based on: ☐ Construction Drawings* ☐ Building Under Construction* ☒ Finis
*A new Elevation Certificate will be required when construction of the building is complete.

C2. Elevations – Zones A1–A30, AE, AH, A (with BFE), VE, V1–V30, V (with BFE), AR, AR/A, AR/AE, AR/A1–A30,
Complete Items C2.a–h below according to the building diagram specified in Item A7. In Puerto Rico only, enter
Benchmark Utilized: NGS 9155H 2008 Vertical Datum: NAVD 88

Indicate elevation datum used for the elevations in items a) through h) below.

☐ NGVD 1929 ☒ NAVD 1988 ☐ Other/Source:

Datum used for building elevations must be the same as that used for the BFE.

		Check the me
a) Top of bottom floor (including basement, crawlspace, or enclosure floor)	9.16	☒ feet
b) Top of the next higher floor	20.73	☒ feet
c) Bottom of the lowest horizontal structural member (V Zones only)	N/A	☐ feet
d) Attached garage (top of slab)	8.12	☒ feet
e) Lowest elevation of machinery or equipment servicing the building (Describe type of equipment and location in Comments)	9.23	☒ feet
f) Lowest adjacent (finished) grade next to building (LAG)	4.86	☒ feet
g) Highest adjacent (finished) grade next to building (HAG)	7.91	☒ feet
h) Lowest adjacent grade at lowest elevation of deck or stairs, including structural support	N/A	☐ feet

FFH= C2.a-C2.f
FFH2=C2.b-C2.f

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https://gis.baycountyfl.gov/elevationcertificates/2020/6653%20NORTH%20LAGOON%20DR.pdf

Expert Models

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Expert Model

a.k.a. expert system or rule-based system

Definition: A program designed to solve problems at a level comparable to that of a human expert in a given domain. [1]

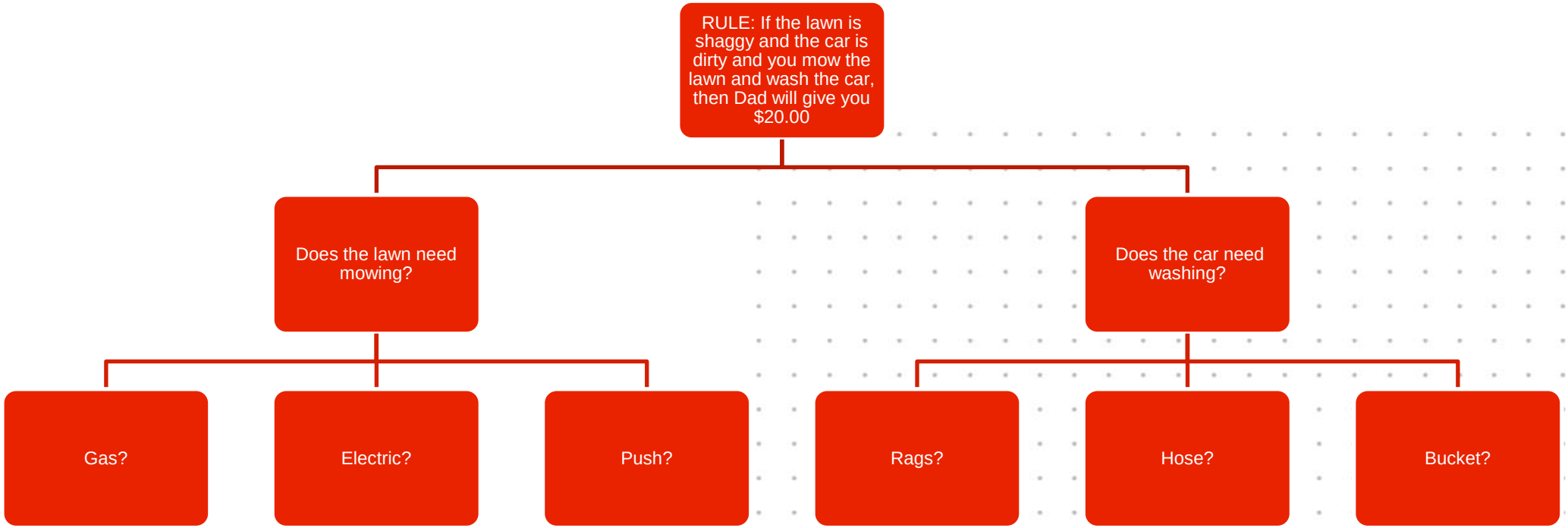
These systems were a popular approach to AI in the 70s and 80s. Most AI research has moved on to statistical approaches now. However the expert system approach is still common and useful in applications, and provides a good paradigm to think about potential solutions through. [2]

A Symbolics Lisp Machine: an early platform for expert systems (link)

1) Cooper, G. F. (1989). Current research directions in the development of expert systems based on belief networks. *Applied Stochastic Models and Data Analysis*, *5*(1), 39-52.
2) Russell, S., & Norvig, P. (2002). Artificial intelligence: a modern approach.

Example

Goal: make $20.00



Factors to Consider For an Expert System

- You lack sufficient data to build a statistical model
  - Too expensive
  - Impossible to collect
- Access to an expert in the field
- Deterministic systems
  - Physical systems
  - Studied cause and effect
  - Regulations
- Variable/Outcome Complexity
  - Too many variables or outcomes make it difficult to reason about a problem
- It can also be a continuum between experts and statistical approaches.
  - Several statistical rule base approaches exist.

What data to predict FFH?

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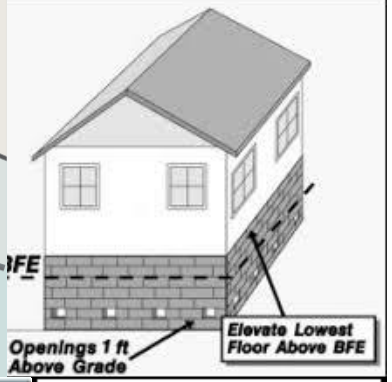
Key Inputs of FFH

Building attributes

- YOC
- Foundation type
- Construction type
- Land Use
- Number of Stories
- Floor thickness

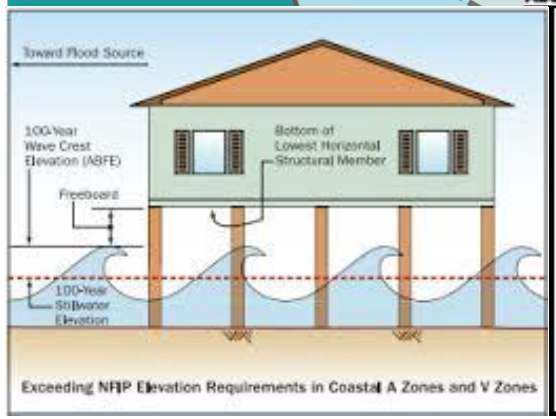
Flood Map

- BFE
- Flood zone
- Coastal vs Inland
- Zipcode



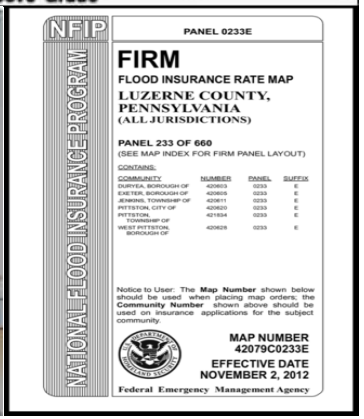
Building Code

- ASCE24 based Freeboard
- DFE based Freeboard



GIS

- LAG
- HAG
- FIRM-Date (Pre, Post FIRM)
- FRS score



Foundation Type

- Foundation Types are critical to understanding floor height
  - The provide hard limits on how high a floor is
  - There are informative averages for each type
- They inform a great deal of the rule-based logic in the solution

Foundation Type Examples

Basement

Crawl

Pile

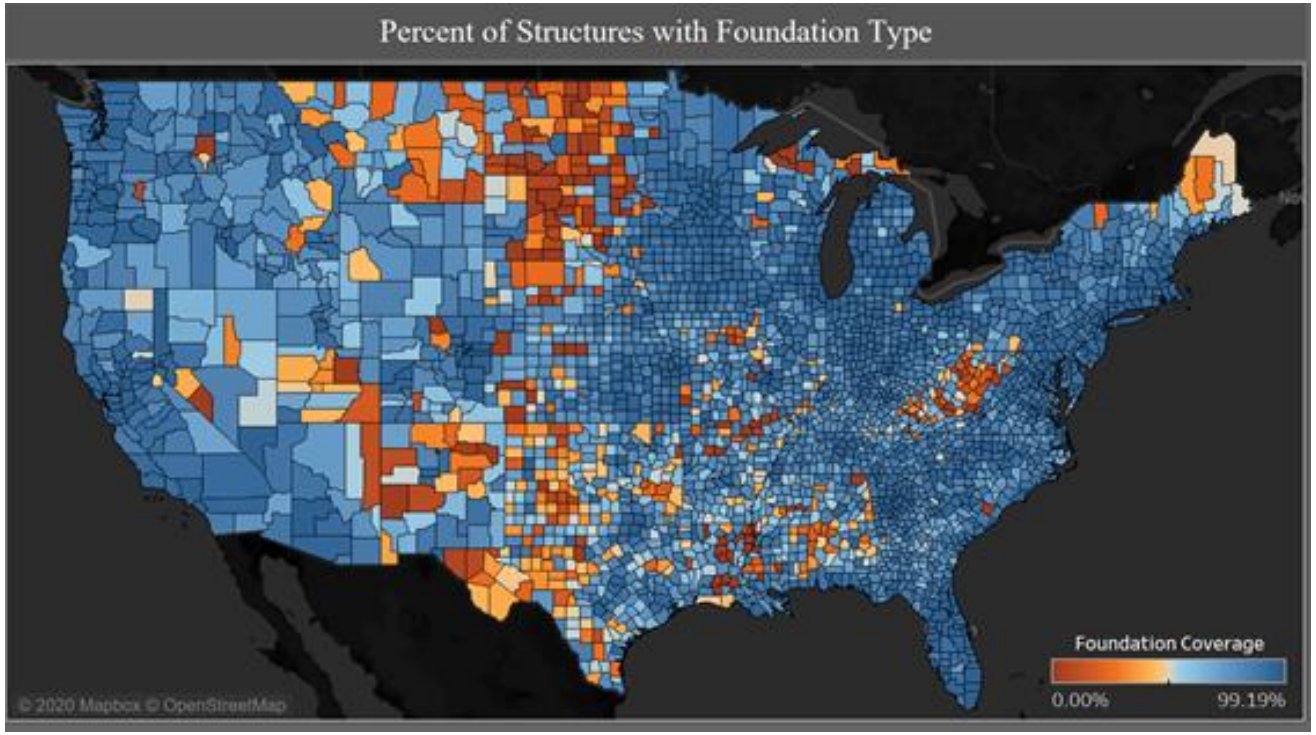
Slab

Data holes and the need for imputation

- Depending on regions, data coverage can vary in:
  - Granularity
  - Fill rate
  - Accuracy

- Where observed data is not available, there can be value in predicting property characteristics (e.g. Foundation Type)

- Predictions can be made, using neighboring properties of known and similar characteristics



Solution

Imagery Approach

- The first-floor height was also estimated using photogrammetric approaches.
- Several imagery models were built to refine and process the data to extract relevant components

Expert Model

- Civil Engineers and Hydrologists built the expert model
- Factors considered:
  - Construction methods
  - Flooding type
  - Federal Flood Regulations
  - Local building codes
  - Topography
- Statistical influence
  - Statistics computed elsewhere can be infused into the expert system.
    - E.g. average heights for a particular foundation type.

Poll

Poll: Guess The First Floor Height

Options:

1. 12
2. 15
3. 17
4. 19
5. 21

Poll: Guess The First Floor Height

Options:

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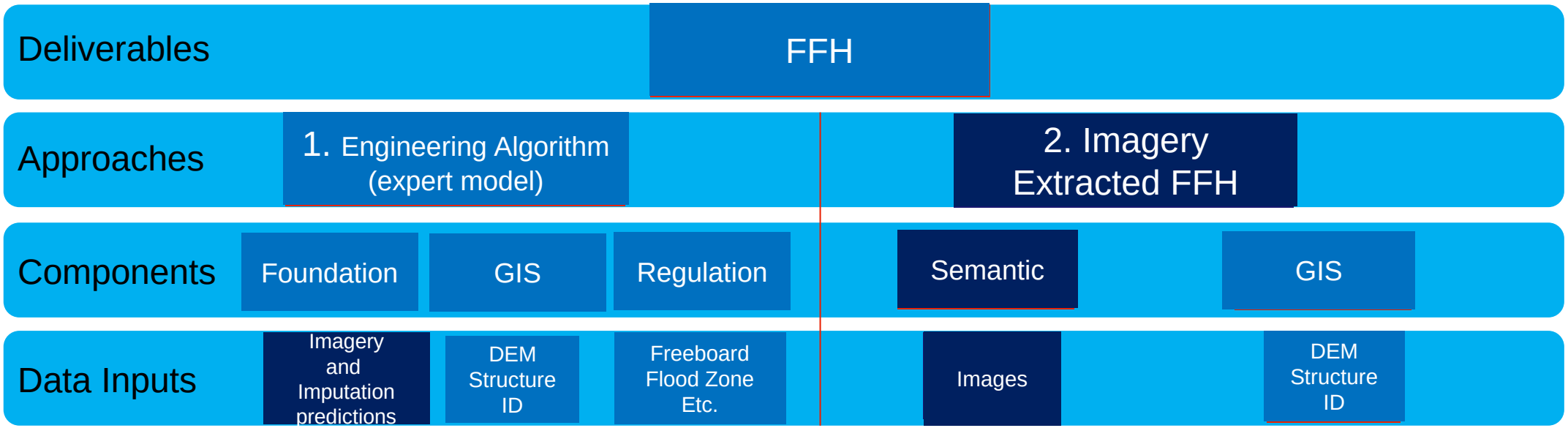
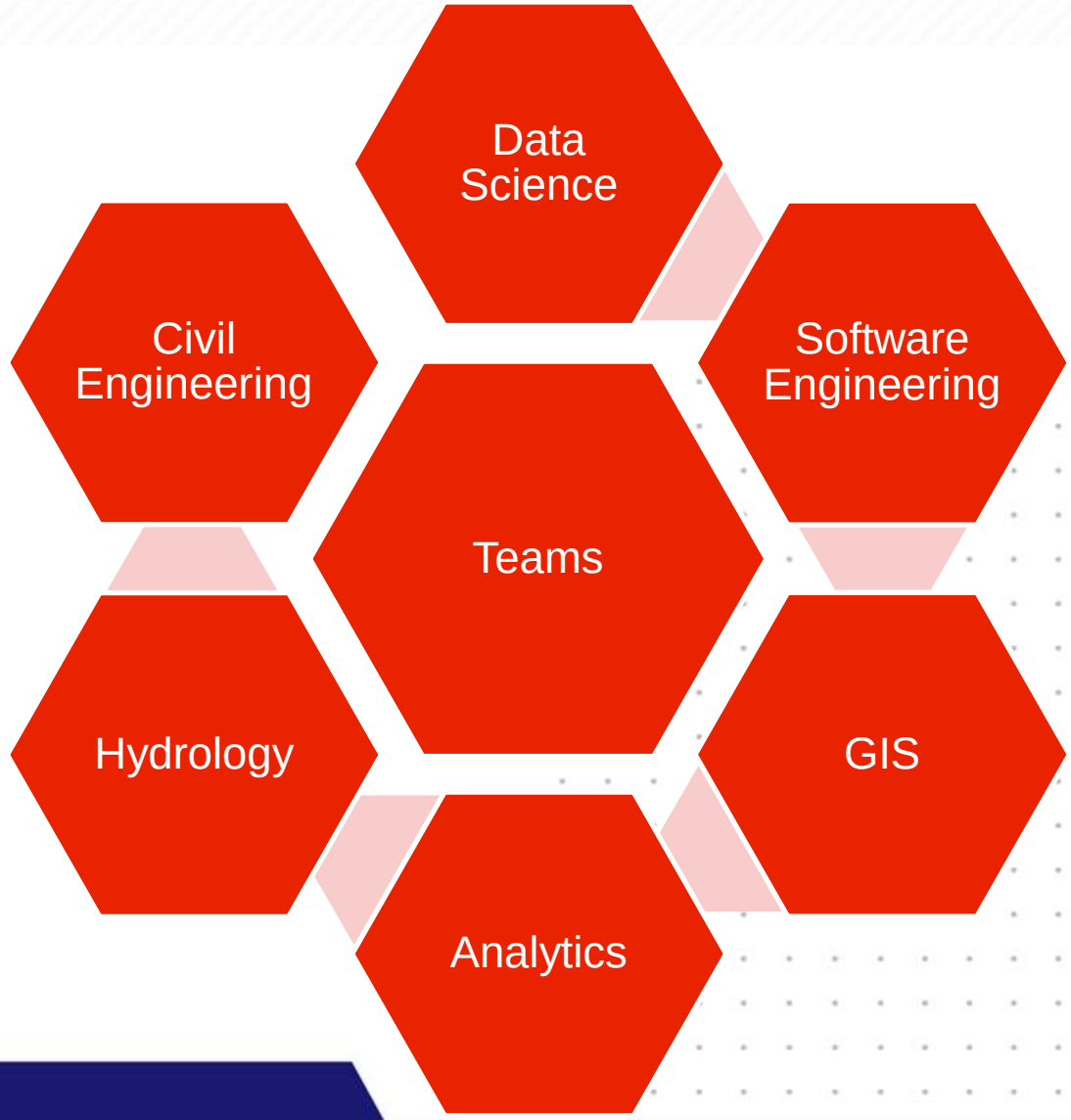
Different models powered by different data



Evaluation

Team Composition



Team Dynamics

Getting Buy In

- Establish buy in up front for evaluation.
  - It’s painful to change the goalpost midway through a project
- Establish statistical thinking
  - Test sets aren’t difficult to grasp, but people must be reminded
  - Held out test sets are critical to prevent overfitting of expert models
- Education is key
  - Seek to understand just as much as you’re understood

Combining Outputs for an Answer

- Combination of Rules and Statistics
- Potential rule sets:
  - Minimum sample size per geographic region
    - No properties in a given county
  - Illogical outputs
    - An 8 ft high slab
- Potential statistical approaches:
  - Minimum model confidence
    - Thresholds chosen by using known areas to apply to unknown areas
  - This is where it is critical to have held out test sets