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CONFERENCE & EXPO

Confronting the Multiple Dimensions of Resilient and Sustainable Building Design

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National Institute of Building Sciences

Provider Number: G168

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TU-3A

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

The building industry must respond to the growing national mandate to better steward our environment, while protecting lives and property in disasters. The joint consideration of a structure's unique vulnerabilities to natural or man-made hazards and its sustainability—over the course of its lifetime or in response to a disaster—is far from trivial. The models and data necessary for this kind of end-to-end evaluation, from hazard characterization to response and projected damage/deterioration and environmental impact, engage various disciplines involved in building project delivery. These disciplinary perspectives—from the fields of architecture, structural engineering and mechanical engineering, among others—affect the conceptualization of buildings in respective modeling environments and the data sources used in their evaluation; leading, ultimately, to the notorious challenges of BIM interoperability. However, **through this project, a fully integrated and automated workflow for life-cycle assessment of buildings has been developed that captures the dependencies between multi-hazard resilience and sustainability, across multiple dimensions of environmental impact and across the modeling environments common to building practice using new semantic data perspectives from computer science.** This presentation will introduce this end-to-end workflow, including modules dedicated to hazard characterization, response, damage/deterioration, repair and environmental impact (lifetime embodied and operating energy).

Acknowledgements/ Credits

The University of Notre Dame
Center for Research Computing
Office of Research
Center for Sustainable Energy

National Science Foundation
CMMI 1537652:"A Green Resilience Framework to Support the Design of Sustainable Buildings Under Multiple Hazards"

Learning Objectives

At the end of the this course, participants will be able to:

1. Develop an awareness of the current challenges and evolving opportunities to advance resilient and sustainable building design
2. Develop an appreciation for the importance of systematically evaluating hazard resilience and multiple dimensions of environmental impact in building design process
3. Understand conceptually how such evaluations can be conducted and integrated with industry-standard modeling environments
4. Appreciate the benefit of structured data to enable data discovery and interoperability of industry-standard tools in the context of such evaluations

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MOTIVATION OF PROJECT:

1. **ARCHITECTS AND ENGINEERS MAKE DECISIONS**

2. THOSE DECISIONS HAVE IMPACT

3. HOW ARE WE MAKING IMPACTFUL DECISIONS TODAY?

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   IMPACT: cities/ settlement patterns; density; coastal population migration, related civil infrastructure to support

   IMPACTED BY: damage related to changing climate and increased intensity and frequency of natural hazard events

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What is a resilient *and* sustainable building -- and how do we currently approach the design of RSB's today?

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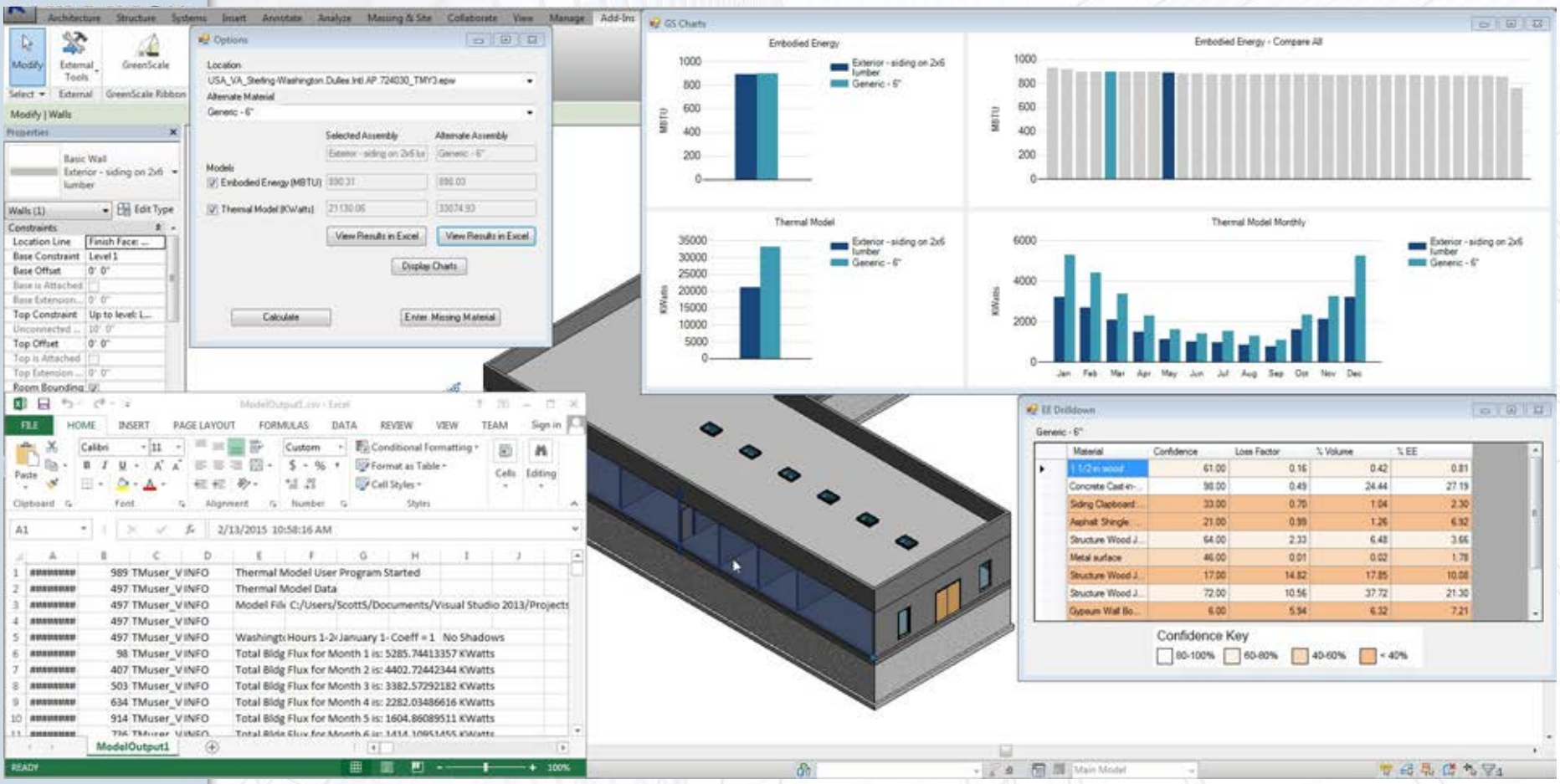
What is a resilient *and* sustainable building -- and **how do we currently approach the design of RSB's today?**

3. HOW ARE WE MAKING IMPACTFUL DECISIONS TODAY?

What are the barriers/ the opportunities to achieve a more resilient *and* sustainable built environment?

GREENSCALE RESEARCH PROJECT

GREEN RESILIENCE PROJECT



EARLY STUDIES REVEALED:

1. Studies were hard to do

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2. Because complete data is hard to find and interpret

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1. Studies were hard to do
2. Because complete data is hard to find and interpret
3. Usefulness of retrospective understanding of building “costs” is limited

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STUDY OF EXISTING TOOLS & METHODS

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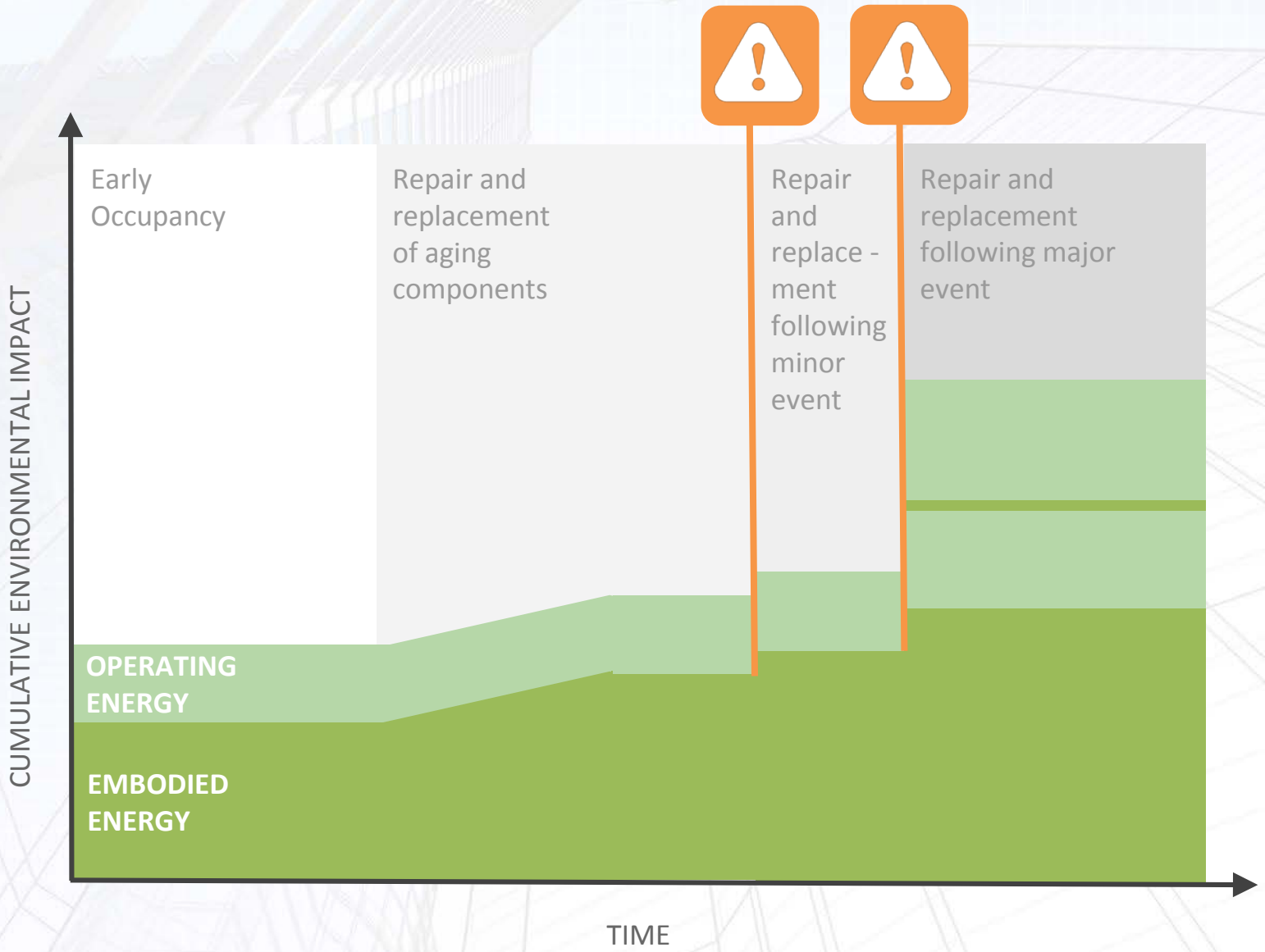
STUDY OF EXISTING TOOLS & METHODS


Early Occupancy
Repair and replacement of aging components
Repair and replace - ment following minor event
Repair and replacement following major event
CUMULATIVE ENVIRONMENTAL IMPACT
OPERATING ENERGY
EMBODIED ENERGY
TIME

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GREEN RESILIENCE FRAMEWORK

Integrated Life-cycle Assessment of Building Resiliency and Sustainability

FRAMEWORK PROGRESSION

- PROBABILISTIC LIFE CYCLE ASSESSMENTS
- ENVIRONMENTAL IMPACT MODULE
- HAZARD DESCRIPTION; LOSS, DAMAGE + RESPONSE MODULES
- BUILDING MODEL
- RSB CONCEPT: BUILDING + SITE CHARACTERISTICS

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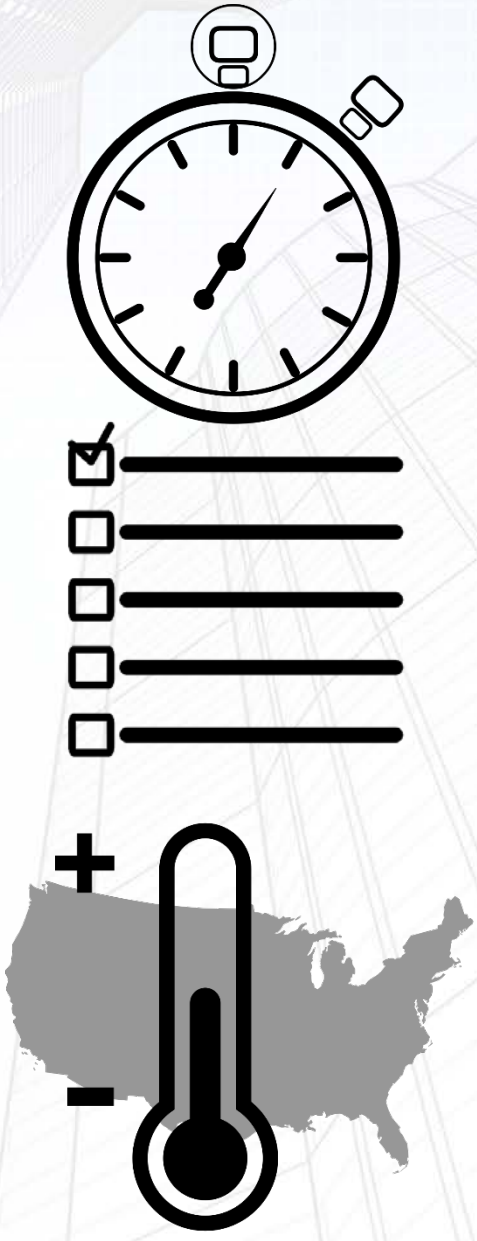
INCREASING DEMANDS ON PROJECT DELIVERY TO INCLUDE METRICS-BASED ANALYSES



FASTER PROJECT DELIVERY

CHANGING CLIMATE

COASTAL MIGRATION & EXPOSURE TO HAZARDS (INTENSITY AND FREQUENCY)

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OBSERVATIONS FROM PRACTICE

1. **Hub-and-spoke model of collaboration prevails**

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GREEN RESILIENCE FRAMEWORK

Integrated Life-cycle Assessment of Building Resiliency and Sustainability

Can we develop models within a comprehensive framework that USEFULLY CONSIDERS SUSTAINABILITY ALONGSIDE MULTI-HAZARD RESILIENCE within the normative workflow of firms already endeavoring to achieve RSBs while lowering the barriers for firms currently struggling (with data and tools) to achieve RSBs?

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FRAMEWORK CAPABILITIES:

Revit Auditor	Extract properties of all components: soil, foundation, structure, envelope and finishes
Hazard Module	Quantify site-specific hazards (wind, earthquake) and resulting load effects
Response Module	Analyze structural response under static and dynamic load effects
Damage Module	Determine hazard-induced damage to components: soil, foundation, structure, envelope and finishes
Deterioration Module	Evaluate aging/deterioration of components: soil, foundation, structure, envelope and finishes
Loss Module	Calculate costs of resulting repair and replacement activities (dollars, downtime)
Embodied Energy Module	Inventory energy embodied in components: soil, foundation, structure, envelope and finishes
Operating Energy Module	Estimate operating energy based on climate, geometry and component properties

OVER LIFE CYCLE

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INDUSTRY PARTNER ENGAGEMENT

SCB

RAMSA

SOM

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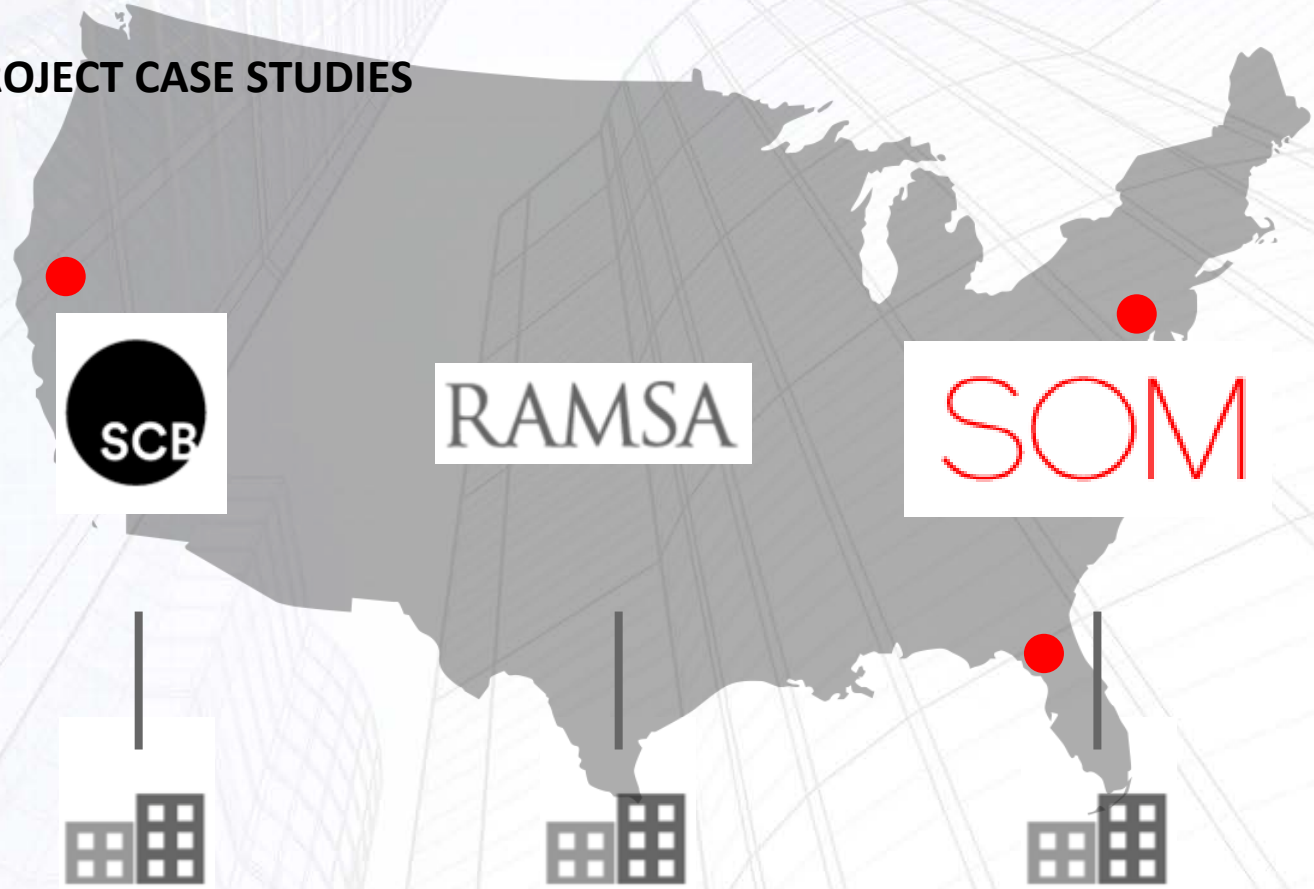
PROJECT CASE STUDIES

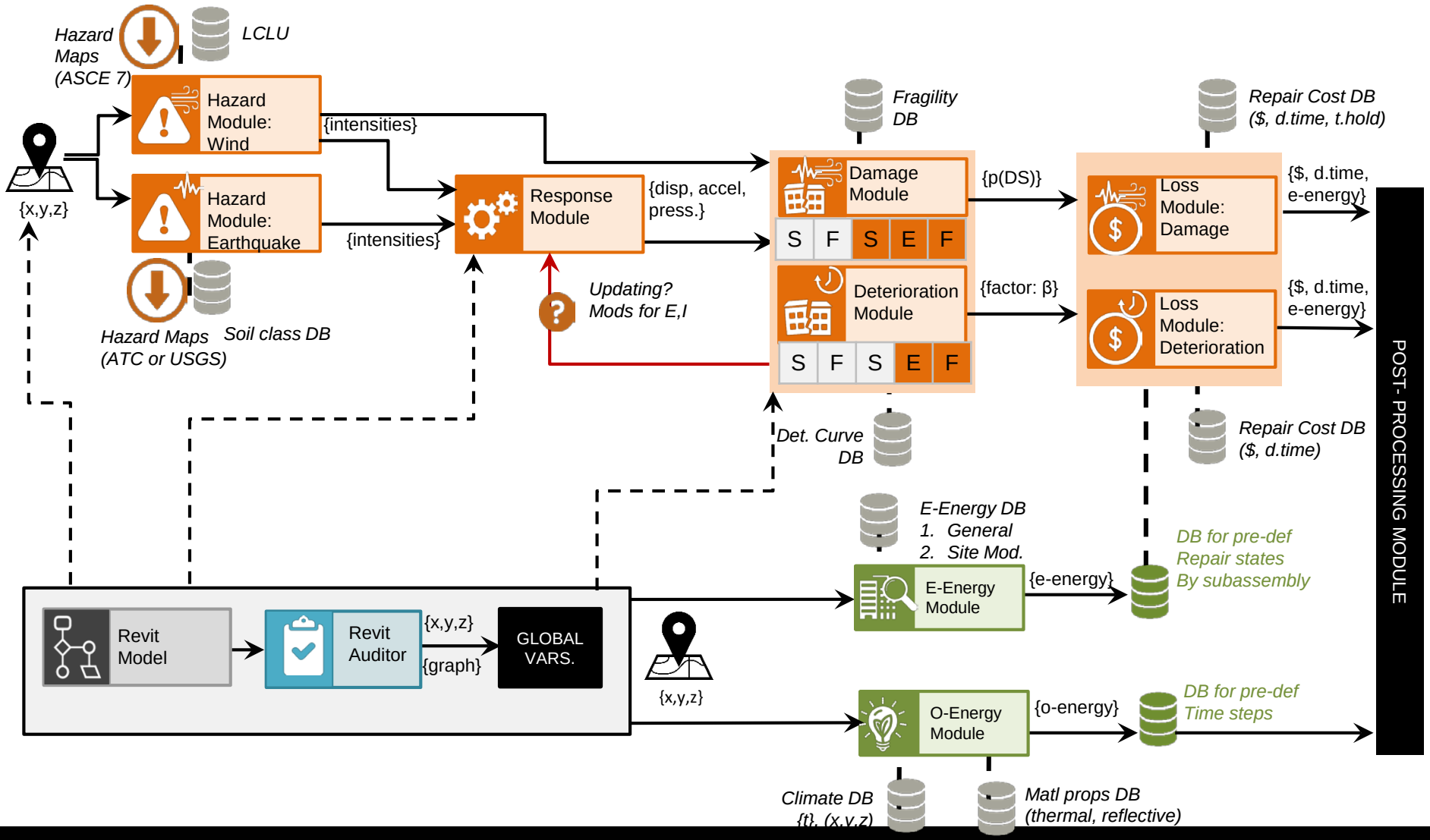


17 story Residential Tower, Northwest U. S.

200 SF Commercial Building, Northeast U. S.

5 story @ 150K SF/ story Medical Building, Southeast U. S.

INTEGRATED LIFE-CYCLE ASSESSMENT FRAMEWORK



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Integrated Life-cycle Assessment of Building Resiliency and Sustainability: Framework Introduction

PRESENTERS: Tracy Kijewski-Correa, Alexandros Taflanidis
LEAD DEVELOPERS: Karen Angeles, Dimitrios Patsialis, Holly Ferguson

Motivation

S	F	S	E	F

Embodied Energy
Operating Energy — ARCHITECT

Vulnerability — STRUCTURAL

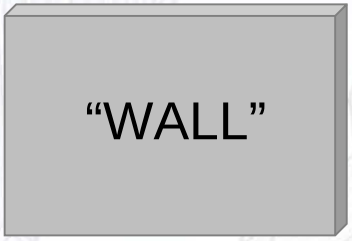
PRE-SERVICE	SERVICE	POST-SERVICE
Fabrication Manufacturing Construction	Occupancy Operations Maintenance	Adaptation Demolition Waste/Recycle
t=0	t=i t=N	

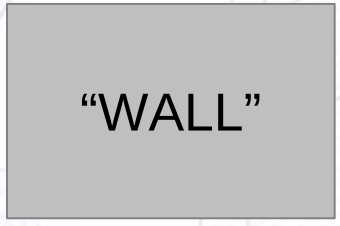
SUSTAINABLE+RESILIENT DESIGN

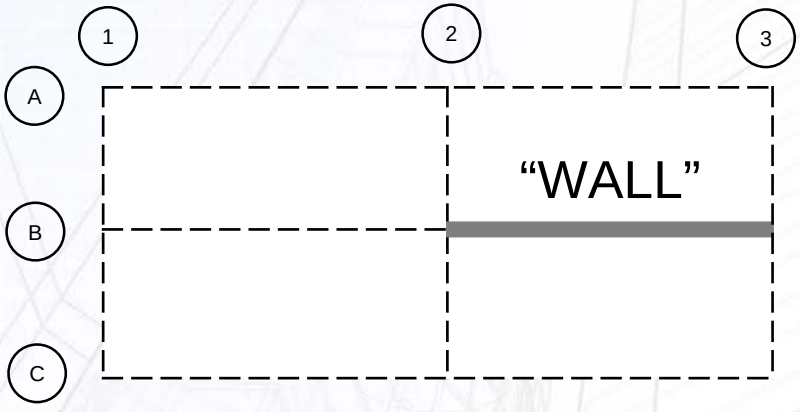
Repair, replacement

NEED: *Designer-facing* integrated life cycle assessments of multi-dimensional environmental impact, accounting for multi-hazard resilience

Reductionism in Design



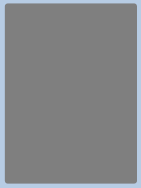
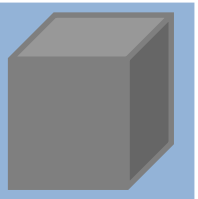




APPLICATION	ABSTRACTION
Massing Costing Etc.	“wall”= [Volume]
Finishes Load Projection Etc.	“wall”= [Area]
Relative Position Stiffness Etc.	“wall”= [Line]

Abstractions in Modeling

CUMULATIVE PROCESS

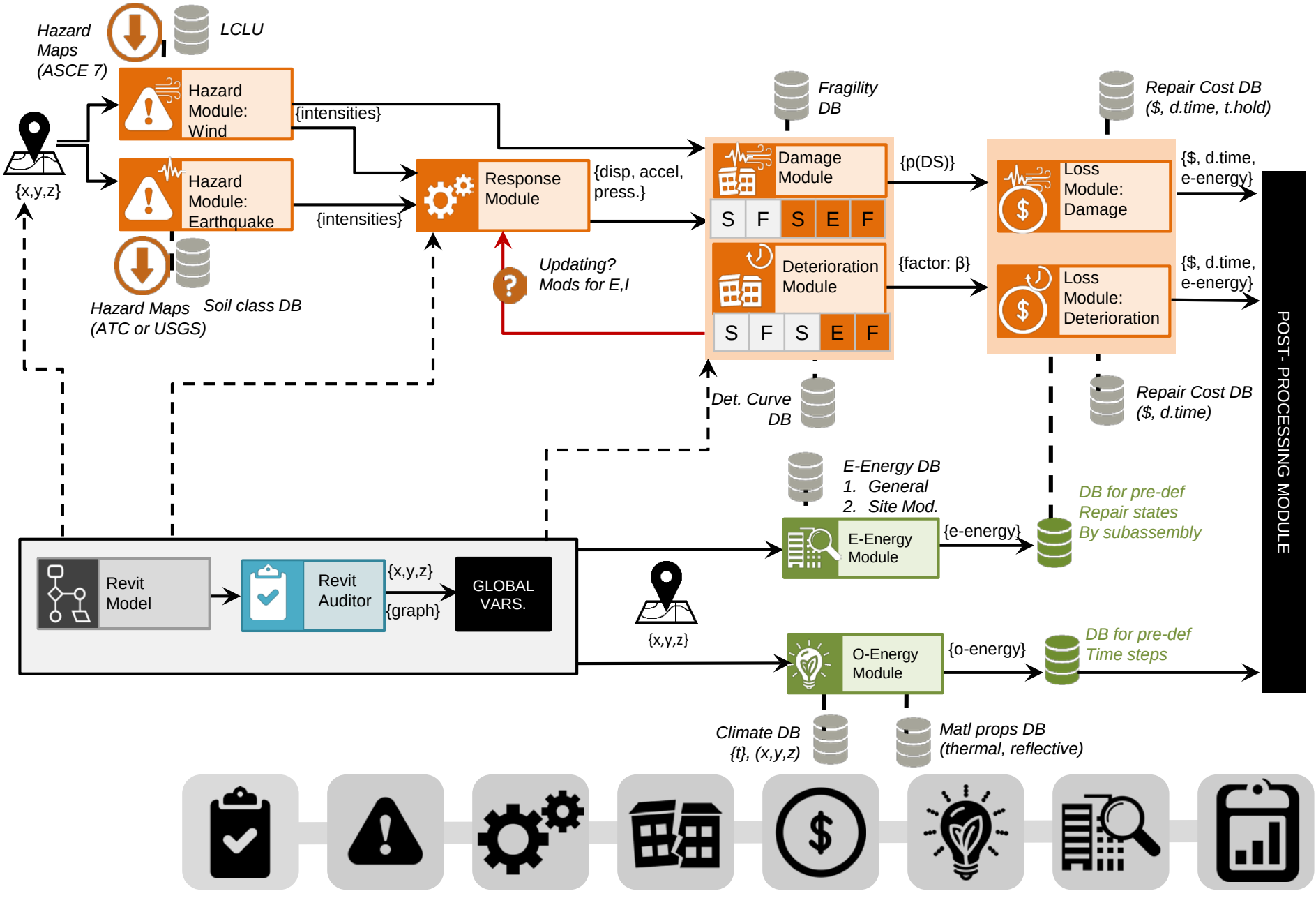
ABSTRACTION	GEOMETRY	LOCATION	FEATURES	BEHAVIOR
Joint (Nodes, Points)		(x,y,z)	►Boundary Condition	► Displacement ► Velocity ► Acceleration
Element  (Line)	Length [m]	Reference Point (x,y,z) + Transformation*	►X-Sec Geometry ►Matl Properties: t_0: Structural, Thermal t_i:t_N: Fragility, Repair	► σ, ε ► M, V, N ► Δ, θ
Surface  (Area, Polygons)	Height X Width Area [m^2]	Reference Point (x,y,z) + Transformation*	►X-Sec depth ►Matl Properties: t_0: Structural, Thermal, Transmissibility t_i:t_N: Fragility, Repair	► σ, ε field ► Interaction (shading) ► Embodied energy
Space  (Volume)	Height X Width X Depth Volume [m^3]	Reference Point (x,y,z) + Transformation*	►Matl Properties: t_0: Structural, Thermal, Transmissibility	► Embodied energy ► Thermal Heat Flux

STRUCTURAL

ARCHITECTURAL

*Transformation: Offset/translation, rotation, extrusion (may exploit symmetry for efficient data storage)

INTEGRATED LIFE CYCLE ASSESSMENT FRAMEWORK



REVIT AUDITOR MODULE

FUNCTION: Characterize geometries, inventory components in Revit model

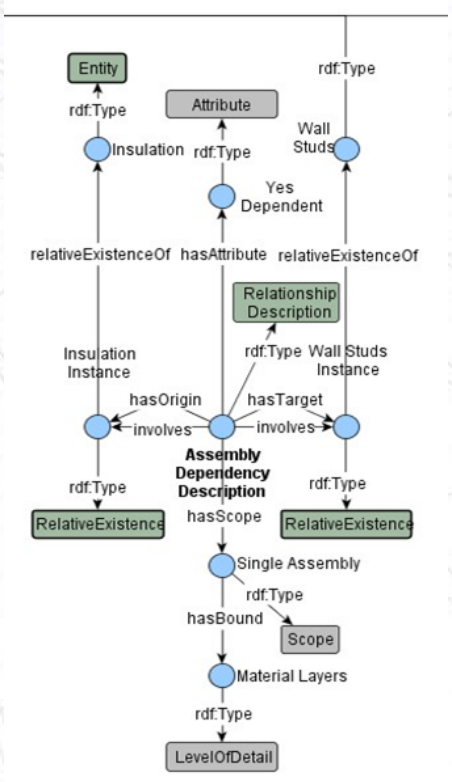
APPROACH: Ontology-based data patterns that connect domain vocabularies

INPUTS: IFCXML file

OUTPUTS: Semantic graph information

DATA SOURCES: Linked data views

KEY FEATURE: Queryable graph so modules can easily access building information



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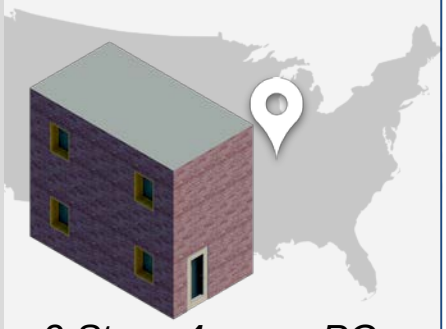
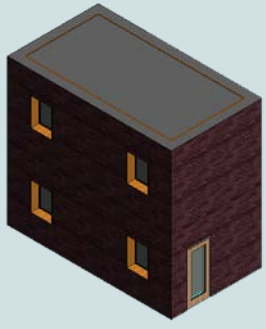
COMPONENT AUDIT: WORKING EXAMPLE

EXAMPLE BUILDING

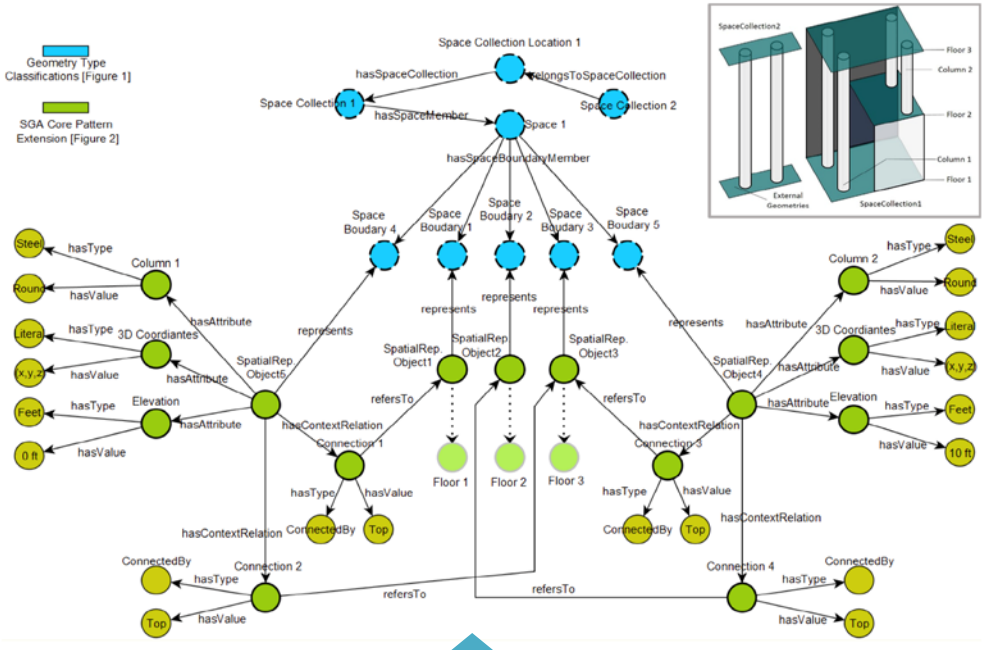


2-Story, 4-room RC Frame in St. Louis, MO

REPRESENTATION



Revit 2016 Model



Revit Auditor

HAZARD MODULE

FUNCTION: Identify hazard exposure at specified location

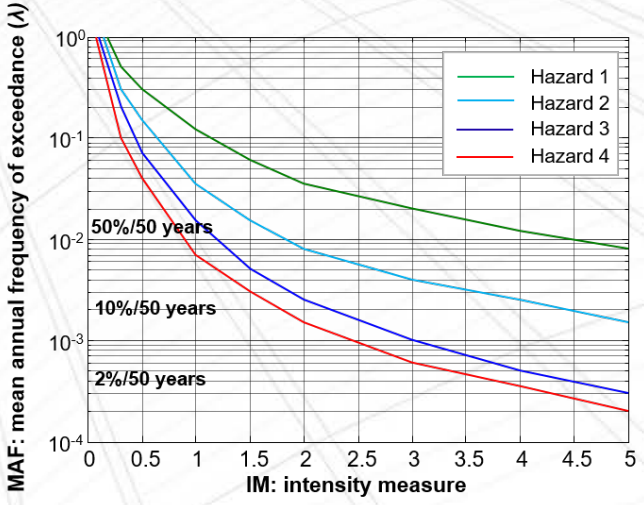
APPROACH: Site-specific hazard curves generated from governing building codes/standards

INPUTS: Site Characteristics, Dynamic Properties

OUTPUTS: Return rates for different intensity measures

DATA SOURCES: Hazard maps (USGS, ATC)

KEY FEATURE: Automated extraction of hazard characteristics

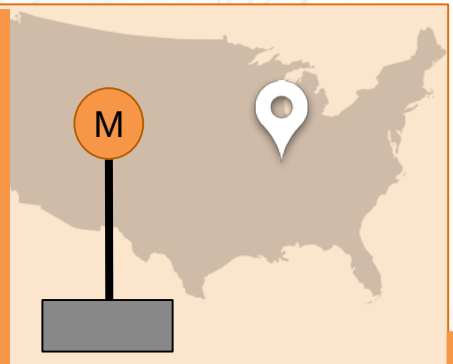


HAZARD DEMANDS: WORKING EXAMPLE

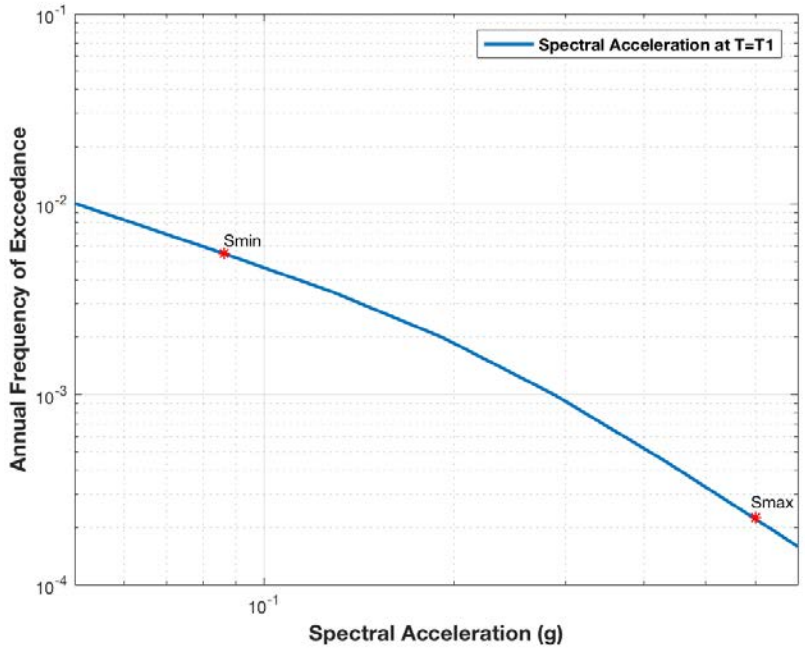
EXAMPLE BUILDING

2-Story, 4-room RC Frame in St. Louis, MO

REPRESENTATION



SDOF @ Specific Locale



Hazard Module

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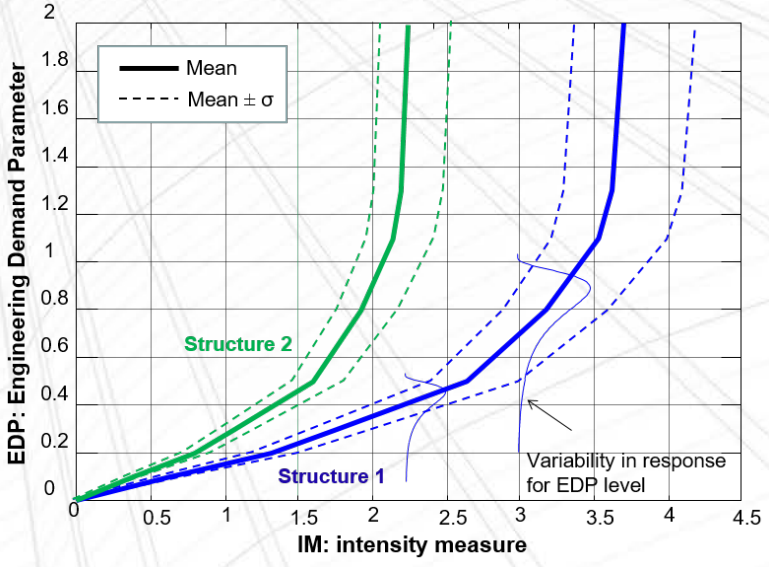
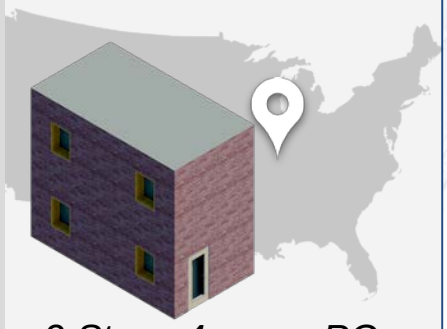
RESPONSE MODULE

FUNCTION:	Calculate engineering demand parameters for specific intensity measures
APPROACH:	Response approximated from linear-elastic FEM
INPUTS:	Intensity measures, building properties
OUTPUTS:	Drift ratios, velocities and accelerations; wind pressures
DATA SOURCES:	Nonlinear response approximations
KEY FEATURE:	Direct interfacing with FEM packages



RESPONSE: WORKING EXAMPLE

EXAMPLE BUILDING



2-Story, 4-room RC Frame in St. Louis, MO

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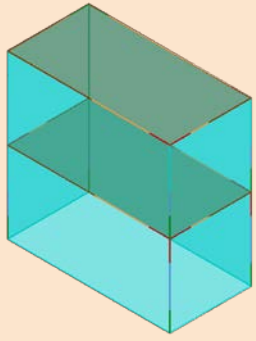
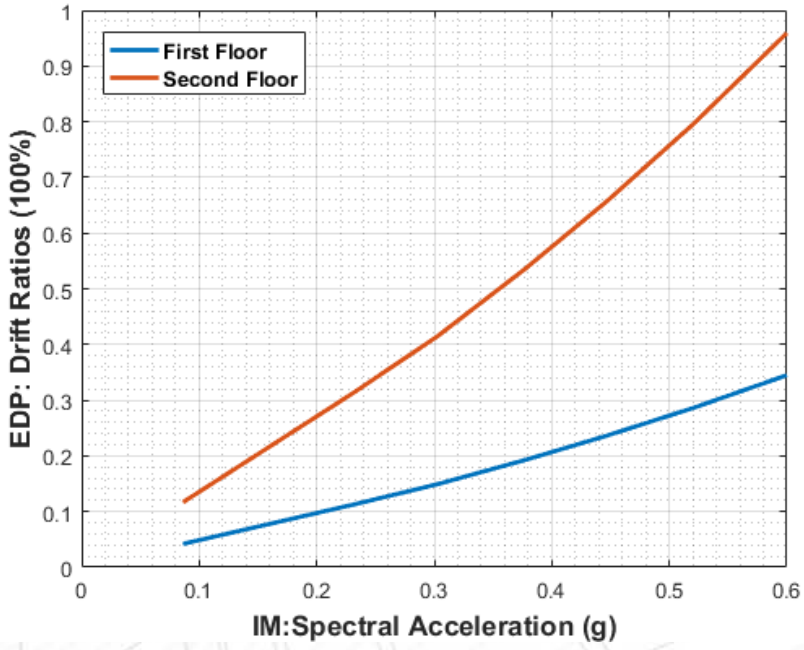


SAP2000 (v. 17) Model



Response Module

DAMAGE-DETERIORATION MODULE

FUNCTION: Calculate the probability of occurrence of the different damage states

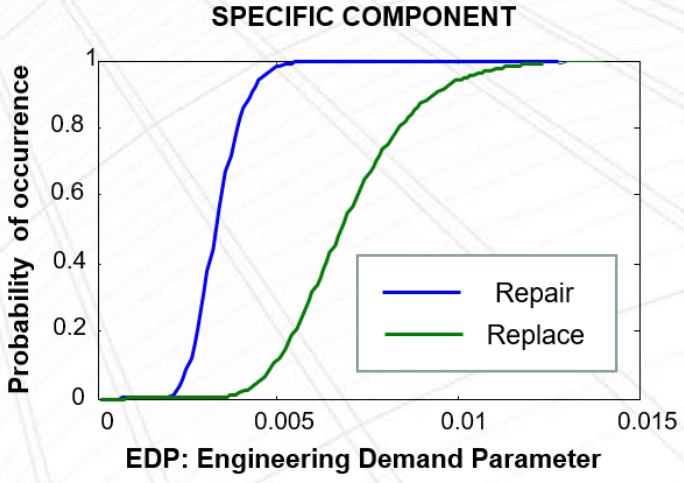
APPROACH: Assembly-based vulnerability methodology

INPUTS: Engineering demand parameters, component assemblies

OUTPUTS: Probabilities of occurrence

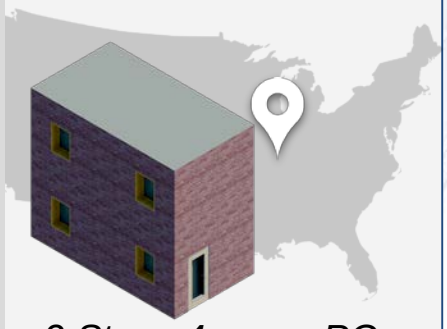
DATA SOURCES: Fragility curves (FEMA)

KEY FEATURE: Detailed loss assessment at component level



DAMAGE LEVELS: WORKING EXAMPLE

EXAMPLE BUILDING

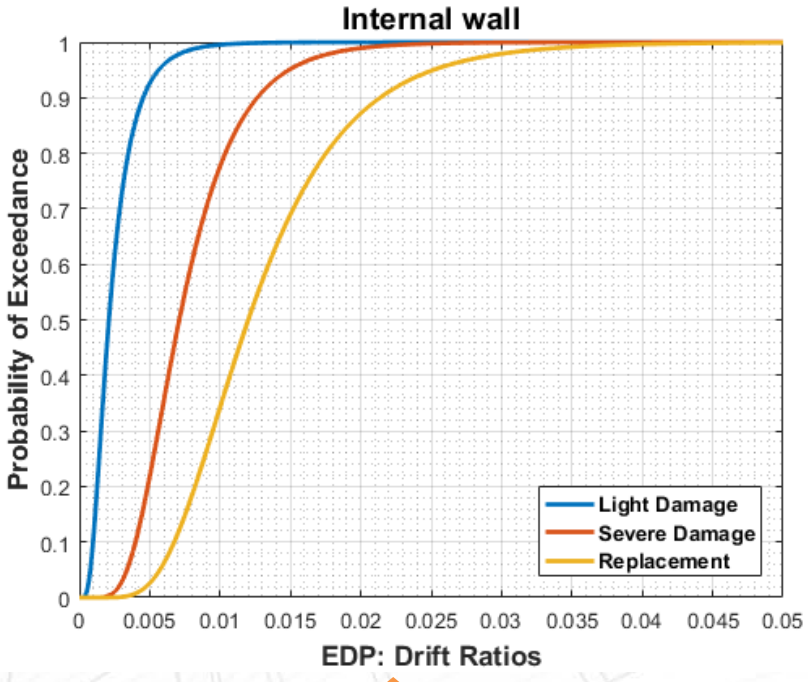


2-Story, 4-room RC Frame in St. Louis, MO

REPRESENTATION

Description	Location
Interior Wall Assembly 1	Floor 2, Bay 1-2
Interior Wall Assembly 2	Floor 1, Bay 1-2

Assembly Inventory



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Damage Module

LOSS MODULE

FUNCTION: Assess maintenance/repair/replacement and downtime costs

APPROACH: Assembly-based vulnerability methodology

INPUTS: Probabilities of occurrence of damage states

OUTPUTS: Repair cost, material, downtime

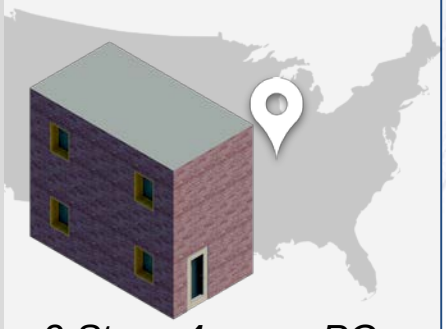
DATA SOURCES: FEMA cost, repair, downtime functions

KEY FEATURE: Supports regional cost functions

DAMAGE LEVEL	COST
Repair Level 1	$25/sq. foot
Repair Level 2	$50/sq. foot
Repair Level 3	$100/sq. foot
Replacement	$200/sq. foot

LOSSES: WORKING EXAMPLE

EXAMPLE BUILDING

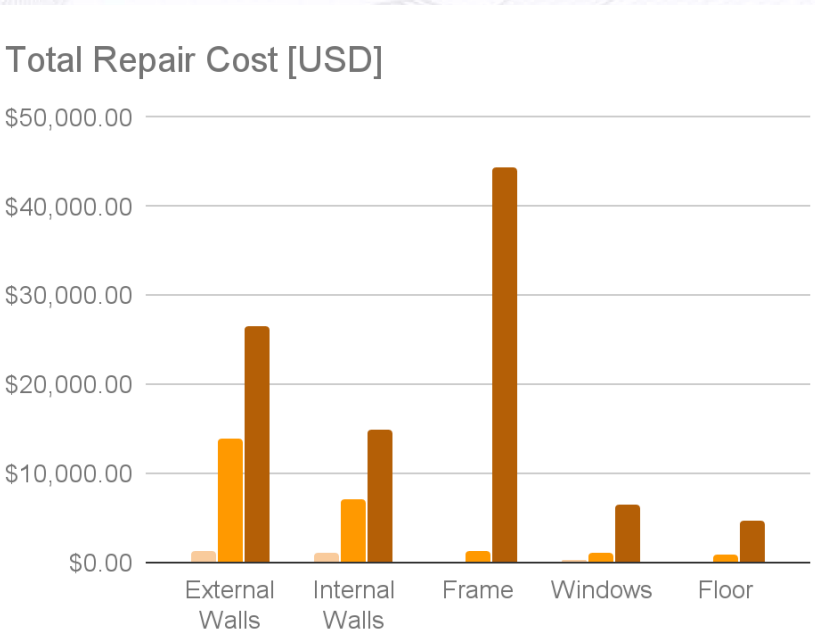


2-Story, 4-room RC Frame in St. Louis, MO

REPRESENTATION

Description
Interior Wall Assembly 1
Interior Wall Assembly 2

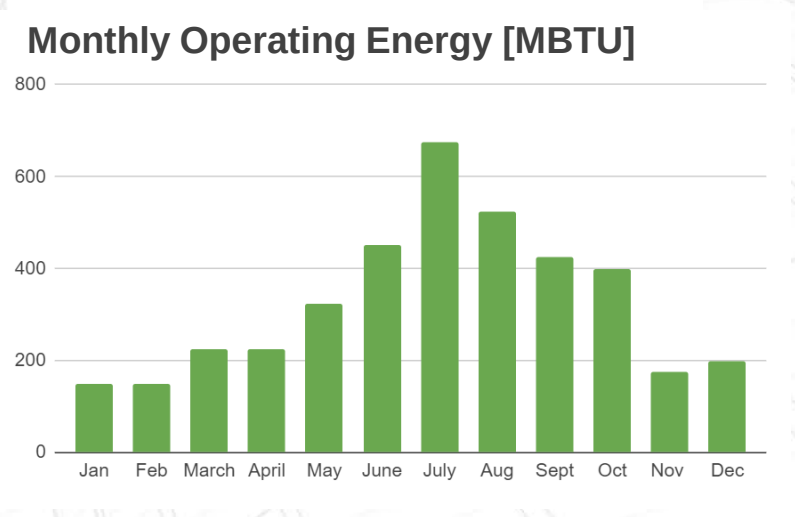
Components @ Specific Locale



Loss Module

OPERATING ENERGY MODULE

FUNCTION:	Asses operating energy of building within a given climate
APPROACH:	Calculation of heat flux based on material and spatial properties (lumped capacitance model)
INPUTS:	GBXML File
OUTPUTS:	Monthly energy consumption
DATA SOURCES:	Energy Plus climatology data
KEY FEATURE:	Customizable thermal properties



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OPERATING ENERGY: WORKING EXAMPLE

EXAMPLE BUILDING

2-Story, 4-room RC Frame in St. Louis, MO

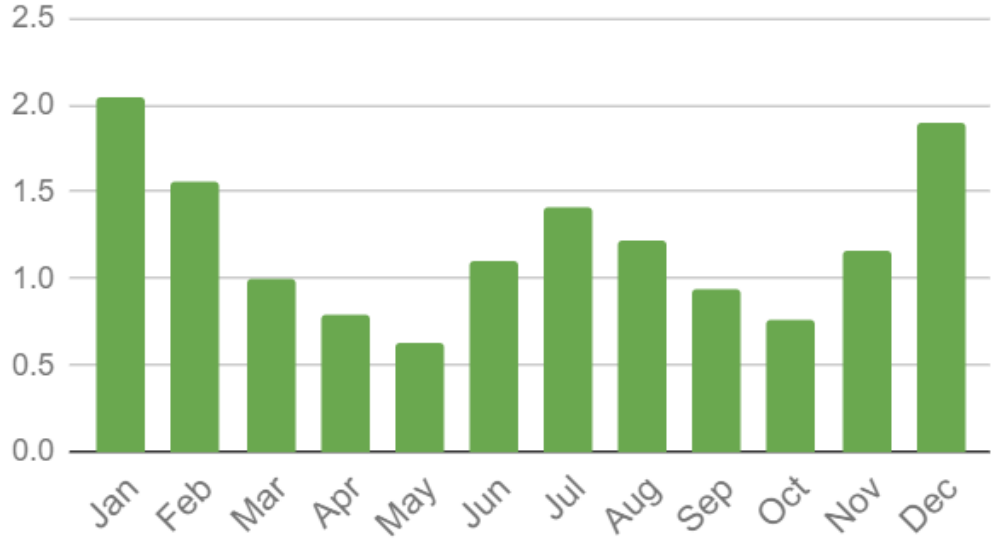
REPRESENTATION

Enclosed Volumes @ Specific Locale

m^3

Operating Energy Module

Monthly Operating Energy [MBTU]



EMBODIED ENERGY MODULE

FUNCTION: Calculates building component embodied energy

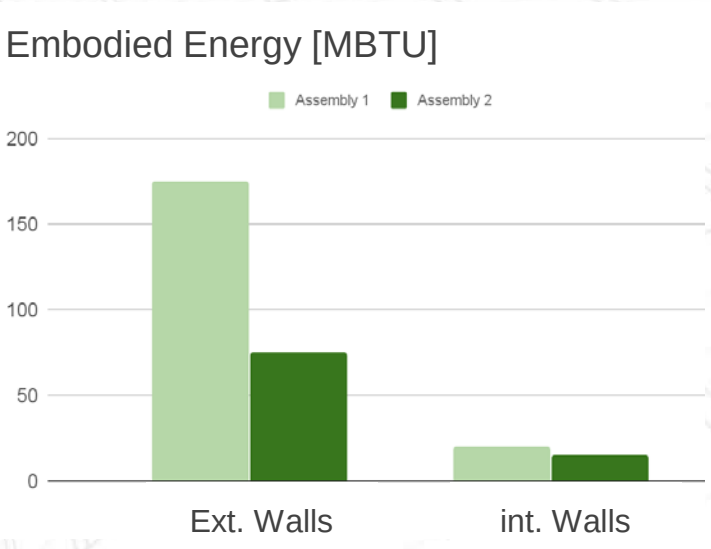
APPROACH: Linked data relates model's component assemblies to energy embodied in component production, transport, etc.

INPUTS: GBXML file

OUTPUTS: Component-level embodied energy

DATA SOURCES: Linked open databases, product declarations

KEY FEATURE: Full accounting of energy embodied in component life cycle



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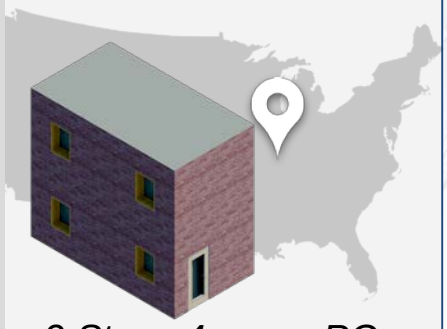
EMBODIED ENERGY: WORKING EXAMPLE

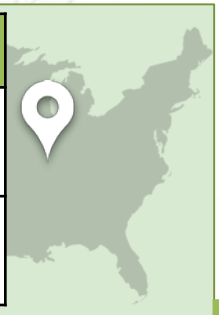
EXAMPLE BUILDING



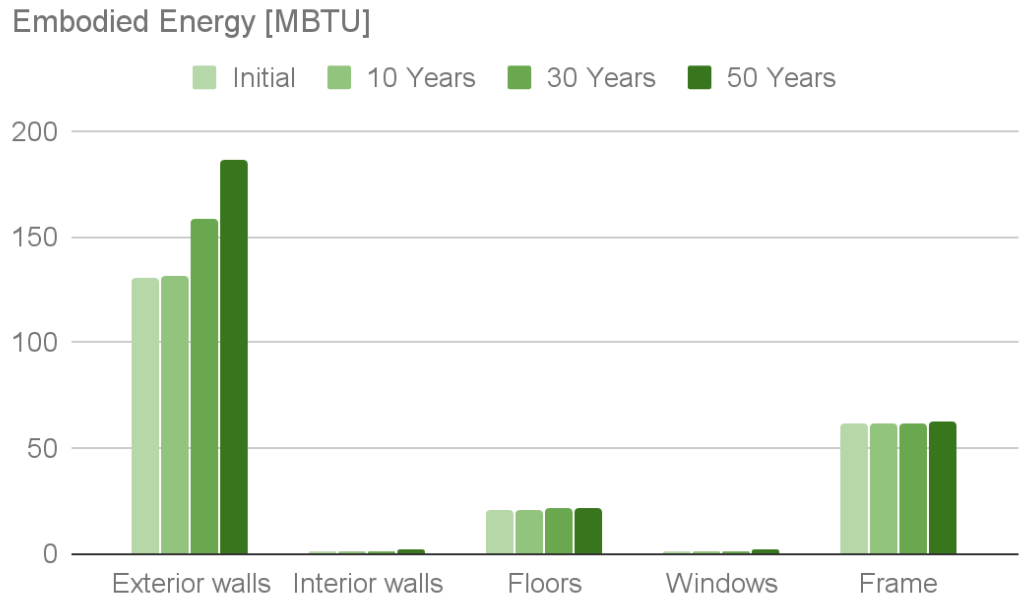
2-Story, 4-room RC Frame in St. Louis, MO

REPRESENTATION

Description
Interior Wall Assembly 1
Interior Wall Assembly 2



Assembly Inventory @ Specific Locale



Embodied Energy Module

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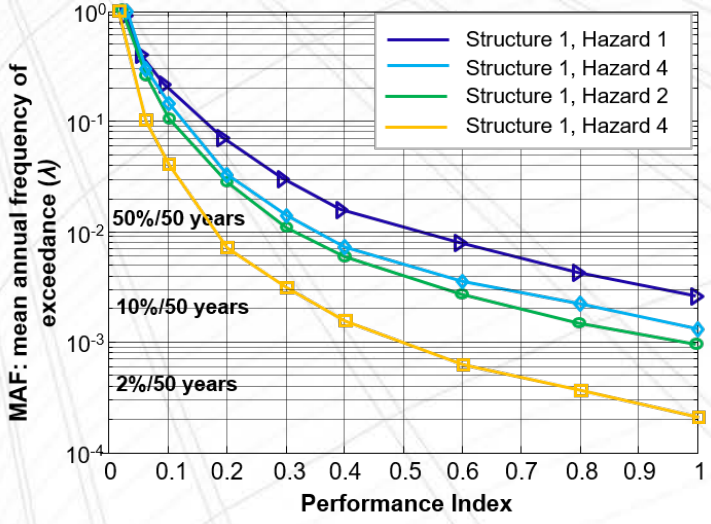
POST PROCESSING MODULE

FUNCTION: Comparative evaluation of component contributions to project's resilience and sustainability goals

APPROACH: Present results over varying service lives to support decision making, evaluation of design alternatives

OUTPUTS: Total Embodied Energy, Operational Energy, Losses (dollars, downtime)

KEY FEATURE: Identifies components that drive hazard resilience and sustainability metrics



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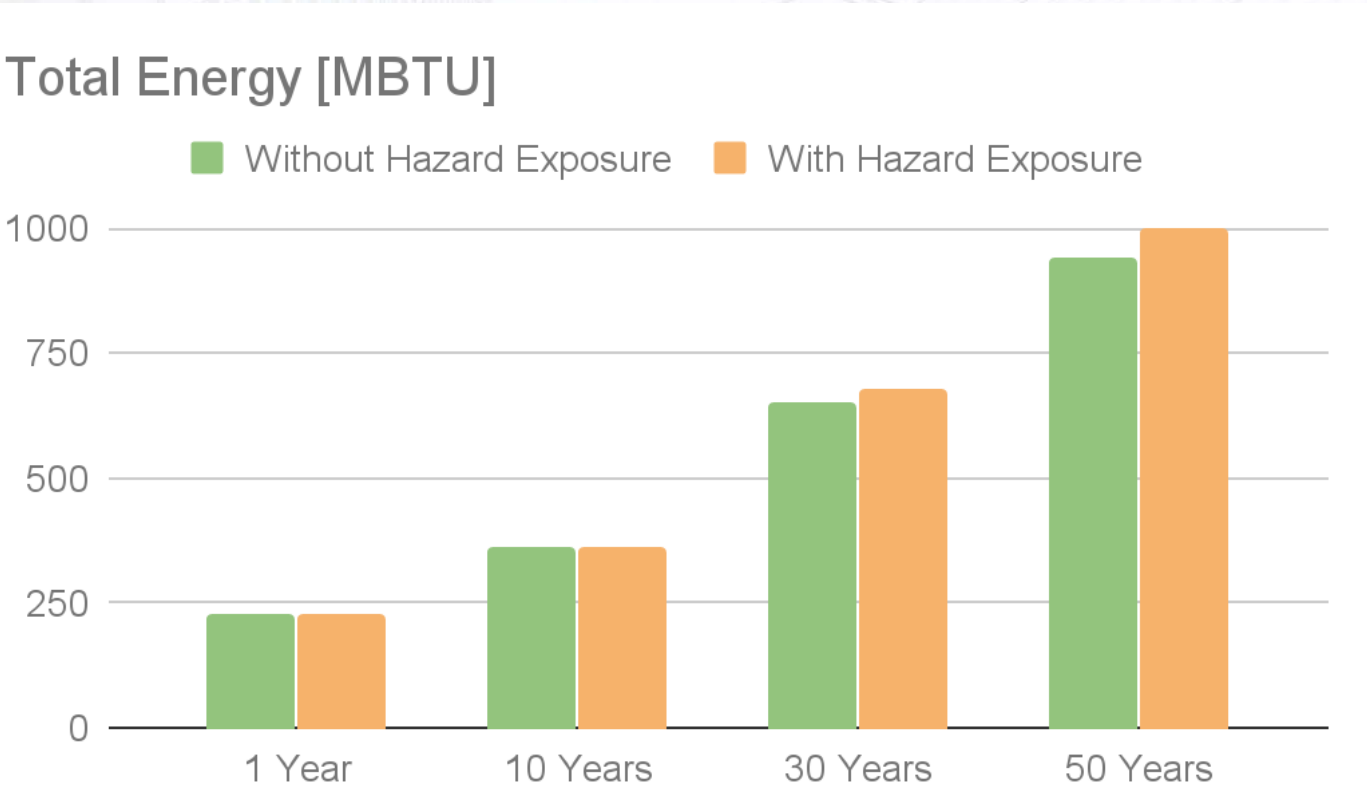
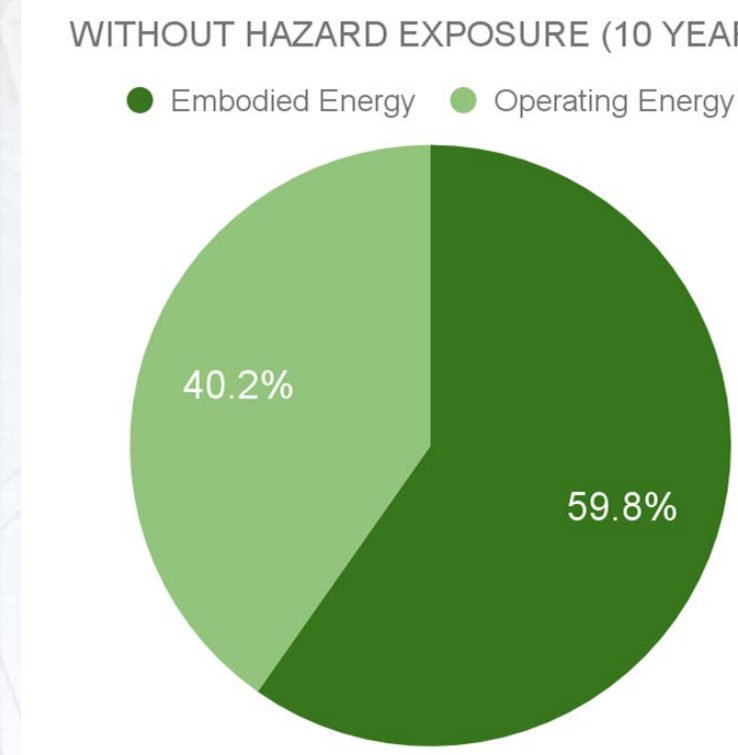
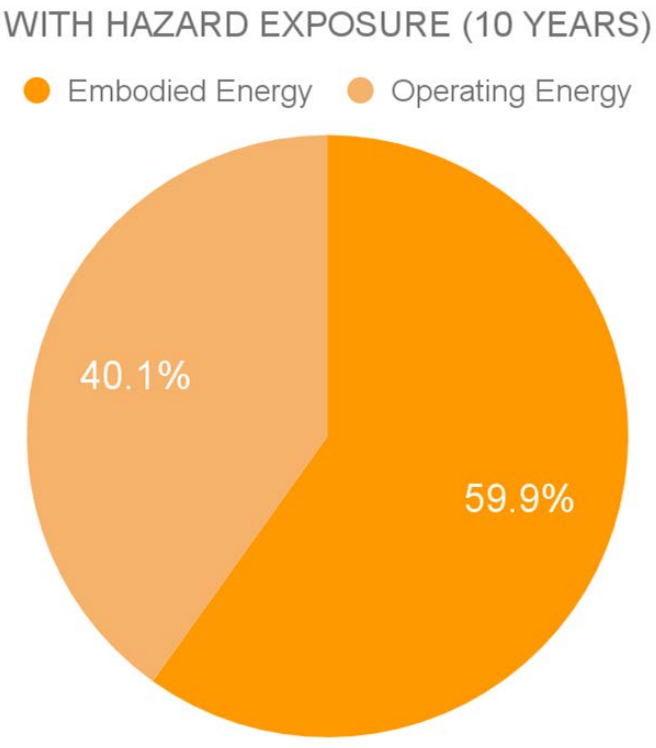
COMPARATIVE ANALYSIS: INFLUENCE OF HAZARD EXPOSURE



COMPARATIVE ANALYSIS: INFLUENCE OF HAZARD EXPOSURE





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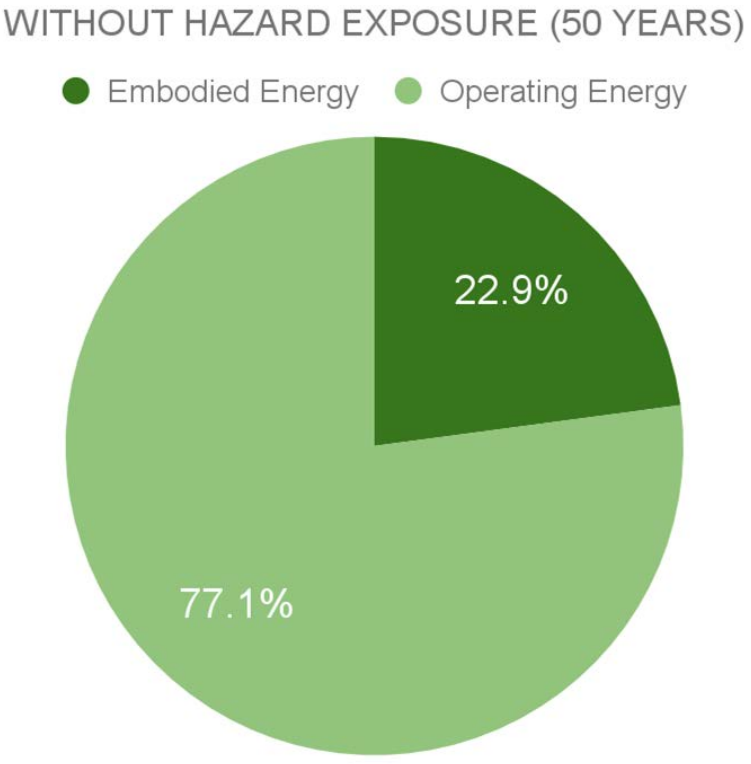
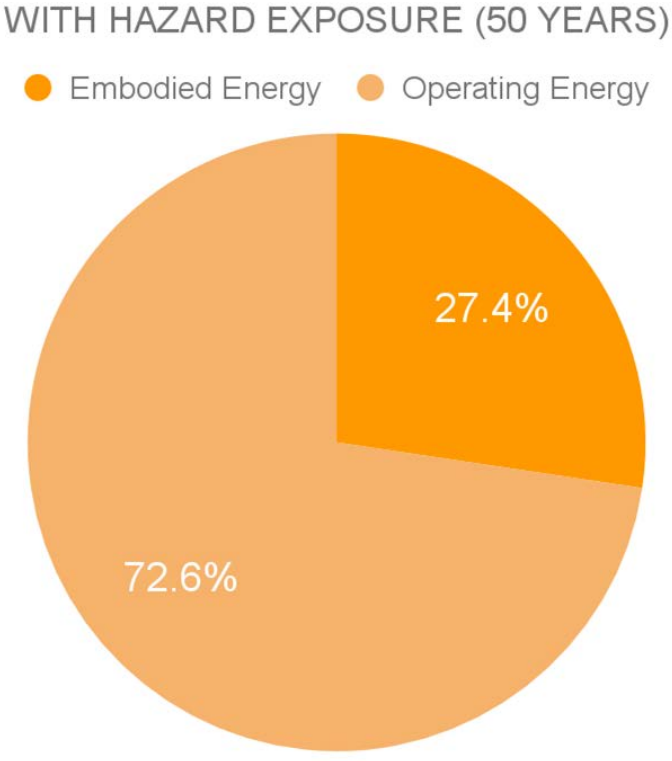
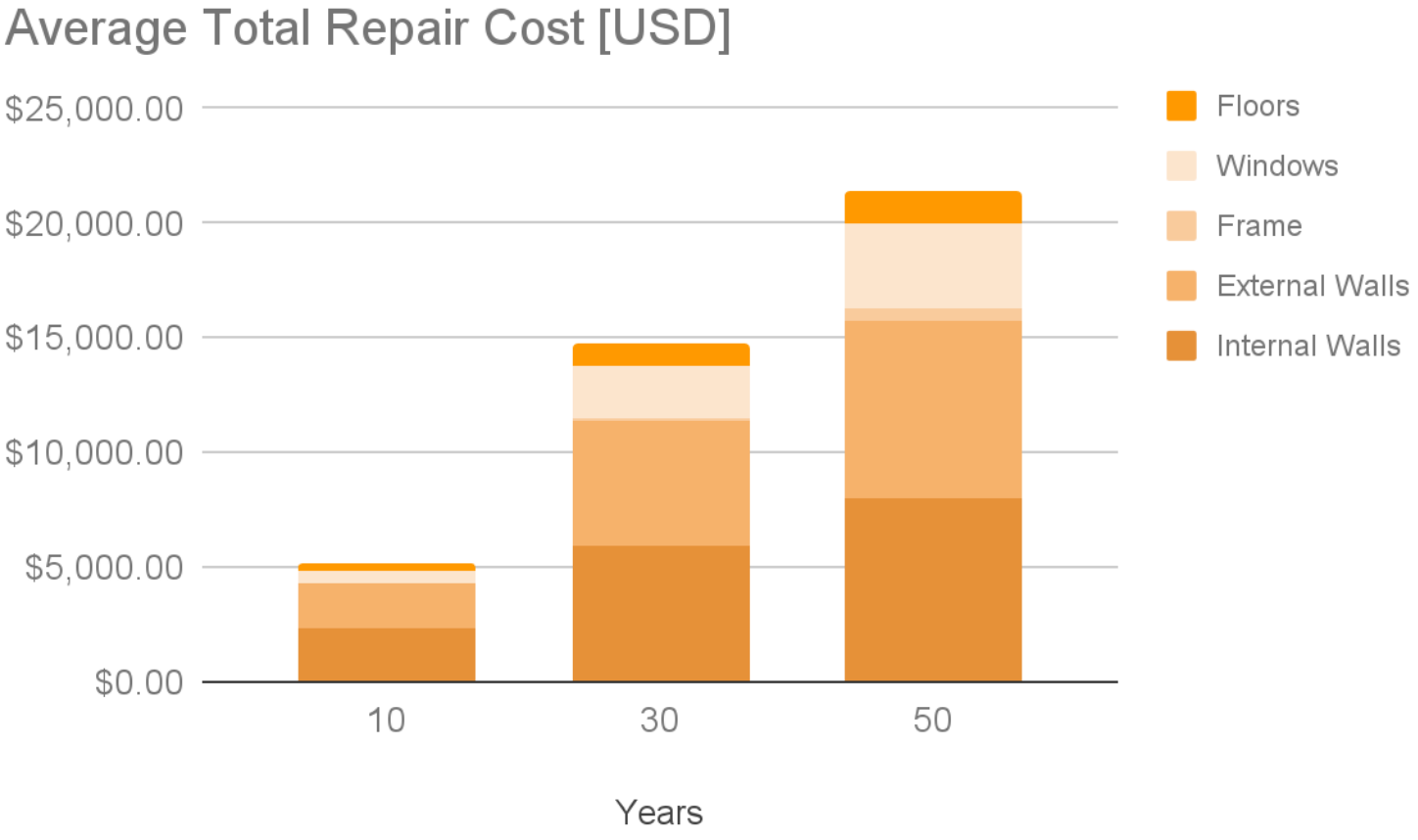
COMPARATIVE ANALYSIS: INFLUENCE OF HAZARD EXPOSURE

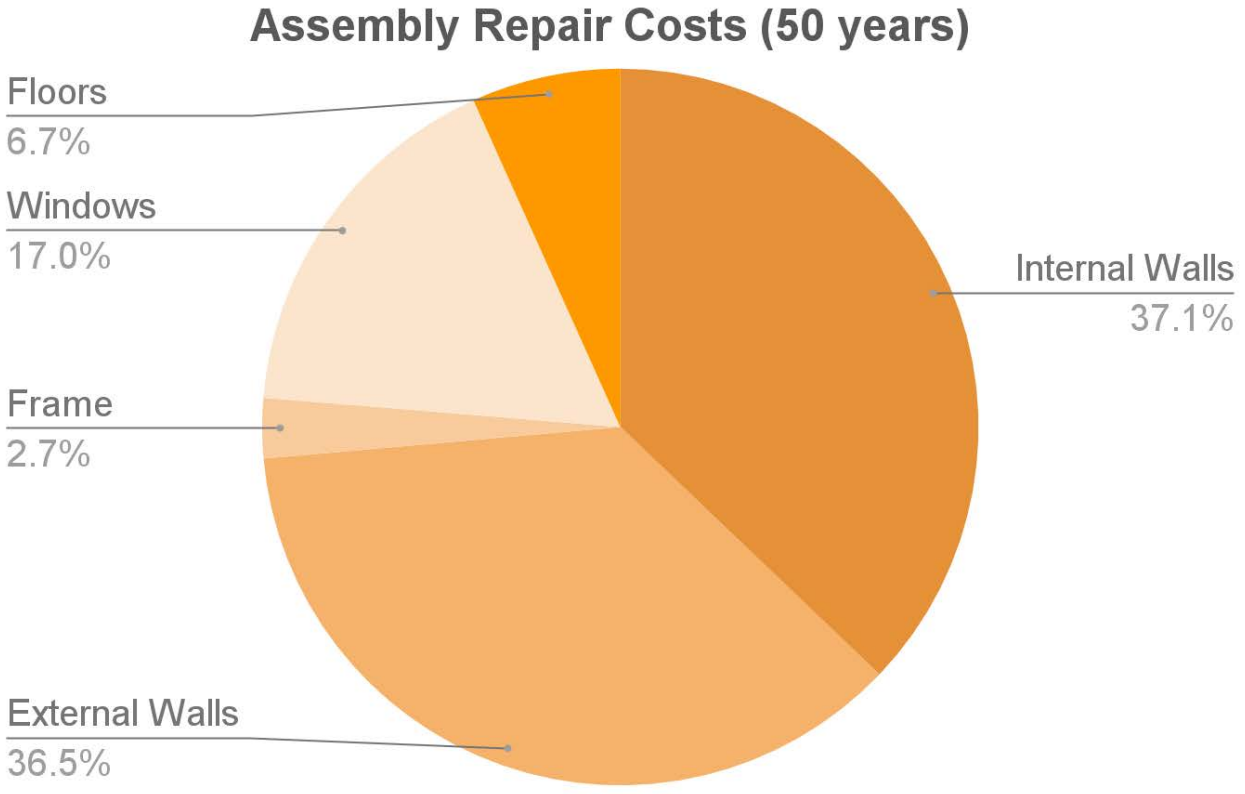




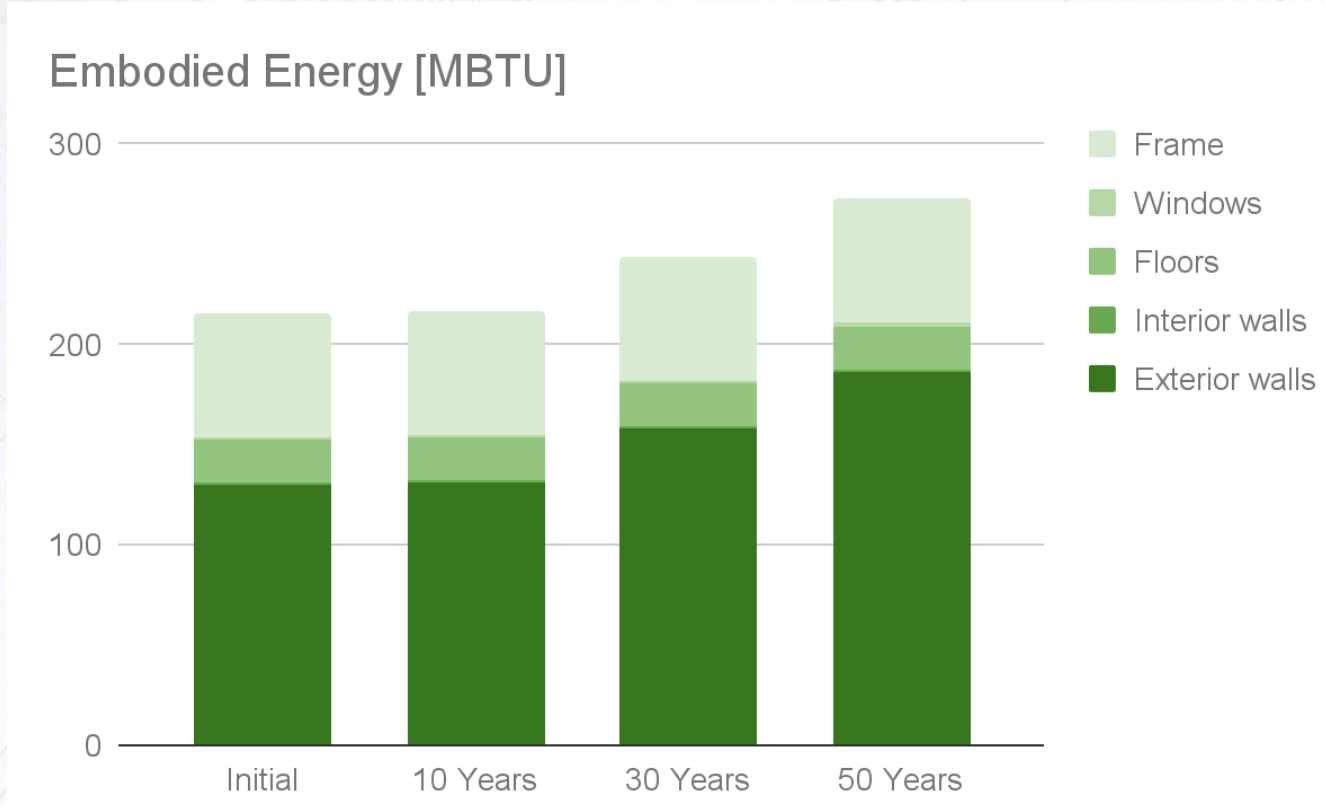
COMPARATIVE ANALYSIS: RESILIENCE METRICS



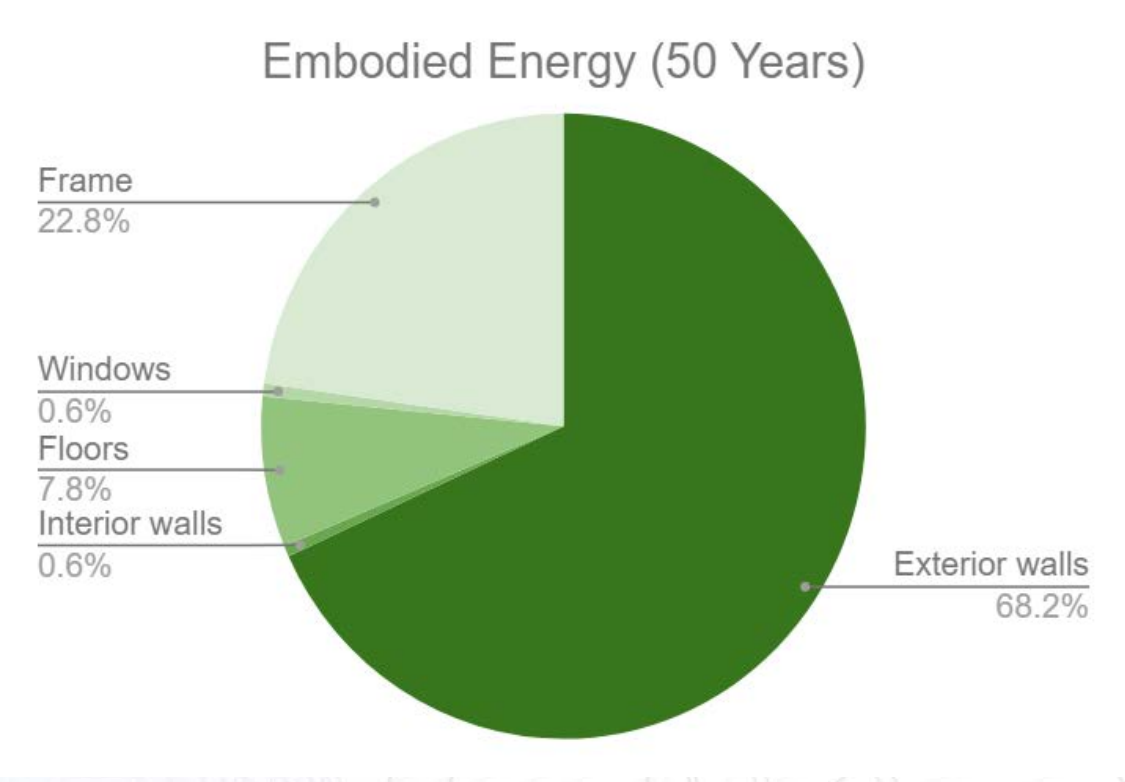
COMPARATIVE ANALYSIS: RESILIENCE METRICS



COMPARATIVE ANALYSIS: SUSTAINABILITY METRICS



COMPARATIVE ANALYSIS: SUSTAINABILITY METRICS



Summary

- Integrated Life Cycle Analysis interfaced to Revit modeling environment
- Modular: build and expand over time
- Enables evaluation of damage due to site-specific hazards, deterioration
  - Repair and replacement costs, downtime
  - Embodied and operational energy
- Identifies component-level impacts
- Accommodates user-supplied and regional data, full component life cycle

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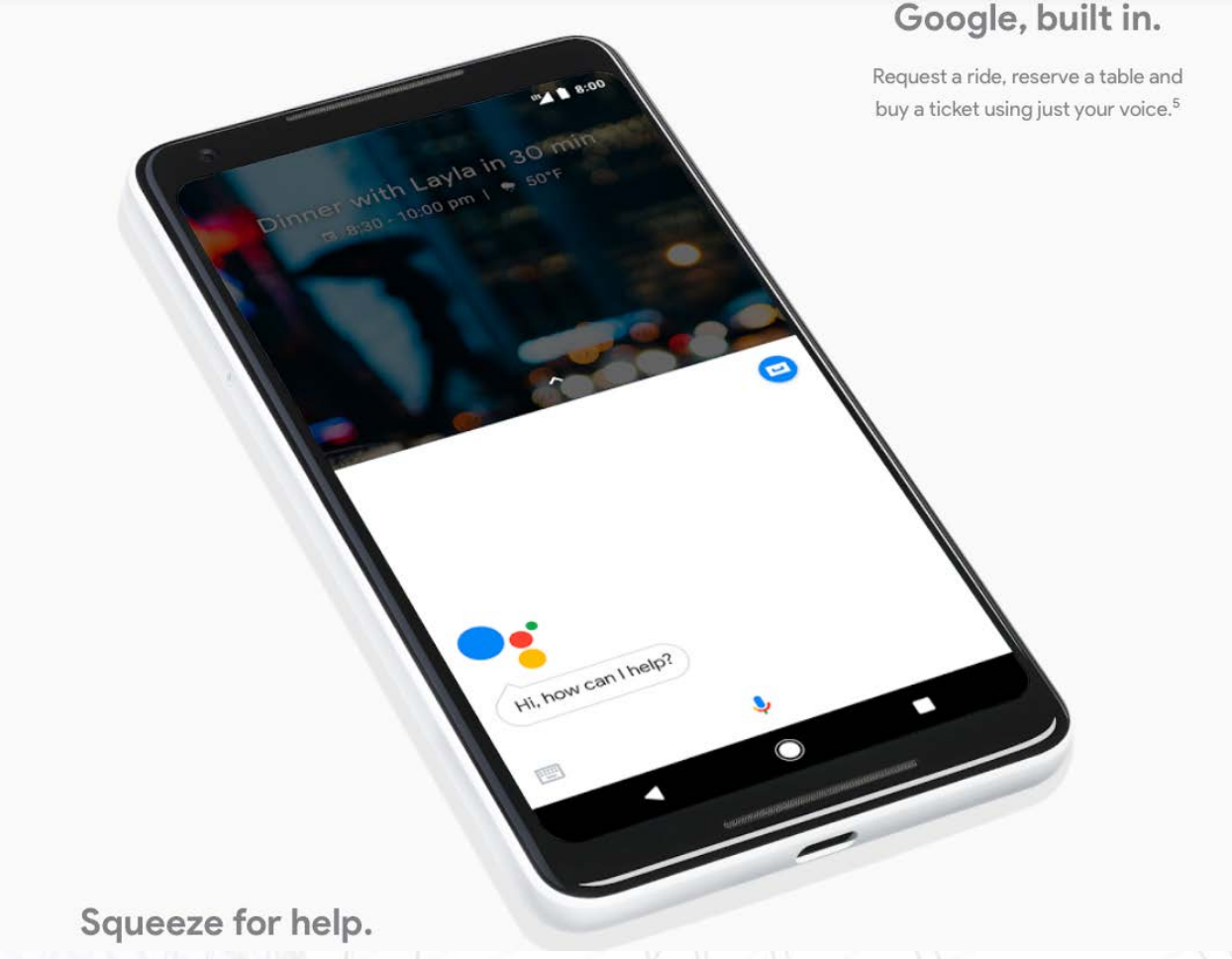
Green-Scale Resilience: Technology Can Build and Connect Community

PRESENTER: Charles Vardeman

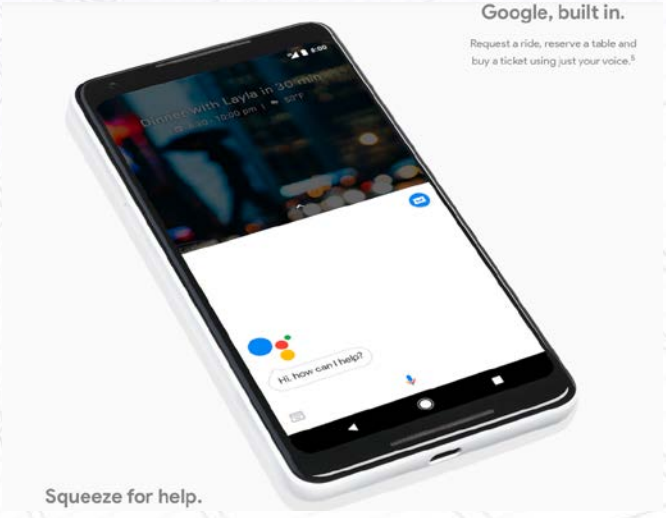
Slight digression in our story...



https://store.google.com/us/product/pixel_2?hl=en-US

Actually, more of a story about these…

https://www.apple.com/ios/siri/



https://assistant.google.com/intl/en_us/

Save time and effort with Cortana, your intelligent assistant.

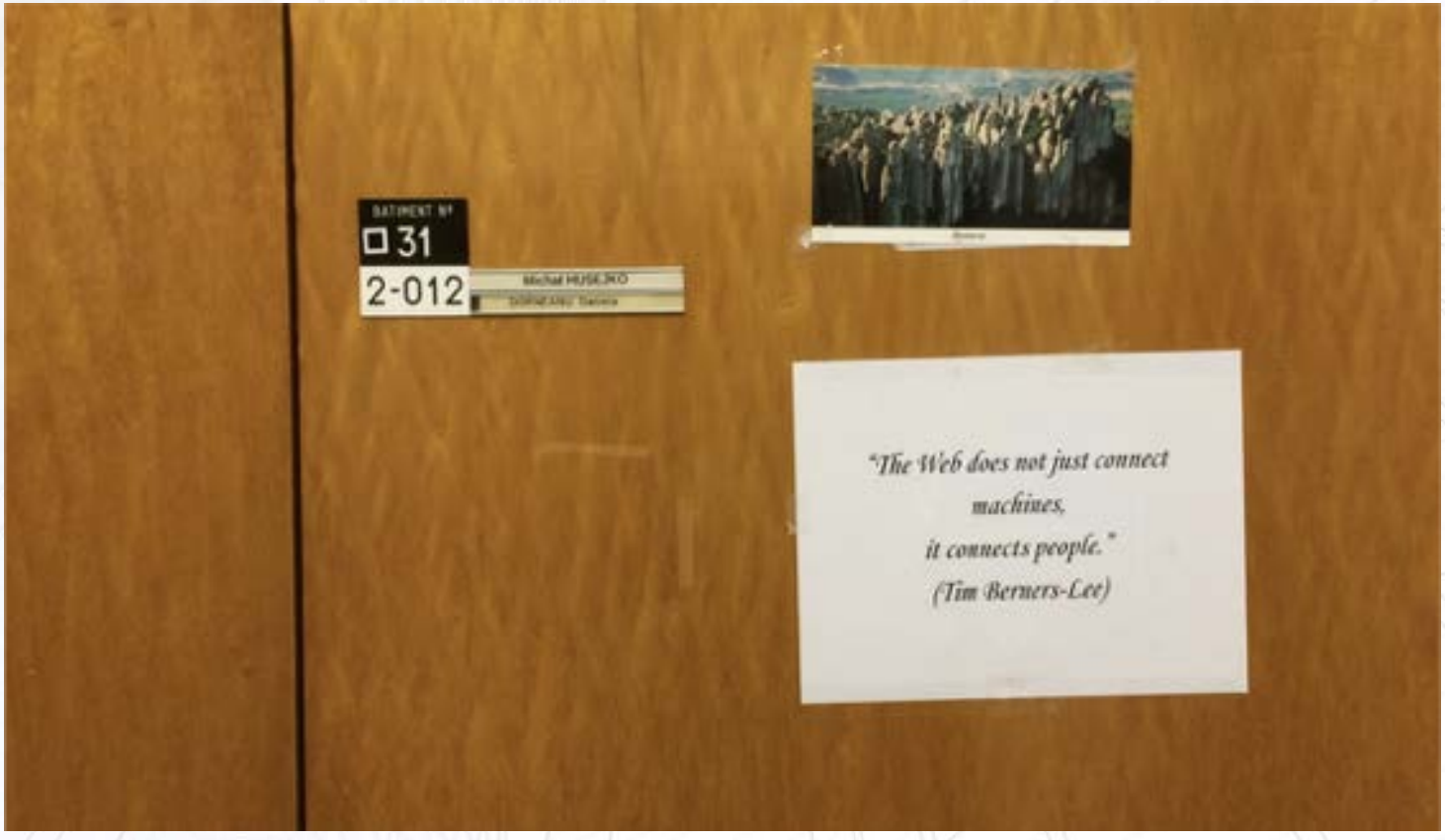
https://www.microsoft.com/en-us/cortana/?

Which would not have possible without what happened here…

Source: Charles F. Vardeman II, License: **(CC BY-SA 2.0)**

Source: W3C20 Anniversary Symposium, https://www.w3.org/20

Source: W3C20 Anniversary Symposium, https://www.w3.org/20



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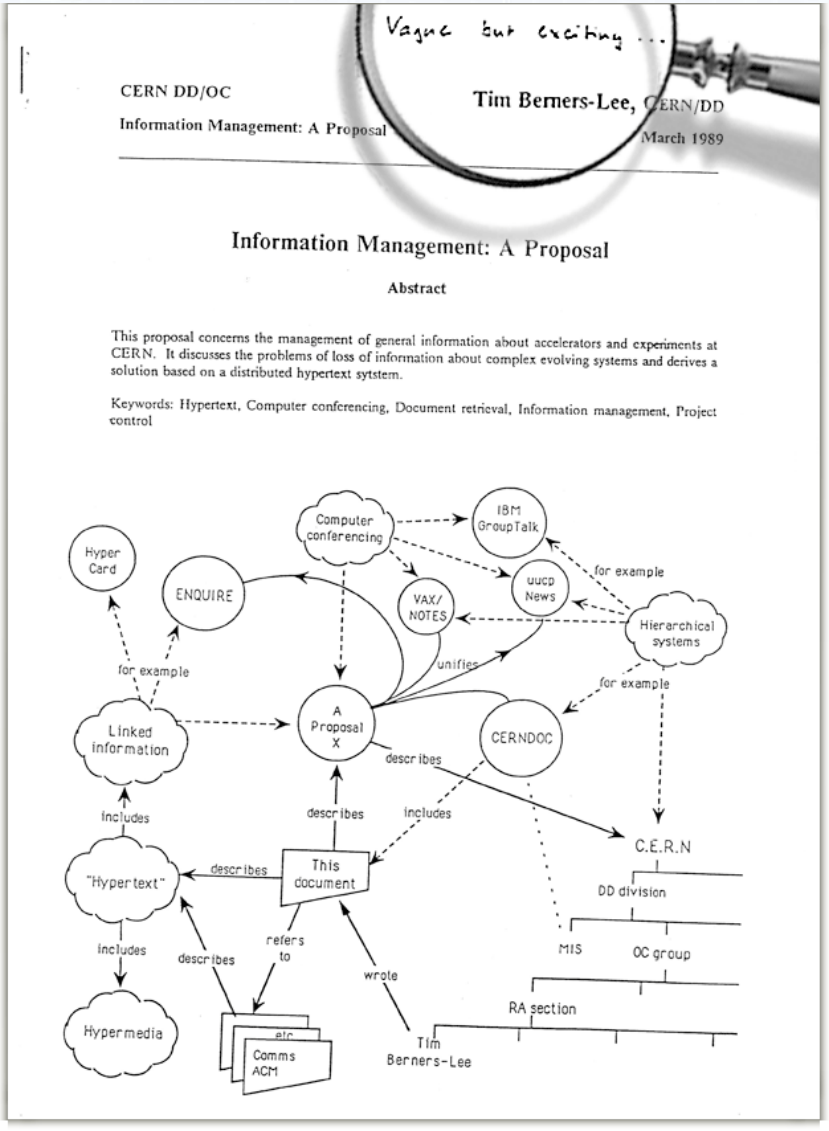
Tim Berners-Lee March 1989
Notice: Subject-Predicate-Object Graph (SPO)



Source:
http://info.cern.ch/Proposal.html

> "The real power of the Semantic Web will be realized when people create many programs that collect Web content from diverse sources, process the information and exchange the results with other programs."

Image Source: http://hi-project.org/blog/

Tim Berners-Lee, James Hendler, Ora Lassila. "The Semantic Web." *Scientific American* 284, no. 5 (2001): 28–37. https://www.scientificamerican.com/article/the-semantic-web/

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Artificial Intelligence 174 (2010) 156–161

Contents lists available at ScienceDirect

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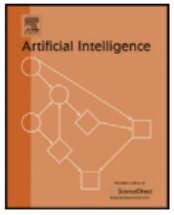
www.elsevier.com/locate/artint



From the Semantic Web to social machines: A research challenge for AI on the World Wide Web

Jim Hendler [a,*], Tim Berners-Lee [b]

[a] Tetherless World Constellation, RPI, United States
[b] Computer Science and AI Laboratory, MIT, United States

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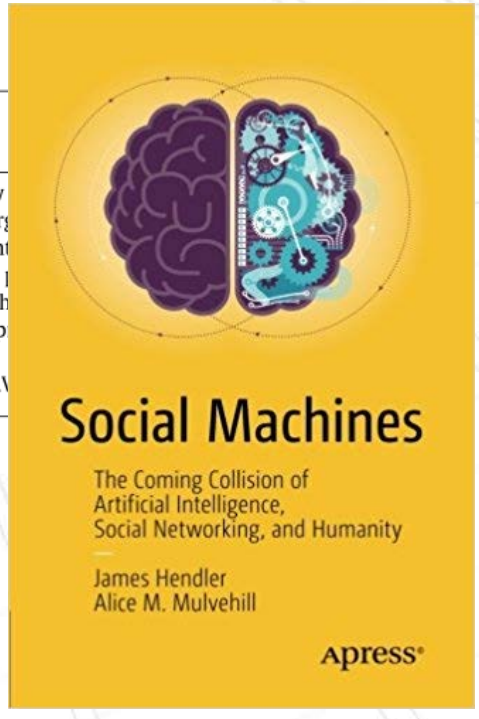
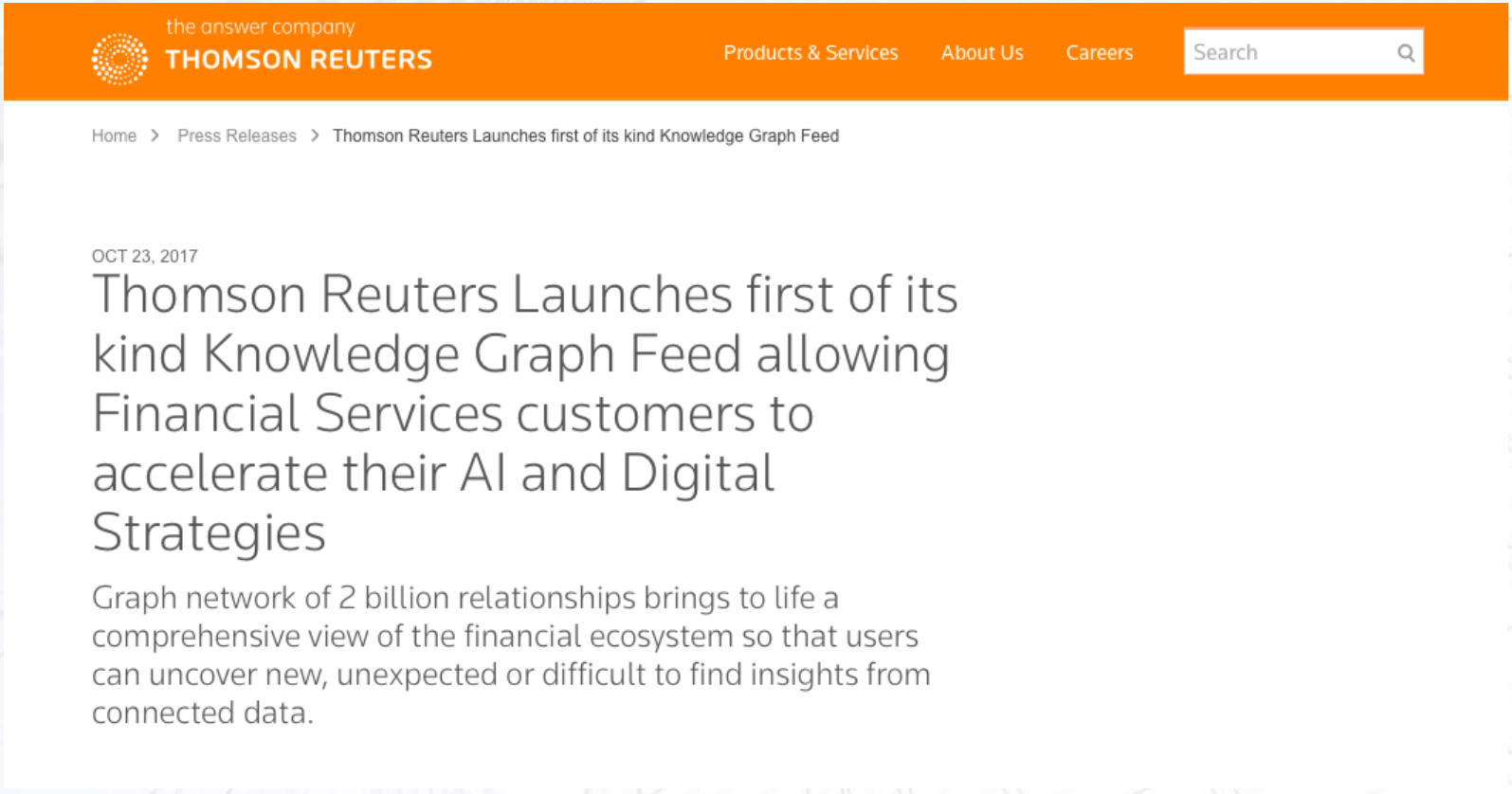
Available online 17 November 2009

ABSTRACT

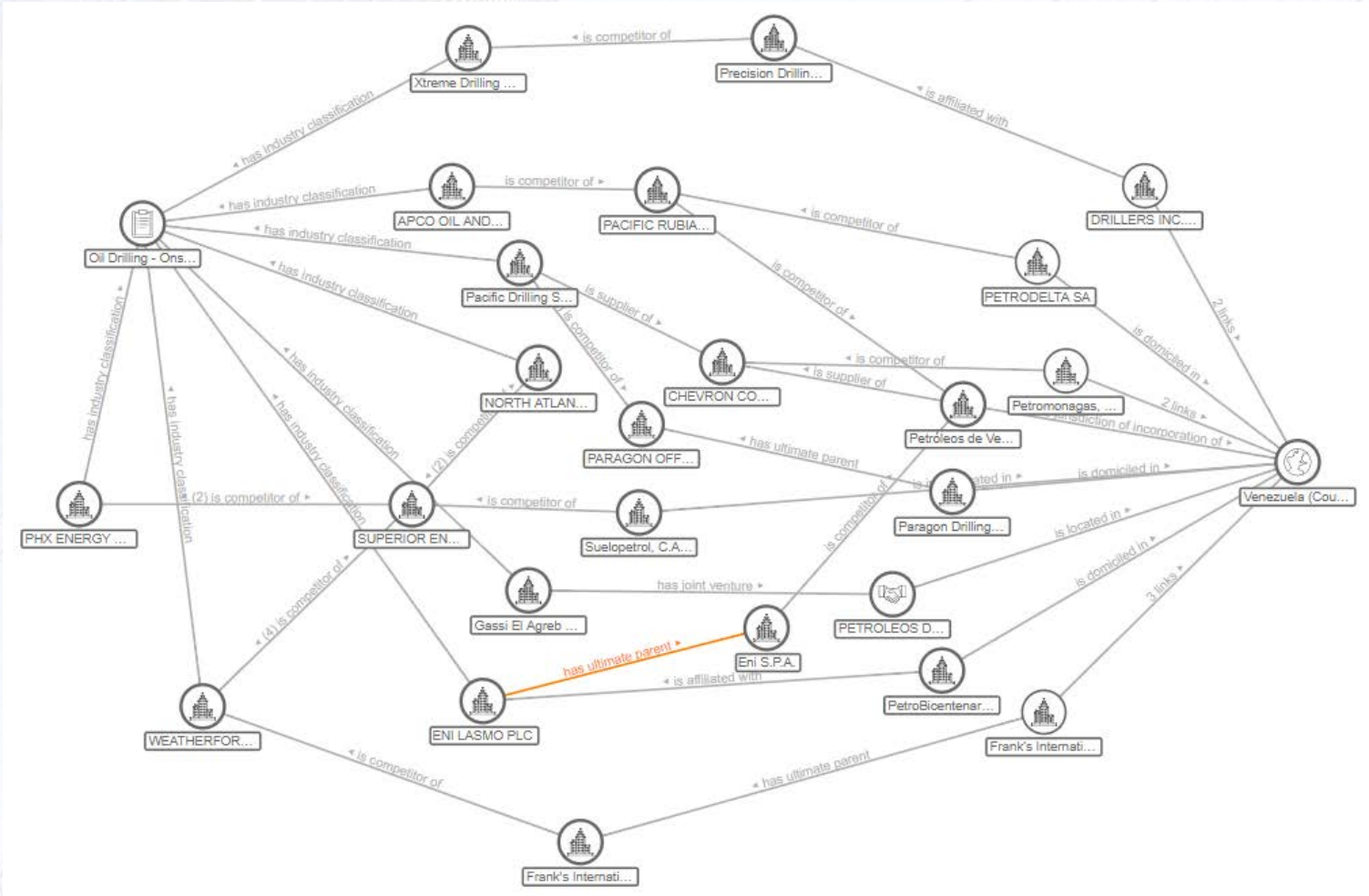
The advent of social computing on the Web has led to a new
applications that are powerful and world-changing. However, we ar
at the beginning of this age of "social machines" and that their cont
growth requires the cooperation of Web and AI researchers. In this
the growing Semantic Web provides necessary support for these tech
challenges we see in bringing the technology to the next level, and p
places for the research.



That’s great!
So, why haven’t I heard of this semantic web thingy?



Source:
https://www.thomsonreuters.com/en/press-releases/2017/october/thomson-reuters-launches-first-of-its-kind-knowledge-graph-feed.html



Source:
http://financial-risk-solutions.thomsonreuters.info/KnowledgeGraphFeed

Source:
https://aws.amazon.com/neptune/

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Tim Berners-Lee

Computer scientist

Sir Timothy John Berners-Lee OM KBE FRS FREng FRSA FBCS, also known as TimBL, is an English engineer and computer scientist, best known as the inventor of the World Wide Web. Wikipedia

Born: June 8, 1955 (age 62), London, United Kingdom

Awards: Order of the British Empire, Royal Medal, Turing Award, MORE

Education: The Queen's College, Oxford (1973–1976), Emanuel School (1969–1973), Sheen Mount Primary School

Spouse: Rosemary Leith (m. 2014), Nancy Carlson (m. 1990–2011)

Books


Weaving the Web: The Origi...
1999


Weaving the Web: The Past...
1999


A Framework for Web S...
2006


Leaders in Computing: Changing...


Foundations and Trends: a...
2006

Profiles

Twitter

Google Inside Search

Home | How Search Works | Tips & Tricks | **Features** | Search Stories | Playground | Blog | Help

The Knowledge Graph

Learn more about one of the key breakthroughs behind the future of search.

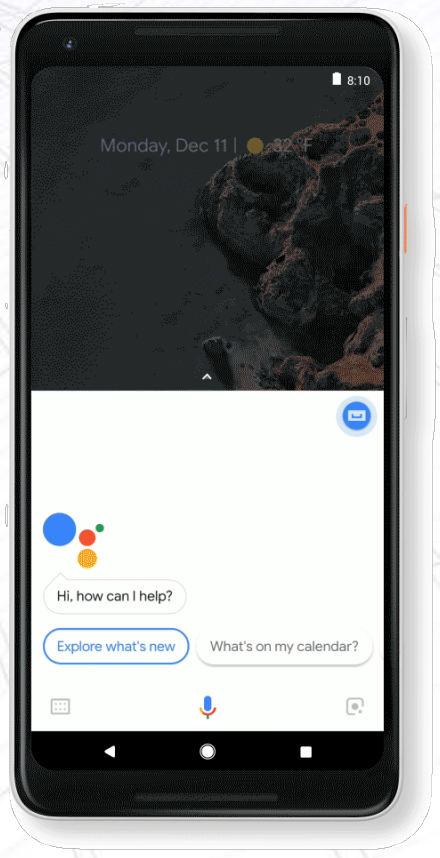
See it in action

Discover answers to questions you never thought to ask, and explore collections and lists.

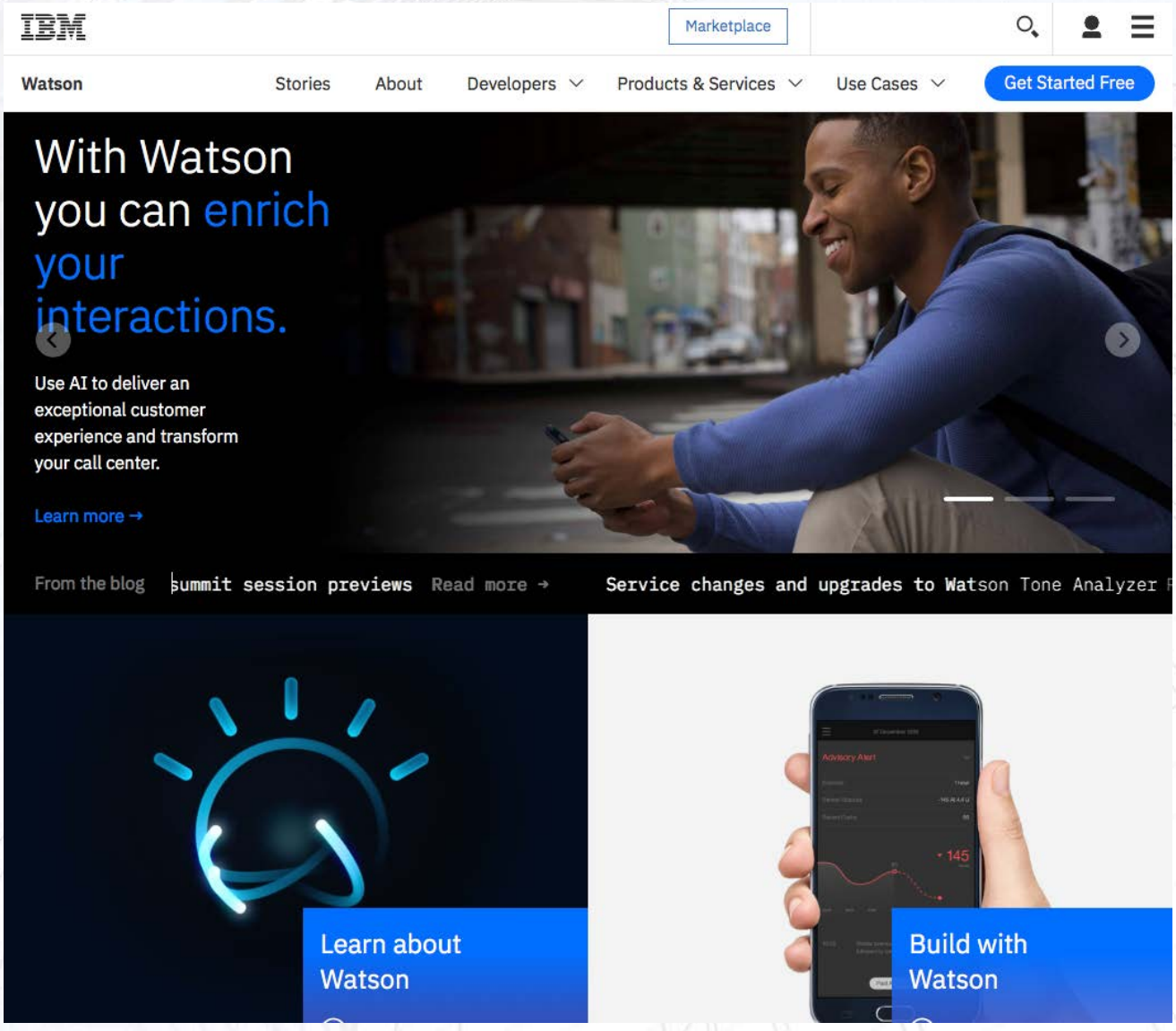
Search what you see

Pixel 2 owners will also get an exclusive preview of Google Lens—a new set of visual smarts that help you learn more about the world around you and get things done. Lens builds on Google's advancements in computer vision and ML, combined with our Knowledge Graph which underpins Google Search. From day one, on your Pixel 2, you'll be able to look up landmarks, books, music albums, movies and artwork by clicking on the Lens icon in Google Photos. You can also use Google Lens to copy URLs and contact info from a picture of a poster or business card. We'll add capabilities on an ongoing basis, including the use of Lens in the Google Assistant.

https://blog.google/products/pixel/new-pixel-2/



https://blog.google/products/assistant/learn-more-about-world-around-you-google-lens-and-assistant/



Source:
https://www.ibm.com/watson/

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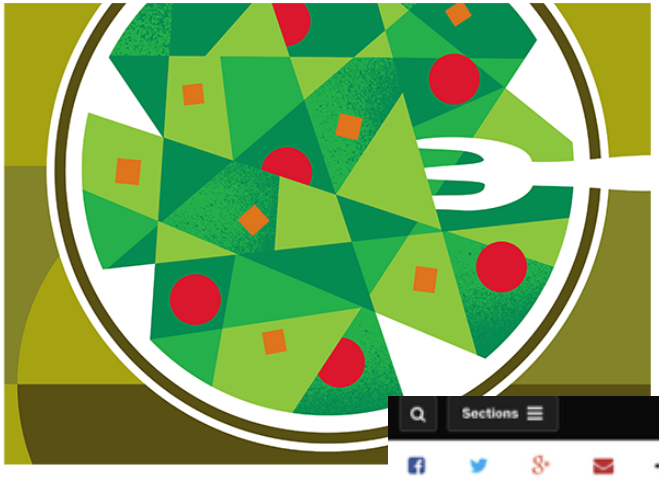
PUBLISHED BY IBM

Better than Cookbooks: Computers Could Make Healthy Eating More Palatable

By Florian Pinel



What if the food of the future was made nc
technology; with the tools and supplies t

Slate

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Why Women Are Missing out on the Tech Boom

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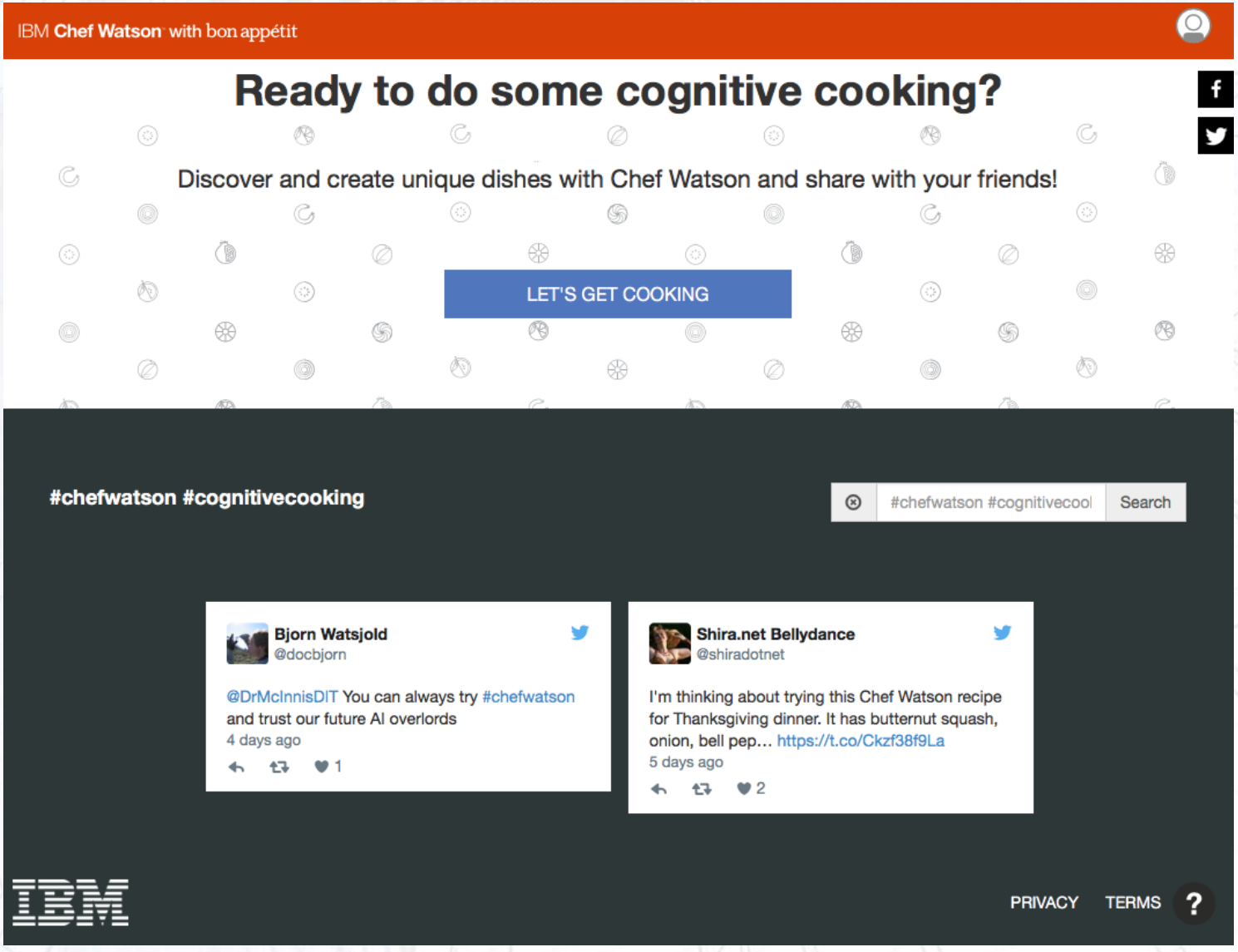
Innovations

How IBM Watson helped me to create a tastier burrito than Chipotle

A | 2 | Save for Later | Reading List

Source:
http://www.slate.com/articles/technology/ibm/2014/11/better_than_cookbooks_computers_could_make_healthy_eating_more_palatable.html



Source: https://www.ibmchefwatson.com/community

"Chef Watson" is helping to explore possibilities that would not have otherwise been considered

"Let's take a look at how this works.

Over the past couple of years, we created a food knowledge database that contains recipes, ingredient ontology, and nutritional facts and characteristics of the flavor compounds contained in different ingredients. We then developed a system that asks for a few inputs about a dish you want to make, such as the key ingredients, cuisine, and dish type. The system then produces hundreds of never-before-seen recipe ideas accordingly, complete with proportions and instructions."

Source:
http://www.slate.com/articles/technology/ibm/2014/11/better_than_cookbooks_computers_could_make_healthy_eating_more_palatable.html

Problem, these are largely proprietary Knowledge Bases BUT they are built on PUBLIC DATA

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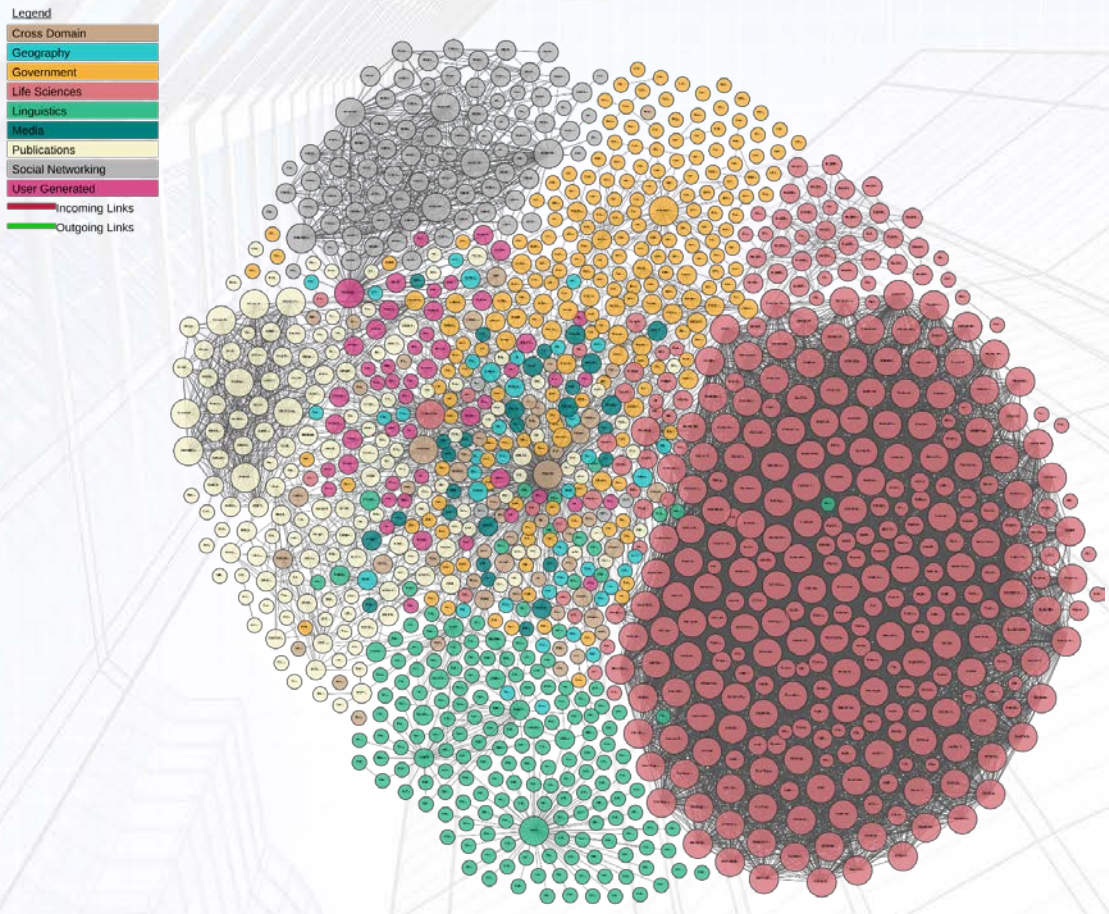

"Linking Open Data cloud diagram 2017, by Andrejs Abele, John P. McCrae, Paul Buitelaar, Anja Jentzsch and Richard Cyganiak. http://lod-cloud.net/" License: CC-BY-SA

Source: Picture, Mike Gogulski (CC BY 2.5).
Krzysztof Janowicz, Frank van Harmelen, James A. Hendler, and Pascal Hitzler. “Why the Data Train Needs Semantic Rails.” AI Magazine, 2014. http://corescholar.libraries.wright.edu/cse/169/.

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KEY IDEA: Use *Structured Data* (Ontologies) based *Knowledge Graphs* as basis for information flow in computational models

A definition from Siri's Dad!

An Ontology is an *explicit specification* of a *conceptualization*[1]

Human ← → Computer

[1]Tom Gruber, "What is an Ontology?", http://www-ksl.stanford.edu/kst/what-is-an-ontology.html

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How can we use Community to capture SHARED Conceptualization?

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Effort between domain experts, facilitators who understand some of the domain and some modeling and formal logics experts to encapsulate concepts

Ontology modeling with domain experts: The GeoVoCamp experience

Pascal Hitzler[1], Krzysztof Janowicz[2], and Adila A. Krisnadhi[1,3]

[1] Wright State University, OH, USA
[2] University of California, Santa Barbara, USA
[3] Faculty of Computer Science, Universitas Indonesia

Abstract. A series of GeoVoCamps, run at least twice a year in locations in the U.S., have focused on ontology design patterns as an approach to inform metadata and data models, and on applications in the GeoSciences. In this note, we will redraw the brief history of the series as well as rationales for the particular approach which was chosen, and report on the ongoing uptake of the approach.

1 Introduction: GeoVoCamps

Since Spring 2012, a series of GeoVocamps has been held in the U.S. which used a modeling approach driven by ontology design patterns (ODPs). In terms of topics they have mostly (but not exclusively) stayed close to the GeoSciences and related disciplines. Events have been held annually in Spring in Santa Barbara, CA, and in Fall in the eastern U.S., mostly in the Washington D.C. area, with additional occasional events in locations such as Notre Dame, IN, or Dayton, OH.[1] Each event usually drew between 20 and 30 participants, including 8-10 "regulars" which come very frequently to the events.

GeoVoCamps are *unconferences*, and as such are loosely structured, with the actual program decided upon by the participants on the spot. Starting with the Santa Barbara event 2012, the organizers suggested to use ontology design patterns as modeling approach, and indeed most of the work at these GeoVocamps has adopted this since.

Pascal Hitzler, Krzysztof Janowicz, Adila Alfa Krisnadhi:
Ontology Modeling with Domain Experts: The GeoVocamp Experience.
Diversity++@ISWC 2015: 31-36

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A Modification to the Hazardous Situation ODP to Support Risk Assessment and Mitigation

Michelle Cheatham[1], Holly Ferguson[2], Charles Vardeman II[2], and Cogan Shimizu[1]

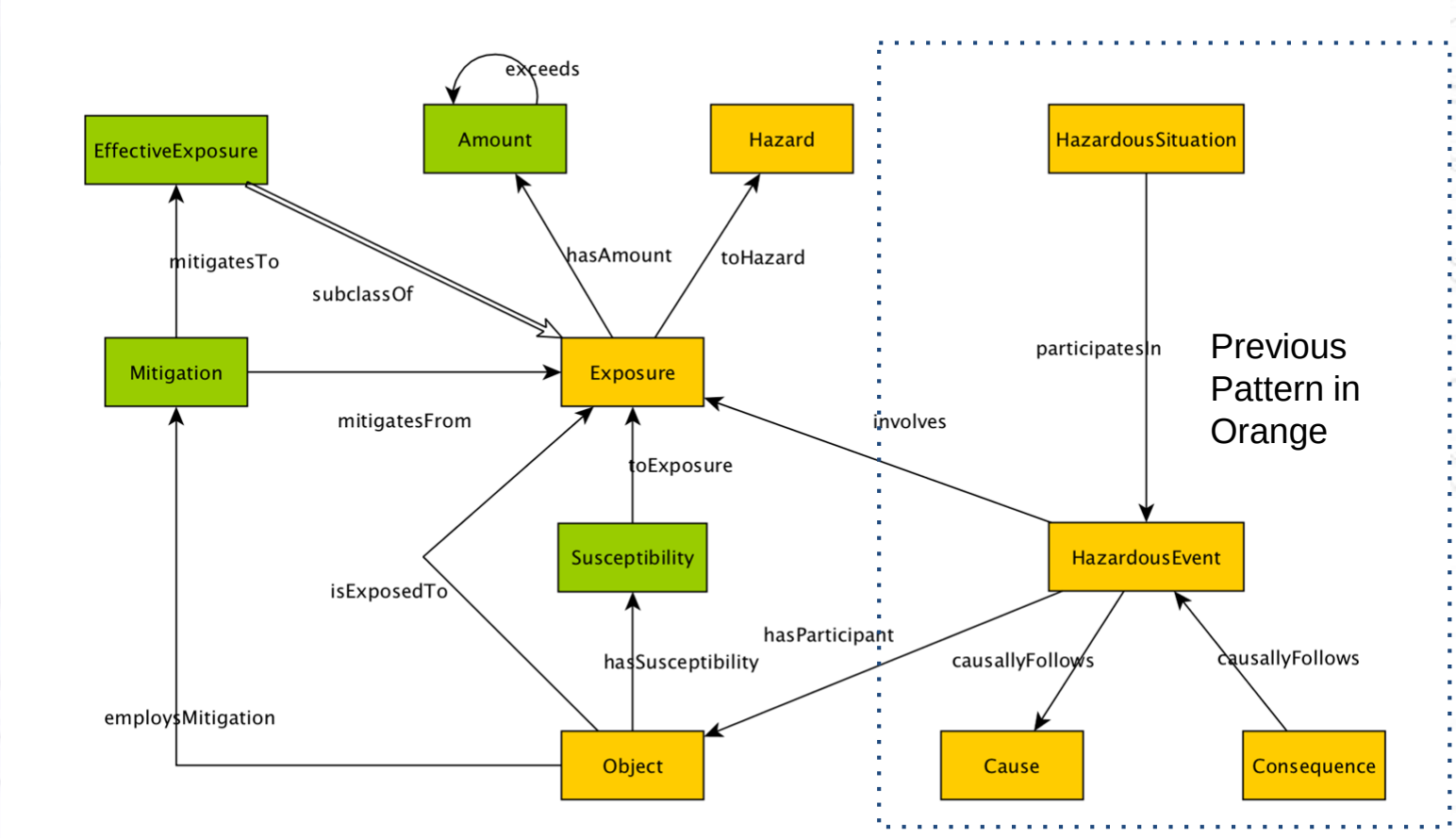
[1] Wright State University
{michelle.cheatham,cogan.shimizu}@wright.edu
[2] University of Notre Dame
{hfergus2,cvardema}@nd.edu

Abstract. The Hazardous Situation ontology design pattern models the consequences of exposure of an object to a hazard. In its current form, the ODP is well suited for representing the consequences of exposure after the fact, which is very useful for applications such as damage assessment and recovery planning. In this work, we present a modification to this pattern that enables it to additionally support proactive questions central to risk assessment and mitigation planning.

Keywords: hazard, ontology design pattern, risk assessment, risk mitigation

Cheatham, M., Ferguson, H., Vardeman II, C., and Shimizu, C., **A Modification to the Hazardous Situation ODP to Support Risk Assessment and Mitigation**, In Workshop on Ontology Design Patterns (WOP), 2016.

“Modified”Hazardous Situation builds on other Patterns!



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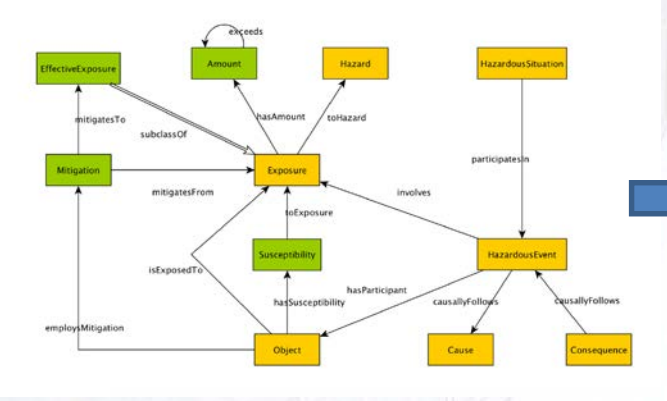
Conceptualization



Formalization (Math)

$$\text{HazardousSituation} \sqsubseteq \exists \text{participantIn}.\text{HazardousEvent}$$
$$\text{HazardousEvent} \equiv \exists \text{hasParticipant}.(\text{Object} \sqcap \exists \text{exposedTo}.\text{Hazard})$$
$$\text{HazardousEvent} \sqsubseteq \exists \text{hasQuality}.\text{Exposure}$$
$$\text{HazardousEvent} \sqsubseteq \exists \text{hasDuration}.\text{TimeInterval}$$
$$\text{HazardousEvent} \sqsubseteq \exists \text{causallyFollows}.\text{Cause}$$
$$\text{Consequence} \sqsubseteq \exists \text{causallyFollows}.\text{HazardousEvent}$$
$$\text{Cause} \sqsubseteq \text{Event}$$
$$\text{HazardousEvent} \sqsubseteq \text{Event}$$
$$\text{Consequence} \sqsubseteq \text{Event}$$

Specification in the Web Ontology Language OWL (Share your KG)

```
@prefix : <http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituationInstance#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@base <http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituationInstance> .


##  http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Amount
<http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Amount> rdf:type owl:Class .

###  http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Consequence
<http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Consequence> rdf:type owl:Class .

###  http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#EffectiveExposure
<http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#EffectiveExposure> rdf:type owl:Class .

###  http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Exposure
<http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Exposure> rdf:type owl:Class .

###  http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Hazard
<http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Hazard> rdf:type owl:Class .

###  http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Mitigation
<http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Mitigation> rdf:type owl:Class .

###  http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Object
<http://daselab.cs.wright.edu/ontologies/ModifiedHazardousSituation#Object> rdf:type owl:Class .
```

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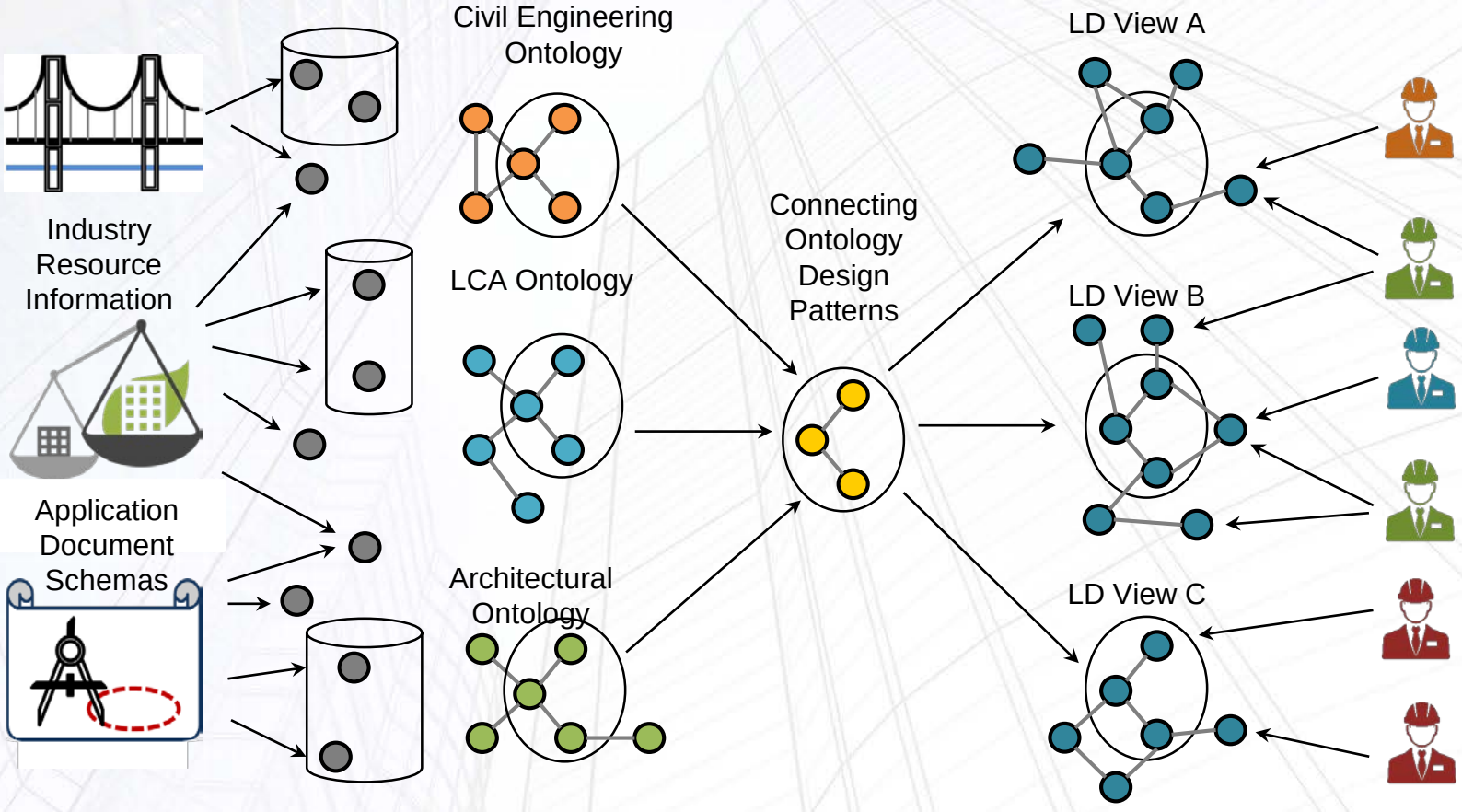
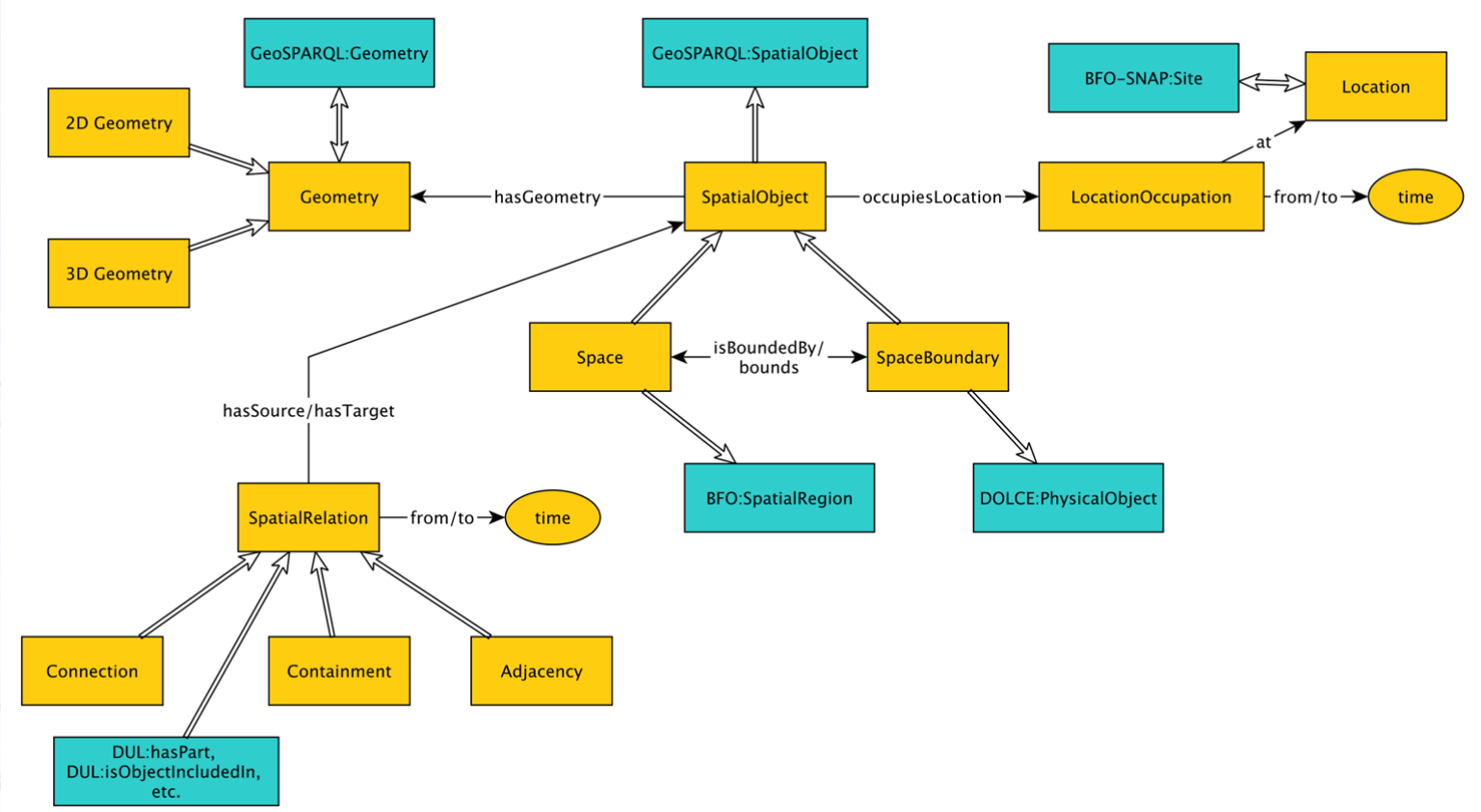
Linked Data Views & Ontology Design Patterns



Spatial Collections and Geometry



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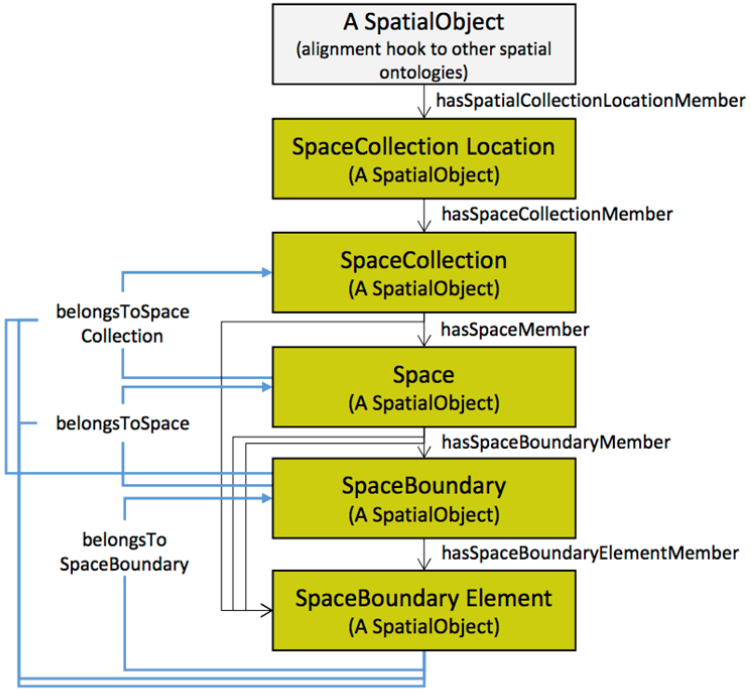
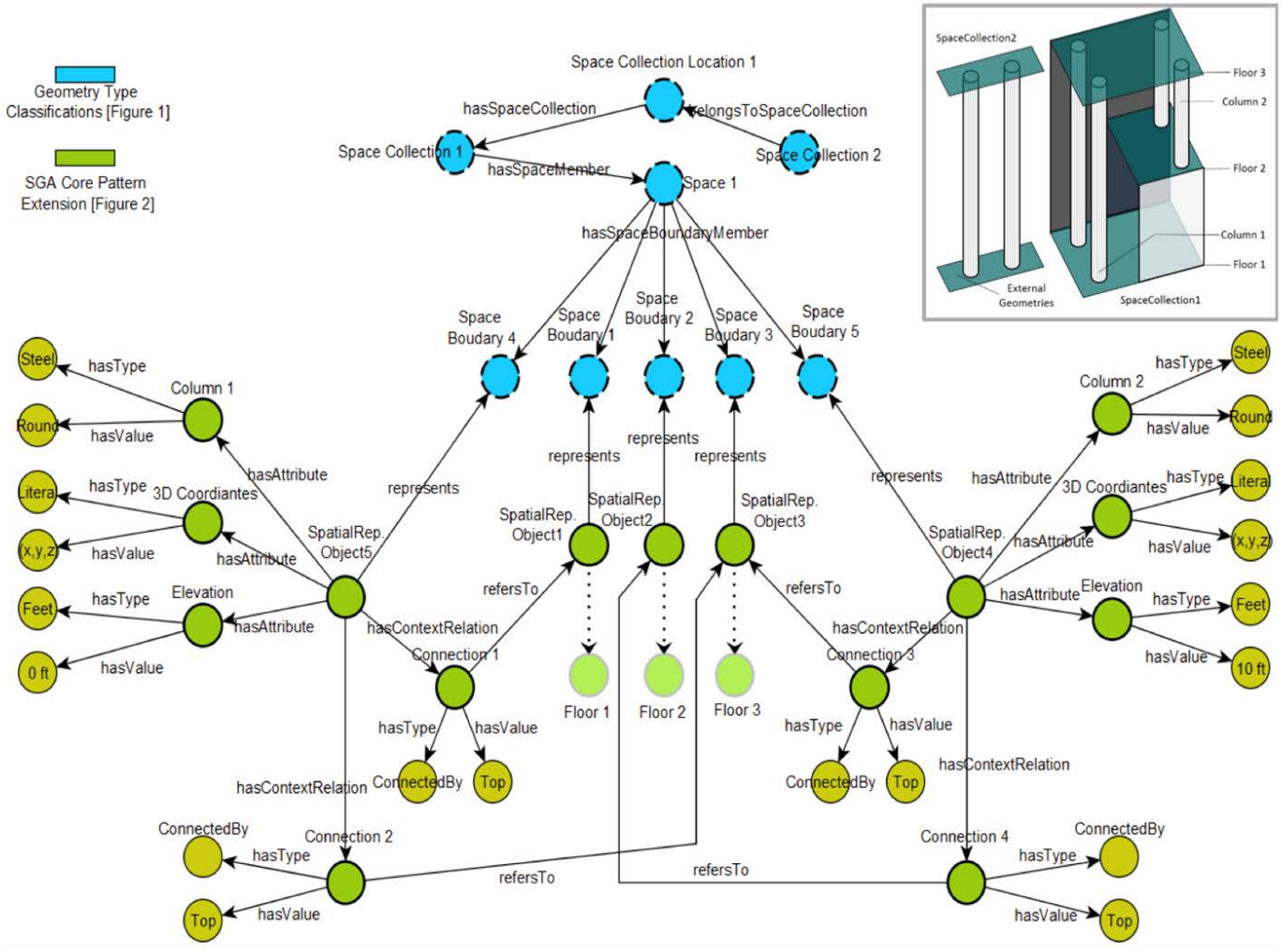
Geometries to Collections

Top Level Spatial Hierarchy for the Organization of BIM Related Geometric Elements



Spatial Object Types	Definition in Context	Example Use Scenario
Space Collection Location	Location of the geometries described in the graph instance.	Commonly the Latitude, Longitude, and Elevation.
Space Collection	Identifier of relevant geometry groupings (3D, 2D, points).	For example, a Building in its entirety.
Space	3D geometry elements in the SpaceCollection.	3D Enclosure in a Building (Room, Elevator etc.).
Space Boundary	2D or 3D geometries 1) creating the Space or 2) part of the SpaceCollection, depending on the schema.	In BIM, typically the Walls, Ceilings, and Floors, or even Shading or Retaining Walls.
Space Boundary Element	2D or 3D geometries 1) creating the SpaceBoundary or 2) part of the SpaceCollectionLocation, SpaceCollection, or Space.	In our research, these are Material Layers within Walls or Landscaping.


Geometry Type Classifications [Figure 1]
SGA Core Pattern Extension [Figure 2]
Space Collection Location 1
hasSpaceCollection
belongsToSpaceCollection
Space Collection 1
Space Collection 2
hasSpaceMember
Space 1
hasSpaceBoundaryMember
Space Boudary 4
Space Boudary 1
Space Boudary 2
Space Boudary 3
Space Boudary 5
SpaceCollection2
Floor 3
Column 2
Floor 2
Column 1
Floor 1
External Geometries
SpaceCollection1
Steel
hasType
Column 1
Round
hasValue
hasAttribute
represents
Litera
3D Coordiantes
(x,y,z)
SpatialRep. Object5
SpatialRep. Object1
SpatialRep Object2
SpatialRep. Object3
SpatialRep. Object4
refersTo
Feet
Elevation
0 ft
hasContextRelation
Connection 1
Connection 3
Floor 1
Floor 2
Floor 3
ConnectedBy
Top
Connection 2
Connection 4
10 ft

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Where are we going next in Knowledge Graphs and AI?

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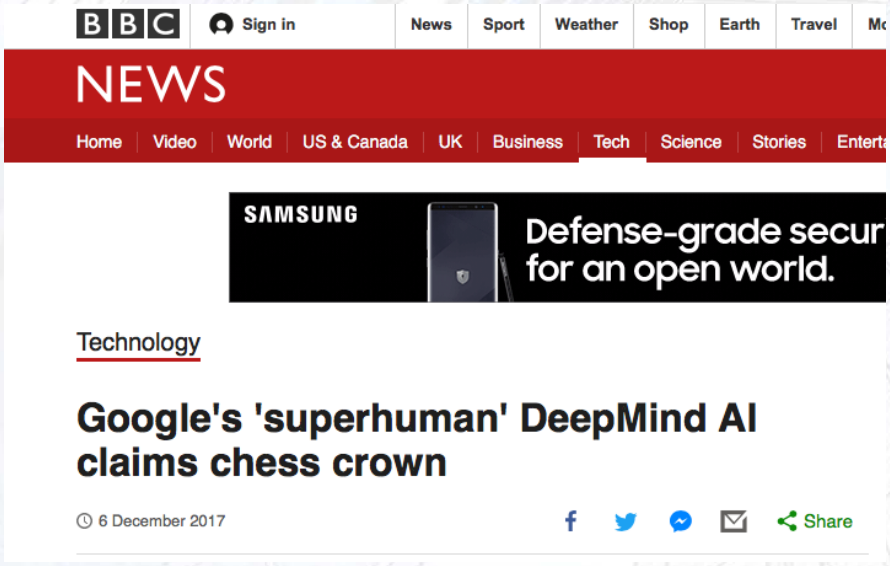
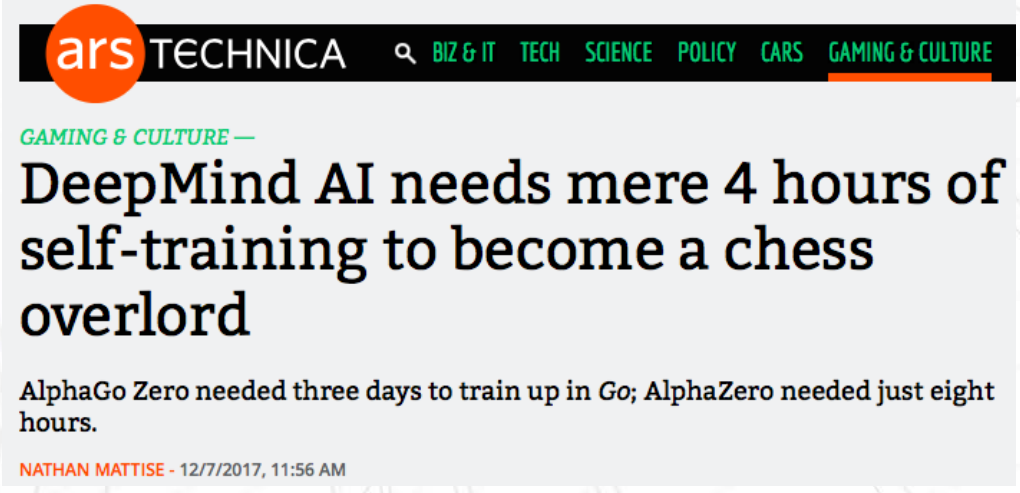


http://www.bbc.com/news/technology-42251535



https://arstechnica.com/gaming/2017/12/deepmind-ai-needs-mere-4-hours-of-self-training-to-become-a-chess-overlord/

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Active research on how to integrate **Neural Networks** and **Deep Reinforcement Learning** methodology with **Knowledge Graphs** and **Reasoning**

Neural-Symbolic Learning and Reasoning: A Survey and Interpretation

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Abstract

The study and understanding of human behaviour is relevant to computer science, artificial intelligence, neural computation, cognitive science, philosophy, psychology, and several other areas. Presupposing cognition as basis of behaviour, among the most prominent tools in the modelling of behaviour are computational-logic systems, connectionist models of cognition, and models of uncertainty. Recent studies in cognitive science, artificial intelligence, and psychology have produced a number of cognitive models of reasoning, learning, and language that are underpinned by computation. In addition, efforts in computer science research have led to the development of cognitive computational systems

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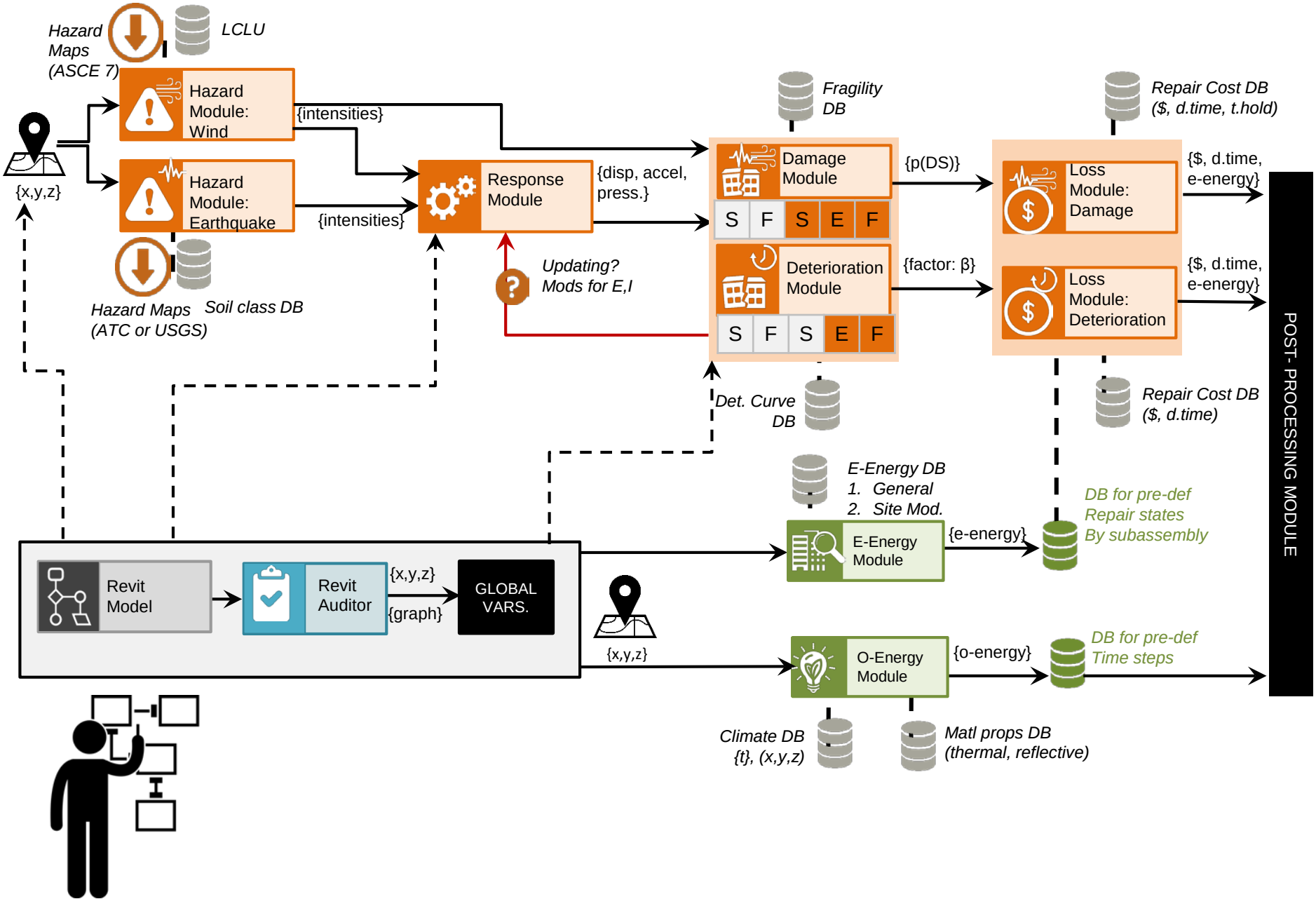
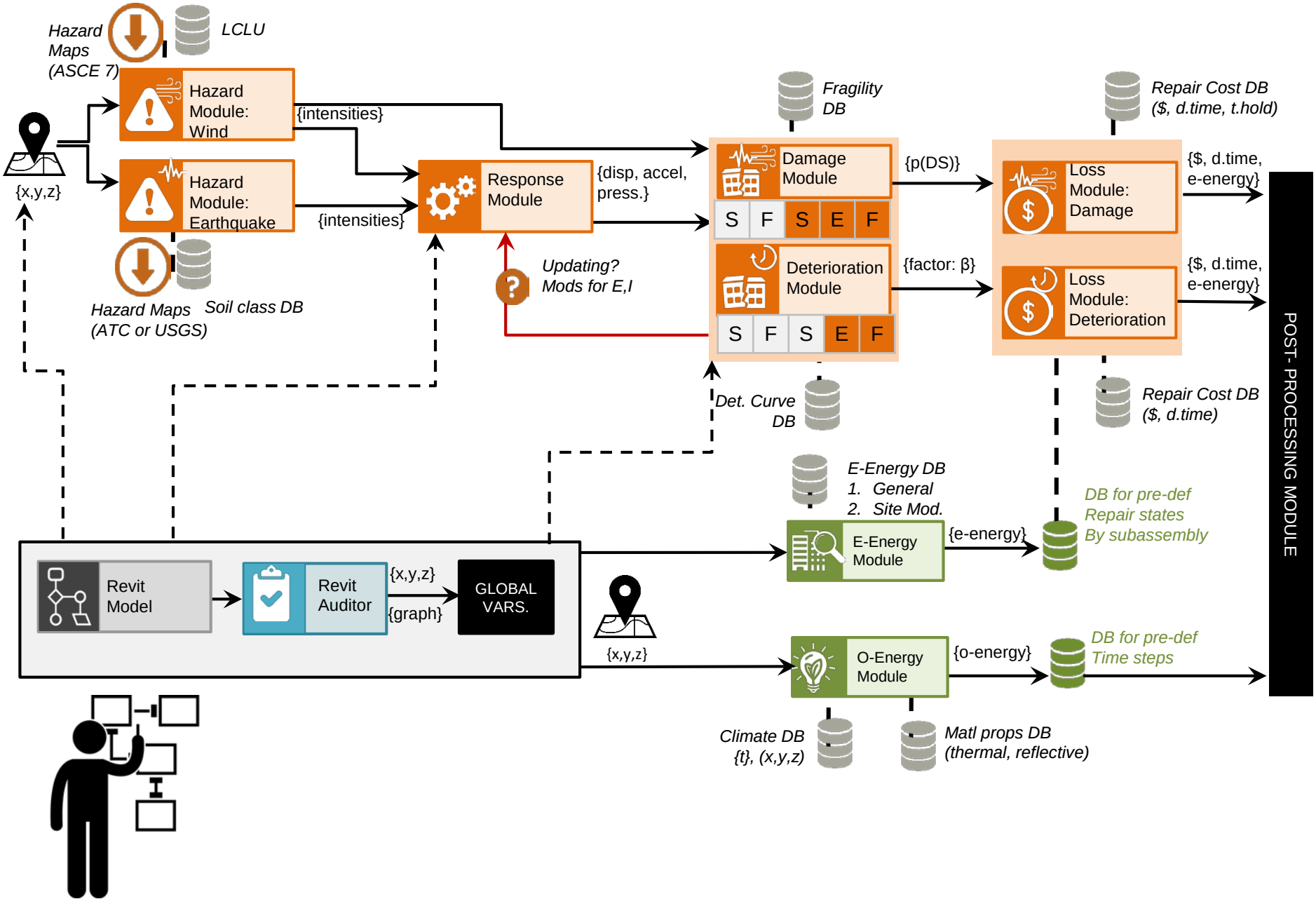
INTEGRATED LIFE CYCLE ASSESSMENT FRAMEWORK



INTEGRATED LIFE CYCLE ASSESSMENT FRAMEWORK



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This concludes The American Institute of Architects Continuing Education Systems Course

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