The "M9" Project –
3-D Simulations of M9 Earthquakes on the Cascadia Megathrust

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NSF Hazards SEES
EAR-1331412

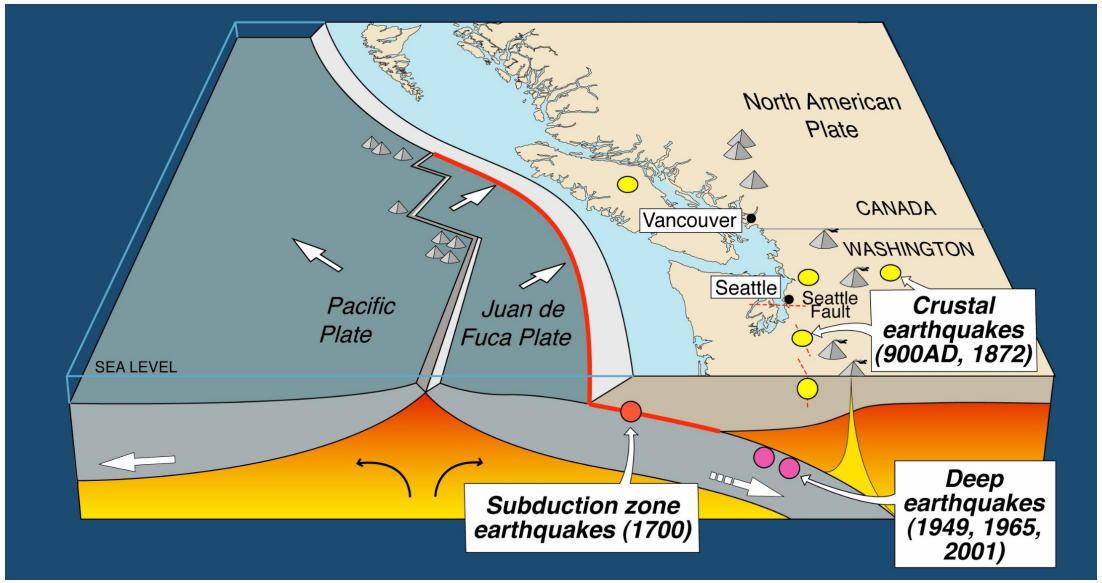
Megathrust Earthquakes in Cascadia

Cascadia Subuction Zone has a history of **M9 Earthquakes**

-Coastal subsidence

-Tsunami records

-Offshore turbidites



USGS

Ghost Forest, Greys Harbor, WA
Brian Atwater, USGS

Tsunami Deposits, Lynch Cove, WA
Carrie Garrison-Laney, UW

Megathrust Earthquakes in Cascadia

Cascadia Subuction Zone has a history of **M9 Earthquakes**

-Coastal subsidence

-Tsunami records

-Offshore turbidites

•Last Cascadia Earthquake in 1700 AD

-Estimated M ~ 8.7 – 9.2 [Satake et al., 2003]

10-14% chance of another M9 earthquake in the next 50 years [Petersen et al., 2002]

The M9 Project

Reduce the **catastrophic consequences of Cascadia megathrust earthquakes** through **advances in science, engineering, & planning**

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The M9 Project was **unique** in terms of…

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… presenting multiple M9 earthquake realizations, framed probabilistically

The M9 Project

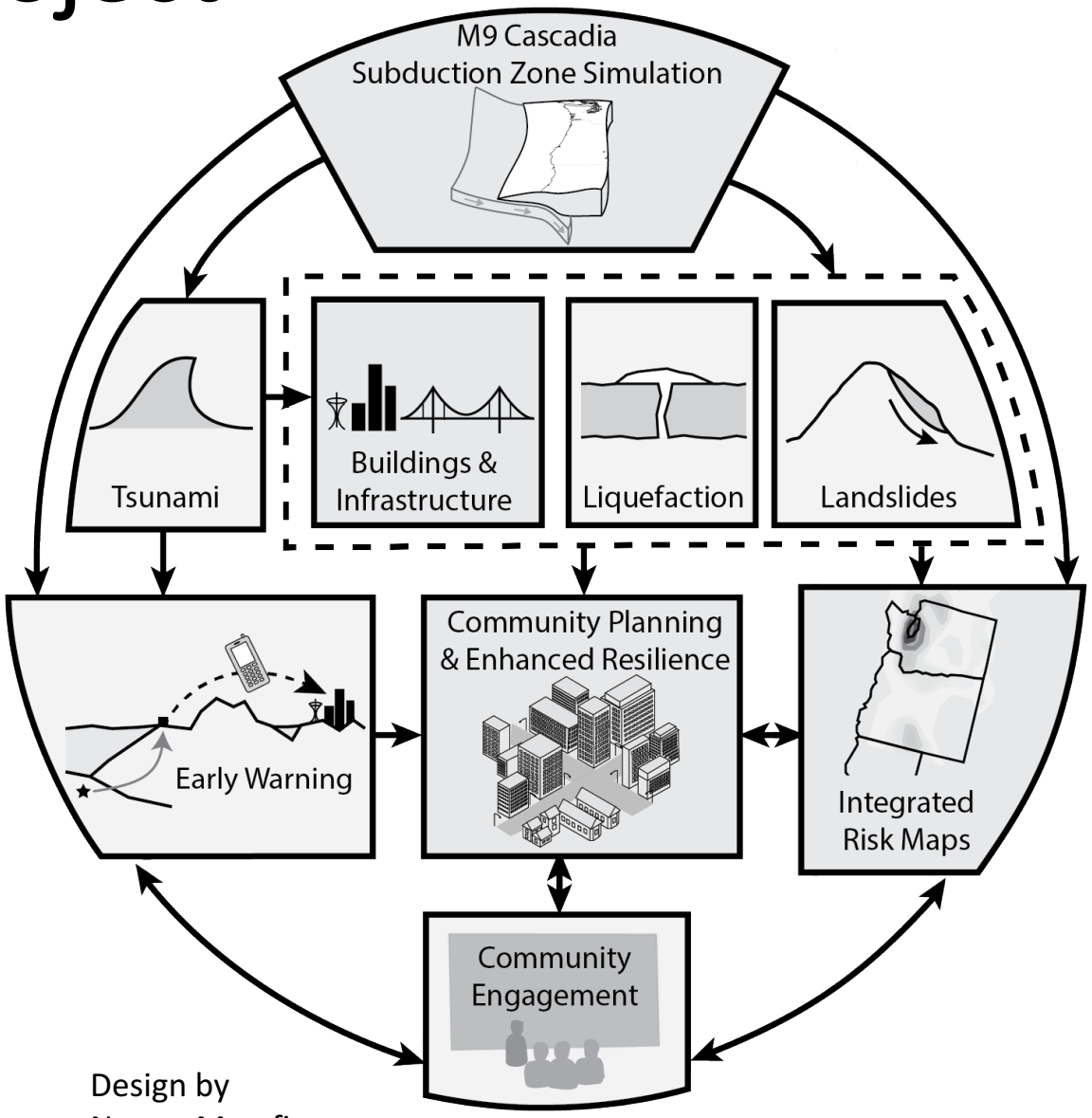
Reduce the **catastrophic consequences of Cascadia megathrust earthquakes** through **advances in science, engineering, & planning**

The M9 Project was **unique** in terms of…

… presenting multiple M9 earthquake realizations, framed probabilistically

…bringing together a diverse team of experts spanning the academic, public, & non-profit sectors

The M9 Project

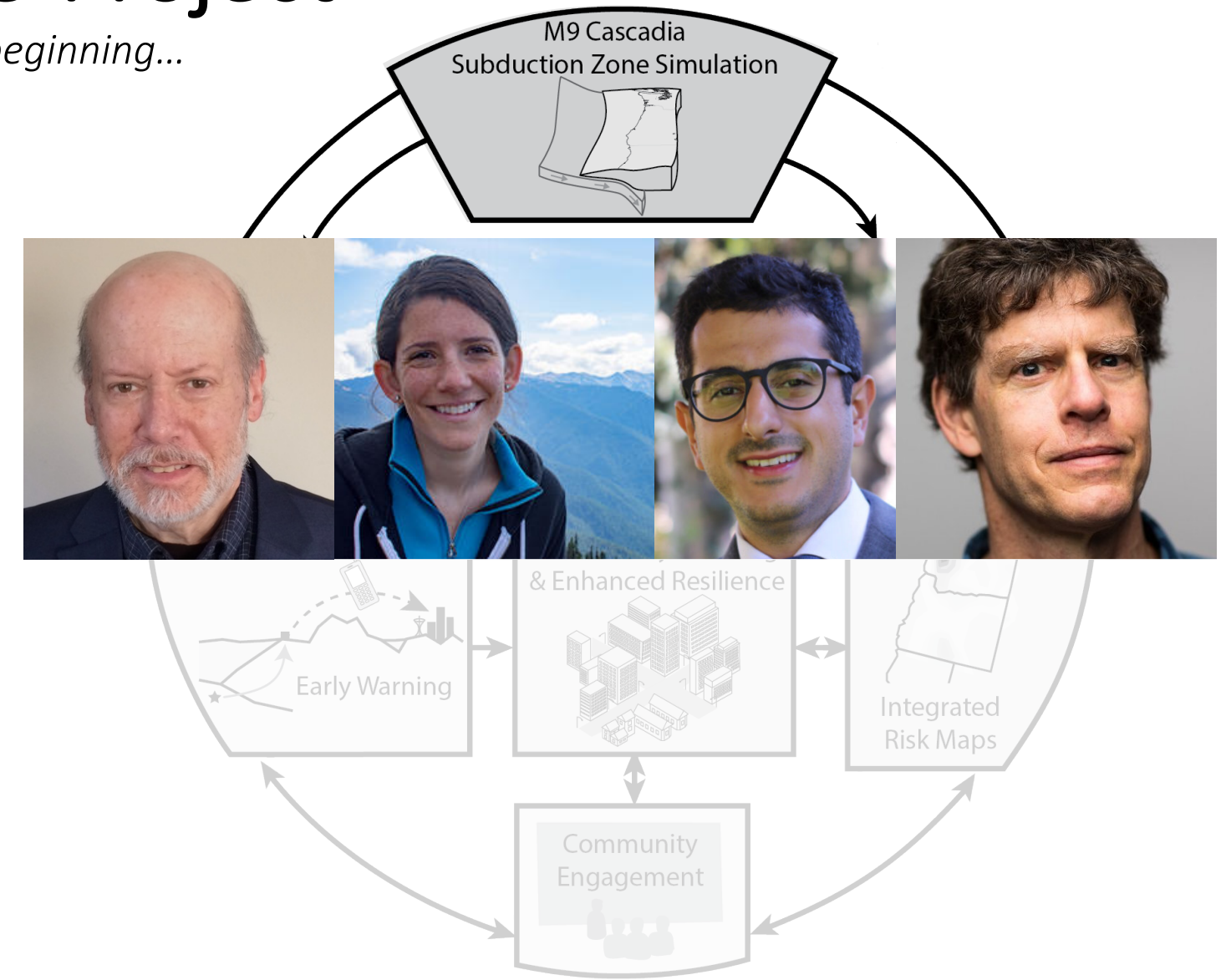


Design by
Nasser Marafi

The M9 Project

An ambitious beginning…

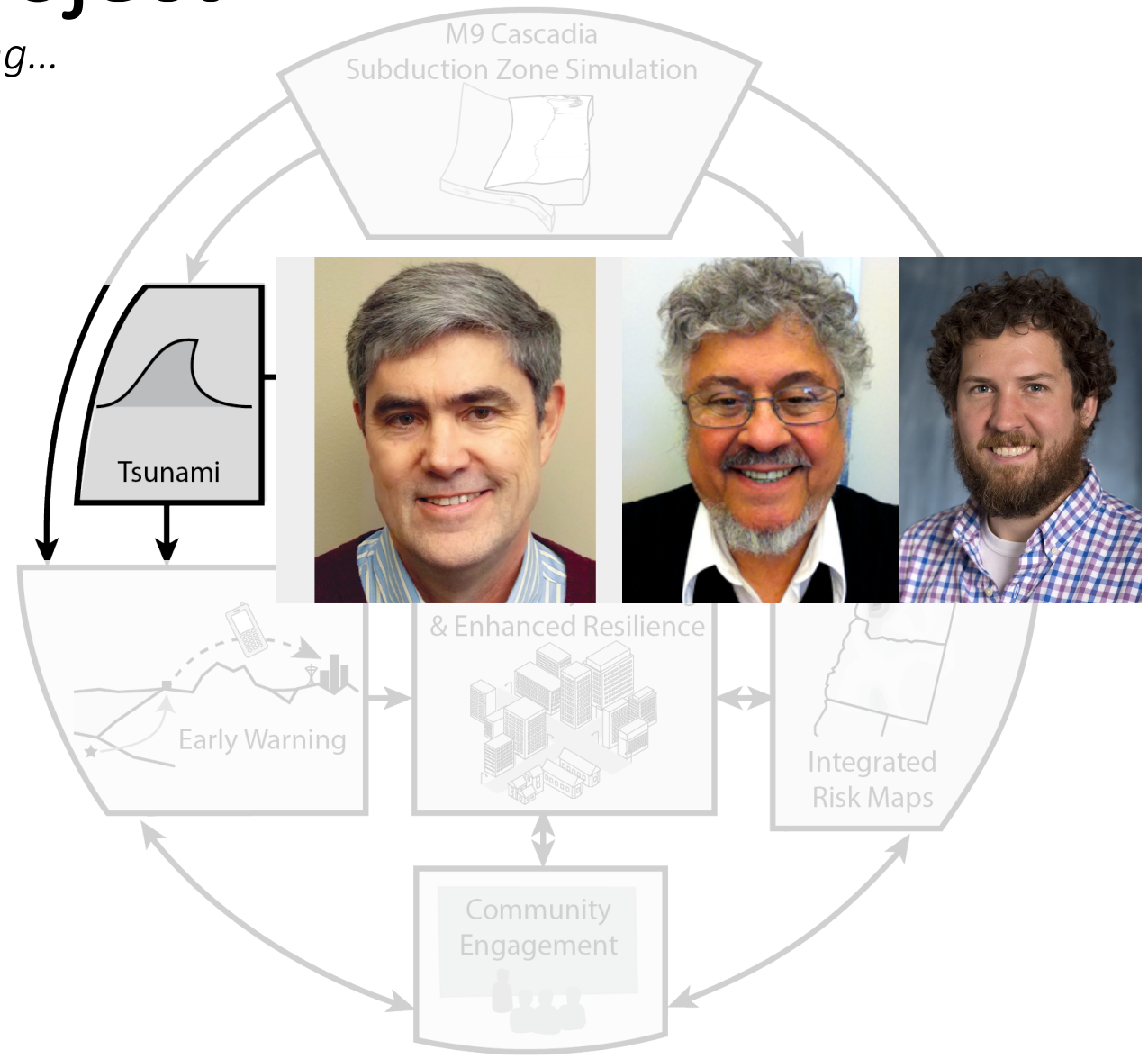
Art Frankel
Erin Wirth
Nasser Marafi
John Vidale



The M9 Project

An ambitious beginning…

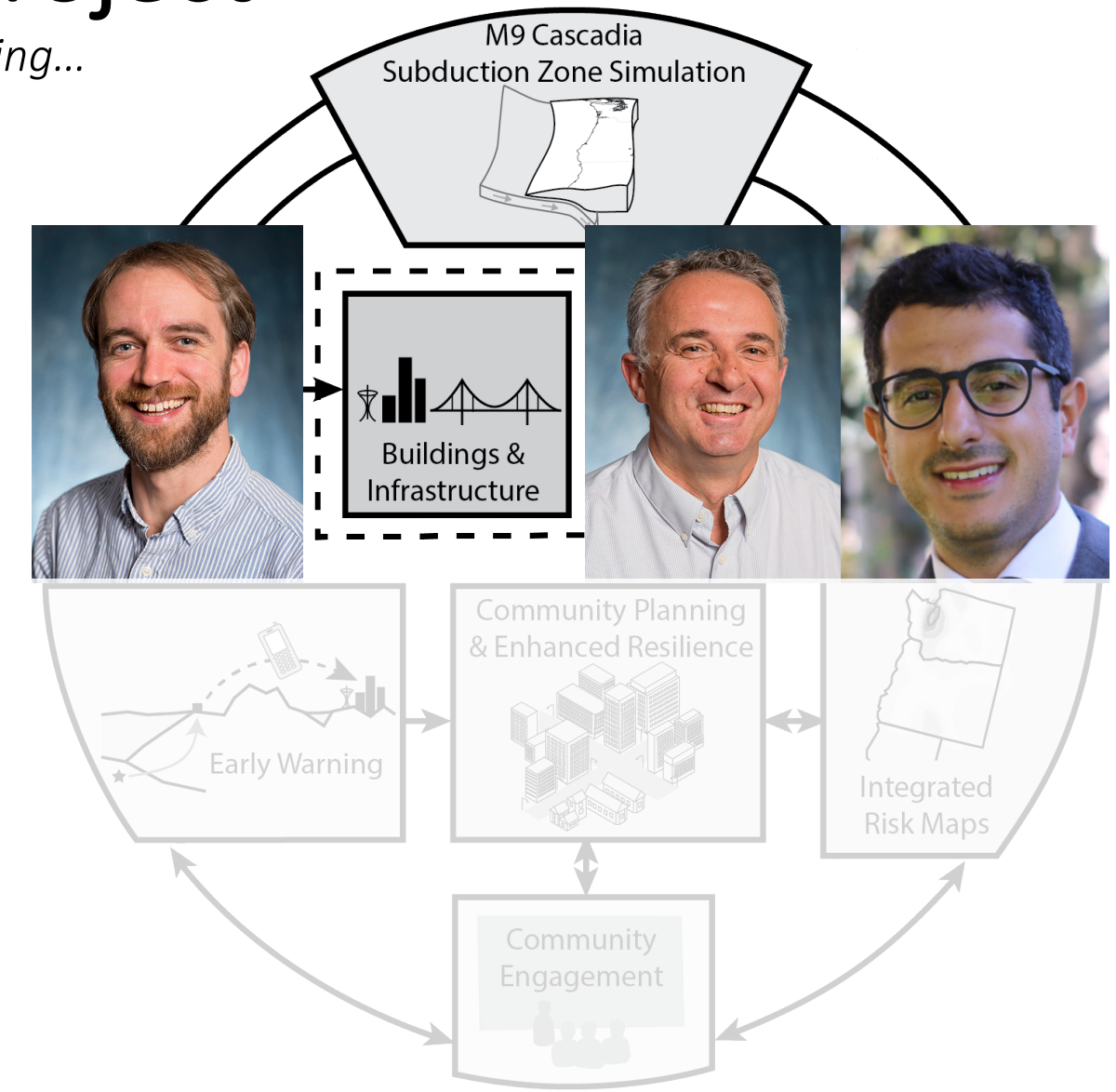
Randy LeVeque
Frank Gonzalez
Mike Motley



The M9 Project

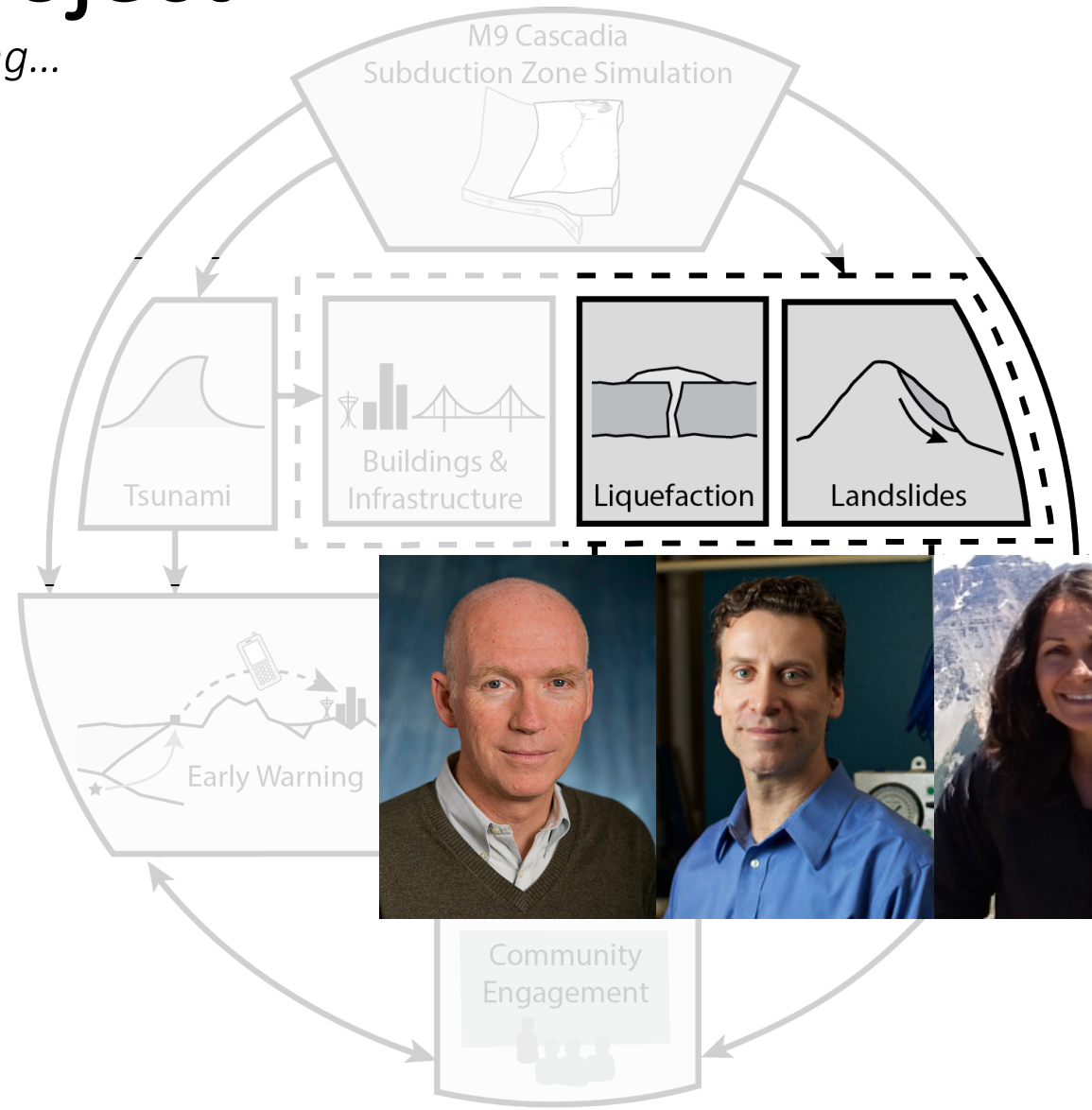
An ambitious beginning…

Jeff Berman
Marc Eberhard
Nasser Marafi



The M9 Project

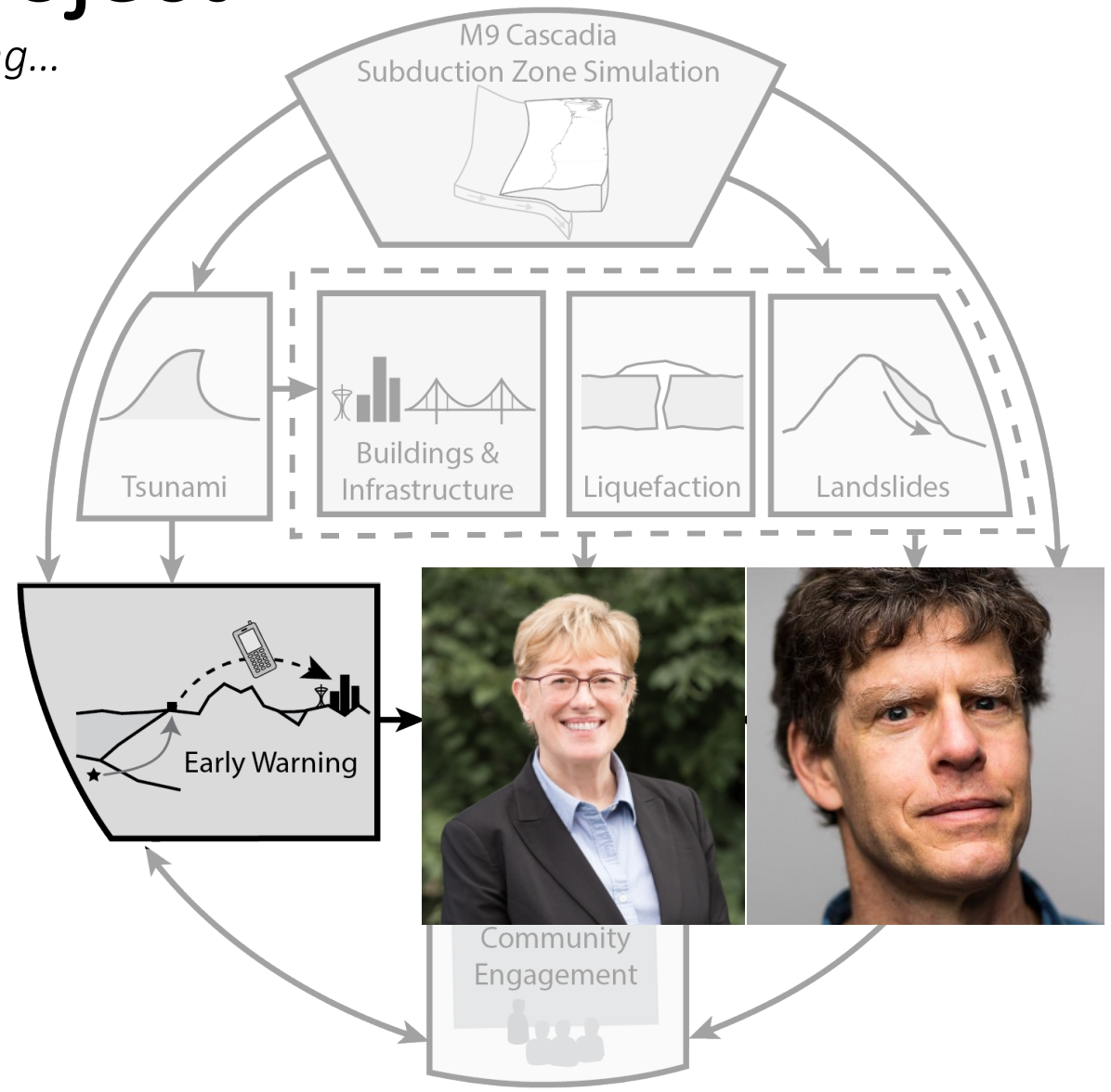
An ambitious beginning…



Steve Kramer
Joe Wartman
Alison Duvall
Dave Montgomery

The M9 Project

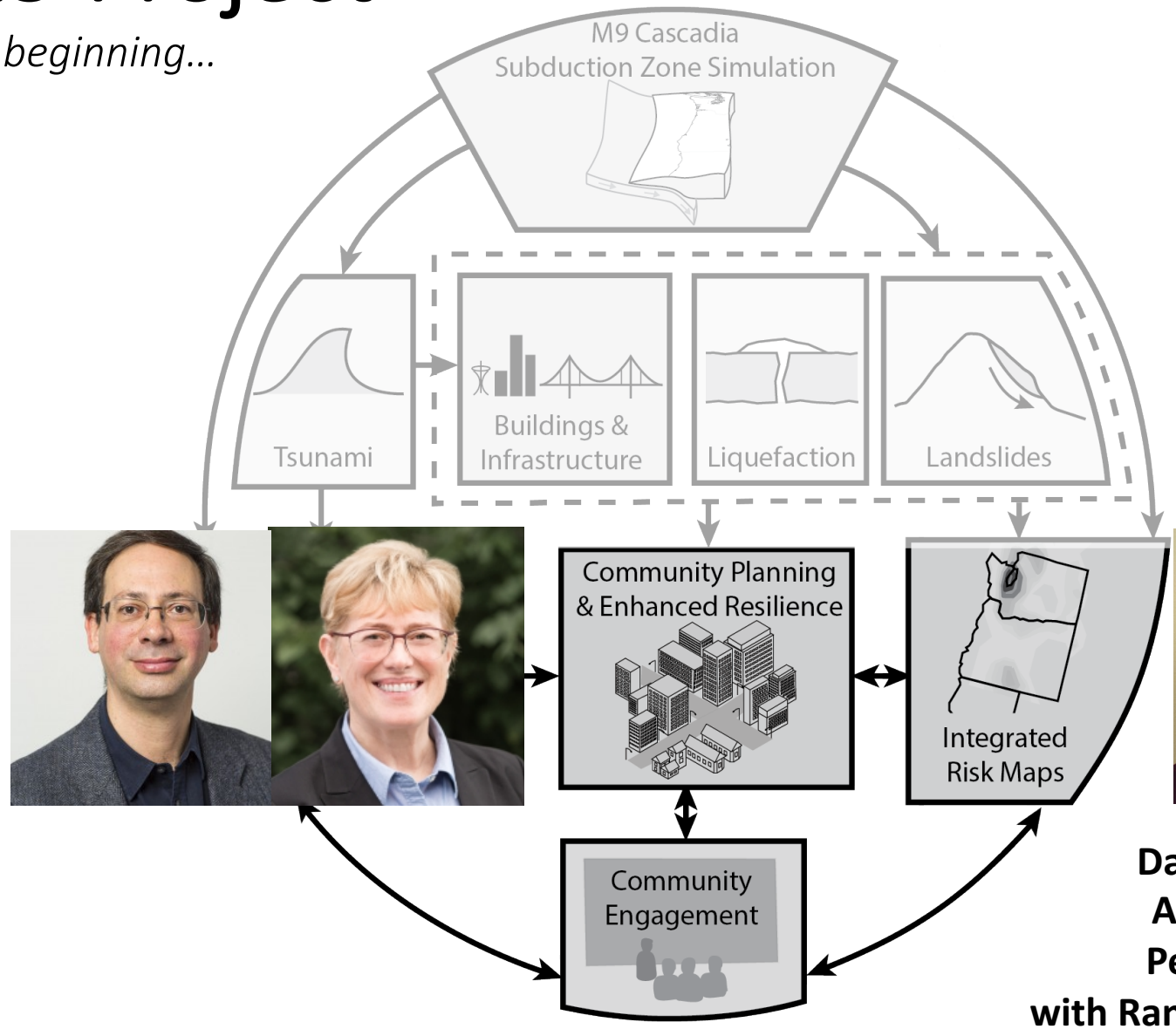
An ambitious beginning…



Ann Bostrom
John Vidale

The M9 Project

An ambitious beginning…



Dan Abramson
Ann Bostrom
Peter Guttorp
with Randy LeVeque, Frank Gonzales, and Loyce Adams

The M9 Project

Graduate Students (Past & Present)

Earth & Space Sciences

Elizabeth Davis
Carrie Garrison-Laney
Jiangang Han
Sean LaHusen
Ian Stone
Mika Thompson

Civil & Environmental Engineering

Alex Grant
Mike Greenfield
Nasser Marafi
Andrew Winter
Gloria de Zamacona Cervantes
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Urban Design & Planning

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Peter Dunn

Evans School of Public Policy & Governance

Alicia Ahn
Drew Bouta

Applied Math

Donsub Rim
Brisa Davis

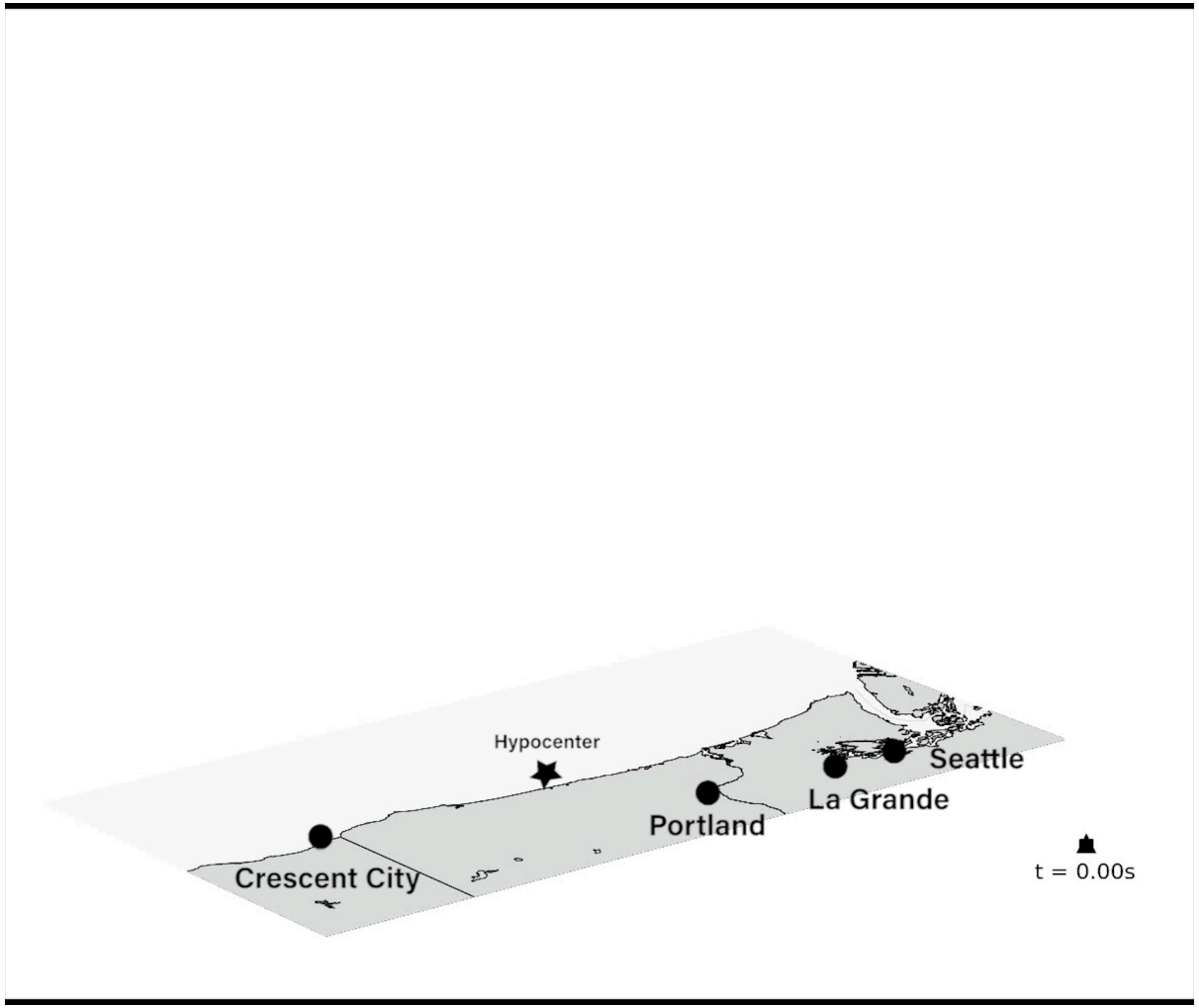
Statistics

Johnny Paige
Max Schneider

The M9 Project

Impact and Results

- 50 Cascadia earthquake realizations publically available on DesignSafe



csz006
Movie by
Nasser Marafi

The M9 Project

Impact and Results

- **50 Cascadia earthquake realizations** publicly available on DesignSafe
- Improved understanding of **shaking amplification by the Seattle basin**
- Found the **collapse risk** of modern reinforced concrete shear wall buildings in the M9 CSZ to be larger than anticipated
- M9 results informed recommendations for the **design of tall buildings** in Seattle
- Created **landslide inventory** for Oregon Coast Range & advanced **modeling of coseismic landslides**
- Developed a framework to **reduce the uncertainty in liquefaction ground deformations** that separates triggering from duration induced deformation
- Advanced probabilistic **modeling of tsunami inundation** scenarios
- Led multiple **community planning & hazard mitigation workshops**
- Advanced understanding of **how perceptions influence earthquake preparedness and preferences for earthquake early warning**

The M9 Project has shown that there are serious issues that need to be addressed….

but progress on resilience is achievable

What is the Last Mile?

- "Research to practice"
  - Different specifics and context for each discipline and stakeholder

- Research projects (especially from NSF) often lack the means to make these meaningful last mile steps
  - What resources might be available to carry out last mile work?

Last Mile Examples

- Maps:
  - Of what? Ground motion measures? Collapse probabilities? Landslide potential? Tsunami inundation?
  - How would they be used?
  - How should uncertainty be quantified?

- Ground motions:
  - Raw ground motions are available on DesignSafe in a less-than user friendly format.
  - Is it important that they more easily accessible?
  - How would you use them? (There are 30 primary scenarios)

Last Mile Examples

>Community planning and hazard mitigation workshops:

--More workshops with probabilistic scenarios for multiple hazards?

--In socio-economically diverse communities? Urban locations?

--How can we work with stakeholders to do this?

> Updating loss estimation for the region:

– New HAZUS fragilities that account for duration and basin?

> Communication and Education:

– Diverse community input on hazard communication strategies?

– Ongoing monitoring of seismic, tsunami and Earthquake Early Warning use and awareness?

What is the Next Mile?

> New fundamental science, engineering and social science questions

> New collaborations between researchers, practitioners and across disciplines

> New efforts to raise awareness and public engagement in seismic resilience: building a seismic culture in the PNW

> New funding sources and initiatives to support the necessary work

Next Mile Examples

> Fundamental Science, Engineering and Social Science Questions:

- What basin amplification might be expected in a Seattle fault earthquake?
- How are infrastructure systems (water, power, etc.) affected by ground motion duration?
- What policies can be developed that address critical seismic vulnerabilities while balancing other social challenges (URM and low income housing)
- What are good tsunami source model for other crustal faults? (e.g. SWIF, Tacoma, Devil's Mountain)

> New Collaborations:

- How can seismologists, engineers and planners work together to improve resilience through local building codes?
- How can we best utilize earthquake early warning?
- What alert and post-alert messaging for EEW will make people safest in most circumstances?

Next Mile Examples

- How can we engage the industry in the PNW (tech, manufacturing, trade) to be partners in earthquake resilience research and implementation?
- How can we improve tsunami early warning?
- How can we close the preparedness gap?
- How do we improve response given known vulnerabilities and probable scenarios?

> Raising awareness:

- How can PNW researchers serve the needs of agencies doing the work on the ground?

We are still just beginning to understand the seismicity, vulnerability and resilience of the Pacific Northwest…

Many unanswered questions remain and collaboration will be critical to make advances

Thank You!

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Visit M9: http://m9.uw.edu

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