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TOOLS FOR ADVANCING UNDERSTANDING OF COMMUNITY RESILIENCE THROUGH POST-EARTHQUAKE RECONNAISSANCE

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Abstract

The EERI Housner Class of 2017's project was designed to build upon prior work on resilience reconnaissance and products that were previously prepared through the National Science Foundation-funded Resilience Observatory Project at the Earthquake Engineering Research Institute. The project's goals were to (1) make resilience concepts accessible and practical for people conducting post-earthquake reconnaissance; (2) encourage post-earthquake reconnaissance teams to think broadly about how communities are affected by earthquakes; and (3) encourage connections and information-sharing across organizations and individuals studying similar topics.

Three tools were developed:

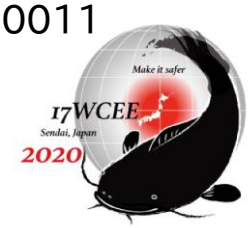
(1) The Resilience Reconnaissance Primer provides high-level guidance and best practices related to resilience concepts for reconnaissance teams. It aims to introduce or refresh those conducting post-earthquake reconnaissance on what resilience is, what resilience reconnaissance is and what the challenges and opportunities of resilience reconnaissance are in order to encourage the integration of resilience concepts in reconnaissance fieldwork and corresponding objectives and conclusions.

(2) The Earthquake Reconnaissance Context Packet, a template for a report to be prepared in advance of deployment of reconnaissance teams, that provides pre-event contextual information on the physical, social, political and environmental history and characteristics of the impacted city or region prior to the earthquake. It identifies characteristics that may be related to the community's pre-earthquake resilience, which can inform recovery patterns, and aims to encourage reconnaissance teams to think broadly about how the community's response and recovery from an earthquake is influenced by pre-event conditions and capacities.

(3) The Resilience Reconnaissance Reference Card, a printable graphic that can also be used as a fillable form, provides teams in-field guidance for identifying interconnections and dependencies between the built, human, and natural environment and prompts team members to ask questions that reveal how different sectors are connected.

The EERI Housner Class of 2017 developed these tools based on guidance provided by various post-earthquake resilience experts, tested these tools in Mexico following the September 2017 Puebla earthquake, and revised them based on first-hand experiences using them in the field. The tools are intended to evolve and be modified as the profession progresses in its understanding and implementation of resilience reconnaissance.

Keywords: Resilience Reconnaissance, tools, post-earthquake, EERI Housner Fellows



1. Introduction

The Housner Fellows Program was established by the Earthquake Engineering Research Institute (EERI) in 2011 to train future earthquake engineering policy advocates and thought leaders in honor of George W. Housner. This paper is authored by the 2017 EERI Housner Fellows and Lead Trainer Lucy Arendt, and describes the project and tools developed by that class. The Housner Class of 2017's project built upon EERI's concepts of resilience reconnaissance and the products that were previously prepared through the National Science Foundation (NSF)-funded Resilience Observatory Project. This paper describes the findings, deliverables, and recommendations developed by the Housner Class which was designed to build upon previous work within EERI's Resilience Reconnaissance Framework. Our project focused on developing three practical tools to make resilience reconnaissance concepts easier to understand and apply by current and future post-earthquake reconnaissance team members This paper describes the reasoning behind our decision to develop these tools, our driving concepts for the tools, and our process for developing them. We also describe our findings from testing these tools for resilience reconnaissance following the September 19, 2017 Puebla, Mexico Earthquake, as well as recommended next steps for how EERI can incorporate these tools into existing EERI initiatives for resilience reconnaissance. We hope that the tools and recommendations resulting from this project advance both the theory and practice of resilience reconnaissance and become incorporated into existing EERI programs, tools, and operations to continue to progress EERI's Learning From Earthquakes (LFE) mission to "accelerate and increase learning from earthquake-induced disasters that affect the natural, built, social and political environments worldwide".

2. Resilience Reconnaissance Context and History

EERI has a long tradition of earthquake reconnaissance. In recent years, this reconnaissance has shifted from a focus on observing short-term engineering damage to a more comprehensive, multi-sector, multi-phased study of impacts from earthquakes over time. This is referred to as "resilience reconnaissance" [1]. This shift to a resilience lens has made EERI a leader in the emerging field of post-earthquake resilience reconnaissance. At the time that this Housner project began in 2017, EERI had several past and ongoing programs and tools to advance the theory and practice of resilience reconnaissance. These efforts served as the foundation for this project, and our intent was for our tools to be easily incorporated into these programs, making them more practical and accessible to resilience reconnaissance teams. The primary EERI programs and tools that served as the foundation for the project included:

1. **Learning From Earthquakes (LFE) [2]**: The mission of LFE is to accelerate and increase learning from earthquake-induced disasters that affect the natural, built, social, and political environments worldwide. The program achieves this through field reconnaissance, data collection and archiving, and dissemination of lessons and opportunities for reducing earthquake losses and increasing community resilience with practitioners. The program's goals emphasize multidisciplinary partnerships as well as partnerships with academics, professionals, societies, and other critical partners worldwide. This program includes the Travel Study Program [3], an initiative targeted towards early career practicing engineers and graduate students and designed to conduct field study trips to earthquake- affected regions around the world.
2. **Resilience Observatory [4]**: An initiative of LFE, the Resilience Observatory was a limited-duration project that developed recommendations for observing, documenting, and measuring community resilience following an earthquake. The following documents were produced during the Resilience Observatory project:
    a. **Resilience Reconnaissance Framework [5]** (2015): 81 pages. This document defines five systems through which to view resilience (built environment, social, economic, natural environment, institutional). It identifies critical elements and interdependencies between

systems and offers a timeline for data collection, extending the concept of reconnaissance beyond the immediate post-disaster phase. A 52-page short version of this document was also developed [6].

b. **Resilience Field Guide** (2016): 27 pages. This document defines resilience in terms of community functions and services (shelter, lifelines, food, healthcare, transport, business, education, culture). It also outlines a rigorous methodology of resilience reconnaissance and includes a sample interview protocol.

c. **Draft Resilience Reconnaissance Interview Protocol** [7] (2016): 5 pages. The document includes questions that seek to understand the earthquake impacts on building clusters and lifeline systems that support a vital service or function within a community or neighborhood.

3. **Virtual Earthquake Reconnaissance Team (VERT) [8]**: Also an initiative of LFE, VERT provides opportunities for EERI members, especially students and younger members, to contribute to reconnaissance teams through desktop data collection and data processing. VERT products are disseminated through the EERI Earthquake Clearinghouse [9].

3. Housner Project Development

Our project sought to develop a clear vision of resilience reconnaissance and align practical tools for application of this vision with EERI's existing efforts. While the limited extracurricular capacity of the team, limited duration of the fellowship (two years), and defined Housner Program objectives constrained the scope of the project, the goal was for our project to add value to resilience reconnaissance by being practical and implementable by EERI after our project ended. The project's goals follow, as does Figure 1 showing the project's timeline and activities:

- Make resilience concepts **accessible and practical** to EERI members and other organizations conducting post-earthquake reconnaissance;
- Encourage reconnaissance team members to **think broadly and systemically** about how communities are affected by earthquakes;
- Encourage **connections** and information-sharing between EERI and other organizations and individuals studying similar topics.

Figure 1: Project Development Process

3.1 Project Definition

At the outset of the 2017 Housner Fellows project, we identified resilience reconnaissance as a topic area that (1) was applicable and consisted of a variety of disciplines; (2) was relevant, timely, and increasingly important; and (3) was an emerging field that would benefit from additional thinking and study. Our work was largely driven by three guiding questions about this developing field:

1. Why do people do post-earthquake resilience reconnaissance?
2. What is the value of post-earthquake resilience reconnaissance?
3. How might we expand the practice of traditional post-earthquake reconnaissance to consider resilience reconnaissance?

Soon after our initial meeting in 2017, the 2017 Puebla, Mexico Earthquake occurred, and in early 2018 we identified it as an appropriate candidate for a resilience reconnaissance case study for our project because: (1) the earthquake was recent enough to be in the early stages of recovery, but enough time had passed for storylines and patterns to emerge; (2) the city's previous earthquake history allowed for longitudinal comparisons; (3) the location was easily accessible; and (4) members of the team had contacts in Mexico City, thus allowing for opportunities to conduct a case study in partnership with local organizations.

Between Fall 2017 and Spring 2018, we conducted desktop research on relevant resilience reconnaissance work and programs, including those described in Section 2 of this paper, as well as a series of stakeholder interviews with critical resilience reconnaissance experts to improve our understanding and vet potential project ideas.

3.2 Mexico City Case Study

In March, 2018, the Housner Fellows traveled to Mexico City to test the application of existing draft resilience reconnaissance tools developed through the Resilience Observatory project. We initially envisioned directly implementing the *Resilience Field Guide* for conducting resilience reconnaissance in Mexico City and using the *Draft Resilience Reconnaissance Interview Protocol* to gather and catalog data according to the community functions and timelines described in the *Resilience Field Guide*. During the trip we had direct interactions with affected community members and local government officials who were tasked with post-earthquake response and recovery. However, we observed some challenges with the practical application of the *Resilience Field Guide.* A few of the most valuable observations from our trip included:

- A rigid interview protocol is not practical to use in the field as-is. Rather, an ability to improvise and conduct a naturally-flowing conversation with a clear sense of purpose is more likely to result in information/findings relevant to resilience, such as cross-sector intersections, dependencies, etc.. Additionally, many valuable "interviews" we had were the result of informal, unplanned, serendipitous interactions in the field.
- Partnerships with local government officials and affected residents are essential for obtaining informed perspectives and gaining access to opportunities for learning that might not be accessible through desktop research or walking around without escorts who have access to places and people that a non-resident will not have.
- Different people may view the same events differently as a function of their prior experiences with earthquakes as well as government, education, status, community role, cultural influences, and other factors. Good field research requires multiple interviews and engagements to gain a comprehensive picture. Relying on one or a small number of sources can yield an incomplete, and potentially misleading, understanding of the post-event reality.
- Language and cultural differences can create barriers to true learning due to challenges with translation, social context, and the nuances of communication and interpretation.
- Longitudinal studies are critical –data and information are not always available immediately after an event, and trust and relationships are built over time. Relationship-building is critical if resilience

reconnaissance seeks to establish a reciprocal, ongoing learning relationship with the community. Furthermore, post-earthquake data and resilience storylines are dynamic and will evolve over time as recovery occurs.

This experience led us to conclude that there was a need to focus on continuing to refine and develop new simple, practical, and flexible tools for implementing resilience reconnaissance.

3.3 Refinement of Objectives, Development and Vetting of Tools

After our March 2018 trip, we refined the objectives of our project to focus on how resilience reconnaissance can be practically applied and spent several months soliciting feedback from EERI resilience reconnaissance thought leaders on our project concept (see Section 7.0 Acknowledgements in this paper). We further refined our concept and tested some initial new tools on a second trip to Mexico City and Jojutla in January 2019. Following this second trip, we began to develop final versions of three resilience reconnaissance tools that may be used by EERI's reconnaissance teams. Our Housner project was completed in July 2019 with the delivery of a white paper and our draft resilience reconnaissance tools to the EERI Board of Directors and LFE Executive Committee. The tools are intended to be modified and adapted as teams use them in the field and provide ideas for further refinement.

4. Project Findings

The documents produced by the Resilience Observatory project prior to the Housner Fellows project had created a solid base of conceptual thought around resilience reconnaissance and ways in which it may be conducted. Through our research and testing using the 2017 Puebla, Mexico earthquake as a case study, four major conceptual challenges for extending resilience reconnaissance concepts in the field coalesced:

Extended duration – Resilience data and stories unfold over time. It is impossible to know the full impact of an earthquake – especially a major earthquake – on society, government, the economy, and the natural environment in the immediate post-disaster phase. Additionally, stories and lessons evolve over time as the community responds and adjusts course throughout the recovery phase. Resilience reconnaissance is therefore very different from traditional reconnaissance, where a team typically deploys relatively soon after the earthquake event. In contrast, resilience reconnaissance could occur over a period of many years. With this challenge in mind, we asked, "What is the best way to keep EERI members and non-EERI post-earthquake reconnaissance contributors – both researchers and practitioners – engaged after the immediate post-earthquake reconnaissance?"

Volume of data – Traditional reconnaissance has often focused on a single sector – e.g. how particular building archetypes performed from an engineering standpoint or what geological phenomena occurred. By definition, resilience reconnaissance is concerned with multiple sectors of society impacted by an earthquake. Attempting to collect data on many sectors without a clear research focus likely would be overwhelming and impractical for the limited scope of most post-earthquake reconnaissance efforts, and may not yield useful information or lessons learned. In considering this challenge, we asked, "How should practitioners decide what to focus on? How should they decide what important themes are evolving from the earthquake event and adjust their focus accordingly?"

Complexity of systems – Similar to the sheer volume of data, the interconnectedness of the sectors that might be studied in resilience reconnaissance is complex and often elaborate. As a result, it may be impossible to assess the true impacts and implications of the earthquake event on every system. However, key stories may emerge that are common between systems. For example, governance challenges may slow down or alter recovery funding across multiple sectors, but come from a common source. To address this challenge, we asked, "What might help those conducting resilience reconnaissance identify and articulate these common threads?"

Broad, theoretical concepts – Resilience reconnaissance inevitably involves taking a step back to see whole systems and how they interconnect. Learning from resilience reconnaissance requires looking

across systems and drilling down to specific lessons that can be applied elsewhere. This approach is not how engineers or technical professionals may have typically practiced reconnaissance and may feel abstract, overwhelming, and difficult to apply in the field. To address this challenge, we asked, "How can practitioners make resilience even more practical to apply to their own work?"

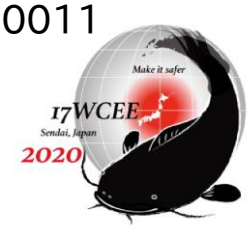
Pulling together desktop research, consultation with experts, and the four conceptual challenges honed by our experiences in Mexico (above), some best practices for resilience reconnaissance began to emerge. A fundamental tenet of resilience reconnaissance identified by the Fellows is the importance of evaluating resilience both before and after an event and understanding how a region or city's resilience evolves over time. In order to fully understand the impact of an event, it is necessary to understand the pre-event conditions—whether physical, political, or social—that influence how a community is impacted by an event and how they respond to it. We suggest, therefore:

The purpose of resilience reconnaissance is to understand the change in social, political, and physical context due to the event over time (in comparison to pre-event conditions), to create a storyline based on these changes, and to better understand new (or exacerbated) needs or gaps that become clear 1-2 years (or more) after a disaster.

This provides a better understanding of how societies are impacted by earthquakes and helps to identify and anticipate the needs and challenges that will emerge in the years that follow an earthquake. This information can help inform more effective mitigation and recovery efforts, programs, and policies.

5. Overview of Tools

The ***Resilience Reconnaissance Primer (Primer)*** provides high-level guidance and best practices related to resilience concepts for reconnaissance teams. It aims to introduce these topics or refresh post-earthquake reconnaissance team members in order to encourage the implementation of resilience concepts in reconnaissance field work and corresponding conclusions and results. The ***Primer*** includes an overview of what resilience reconnaissance is, a summary of challenges and opportunities for resilience reconnaissance, guidelines on resilience reconnaissance best practices, a recommended approach to developing storylines, an overview of resilience reconnaissance tools, and our Jojutla, Mexico case study to show how these concepts apply to a real-world earthquake. The ***Resilience Reconnaissance Primer*** is currently formatted as a slide deck for fast learning or group training (Figure 2). The ***Resilience Reconnaissance Primer*** is intended to be reviewed by reconnaissance team members preparing to depart or on their way to an earthquake-affected city or region along with the ***Context Packet*** (described next). While the primary target audience for the ***Primer*** is reconnaissance teams about to go into the field, both the ***Primer*** and the ***Reference Card*** (described below) may be useful as educational tools on their own.



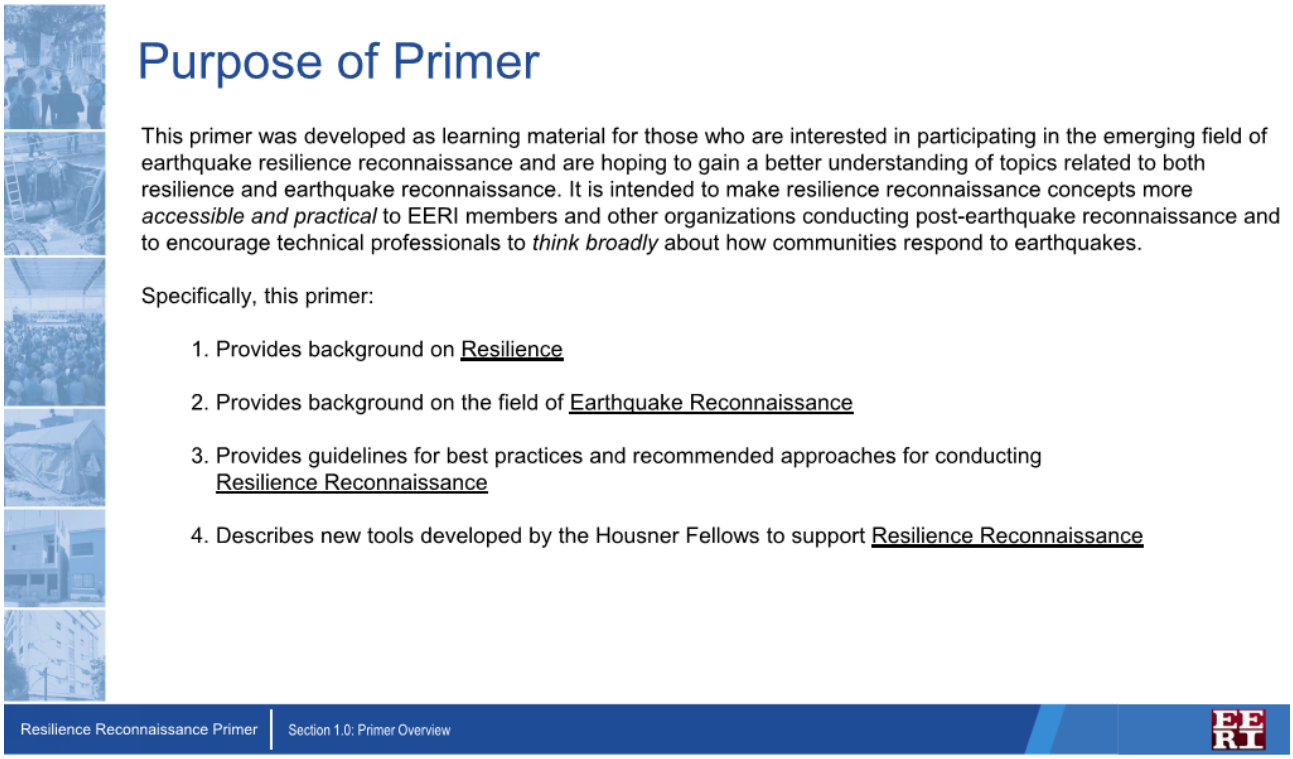


Figure 2: Introduction slide from the Resilience Reconnaissance Primer Slide Deck

The ***Earthquake Reconnaissance Context Packet (Context Packet)*** is a short report prepared by VERT volunteers in advance of deployment of reconnaissance teams. The ***Context Packet*** provides pre-event contextual information on the physical, social, political, and environmental history and characteristics of the impacted city or region prior to the earthquake. It suggests how these characteristics may impact the community's resilience and recovery, and aims to encourage reconnaissance teams to think broadly about how a community's pre-event conditions and capacities influence how it responds to and recovers from earthquakes over time.

While similar to VERT's *Phase 1 Report*, which uses desktop research to summarize the damage and disruption caused by an earthquake, the ***Context Packet*** focuses on summarizing the affected community's *pre-event* characteristics, thereby allowing for comparisons with what the reconnaissance team will observe and learn about in the field *post-event*. The ***Context Packet*** is designed to be used in conjunction with the *Phase 1 Report* to prepare reconnaissance teams for field work (Figure 3). Additionally, because these two are closely integrated, we suggest that it may make practical sense for VERT to develop and incorporate the ***Context Packet*** into its existing data collection and dissemination practices.

The target audience for the ***Context Packet*** includes any reconnaissance teams – not only teams focusing on resilience. We anticipate that it may also be used to inform the LFE Executive Committee in determining if and when to deploy teams to conduct traditional reconnaissance or resilience reconnaissance.

Earthquake Reconnaissance Context Packet for	[city/region]	Date Created:	[date]

Purpose: The Context Packet is a report, prepared in advance of deployment of reconnaissance teams, that provides contextual information on the physical, social, political and environmental history and characteristics of the impacted city/region prior to the earthquake. It identifies characteristics that may be related to the community's resilience, and it aims to encourage technical professionals to think broadly about how communities respond to and recover from earthquakes over time.

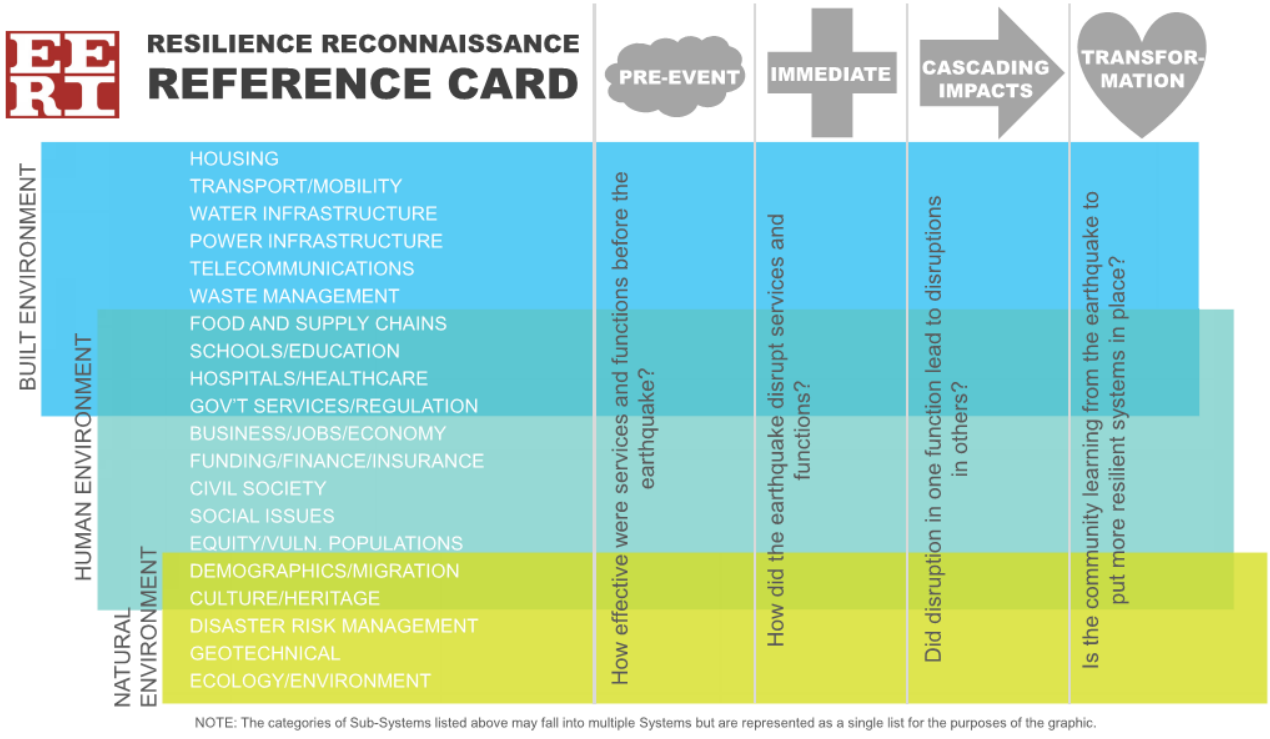
Process: EERI Virtual Earthquake Reconnaissance Team (VERT) completes the yellow cells. (Other cells in this template do not change.) Links in the "Resources" column may be helpful starting points for the VERT team's research. EERI provides the completed packet to field team members, who read it (such as on the plane) prior to field reconnaissance.

Guidance to VERT for completing this form:

- All of the questions in this packet address existing conditions PRIOR TO THE EARTHQUAKE (not the damaged/disrupted condition after the earthquake).
- Responses should be concise, providing summary information to reconnaissance teams in a way that they do not need to follow links to get the idea.
- Responses need not be perfect. If a question is difficult to answer, it is OK to skip that question, or better yet write down what information is available, with qualifiers. For example, if a question asks for data about a city, and there is available data at the country-level only, provide the country-level data.
- In addition to concise written responses, it is encouraged (though not required) to also include a link(s) to the data source in the yellow box. If desired, use the Appendix at the end of the packet to include links, images, or other information that does not fit well into the concise response box.

Figure 3: Cover page of the Earthquake Reconnaissance Context Packet template

The ***Resilience Reconnaissance Reference Card (Reference Card)*** is a printable graphic that can also be used as a fillable form. It serves to provide teams in-field guidance on identifying interconnections between the built, human, and natural environments and to prompt reconnaissance teams to ask questions that reveal these interconnections. There are two components to the ***Reference Card***: (1) a summary of key resilience concepts, references, and questions to consider during reconnaissance; and (2) a simple graphic that may be referenced when conducting field interviews that prompts users to consider both the temporal and systemic factors that are key to resilience reconnaissance. The ***Reference Card*** is intended to be used in the field (Figure 4).



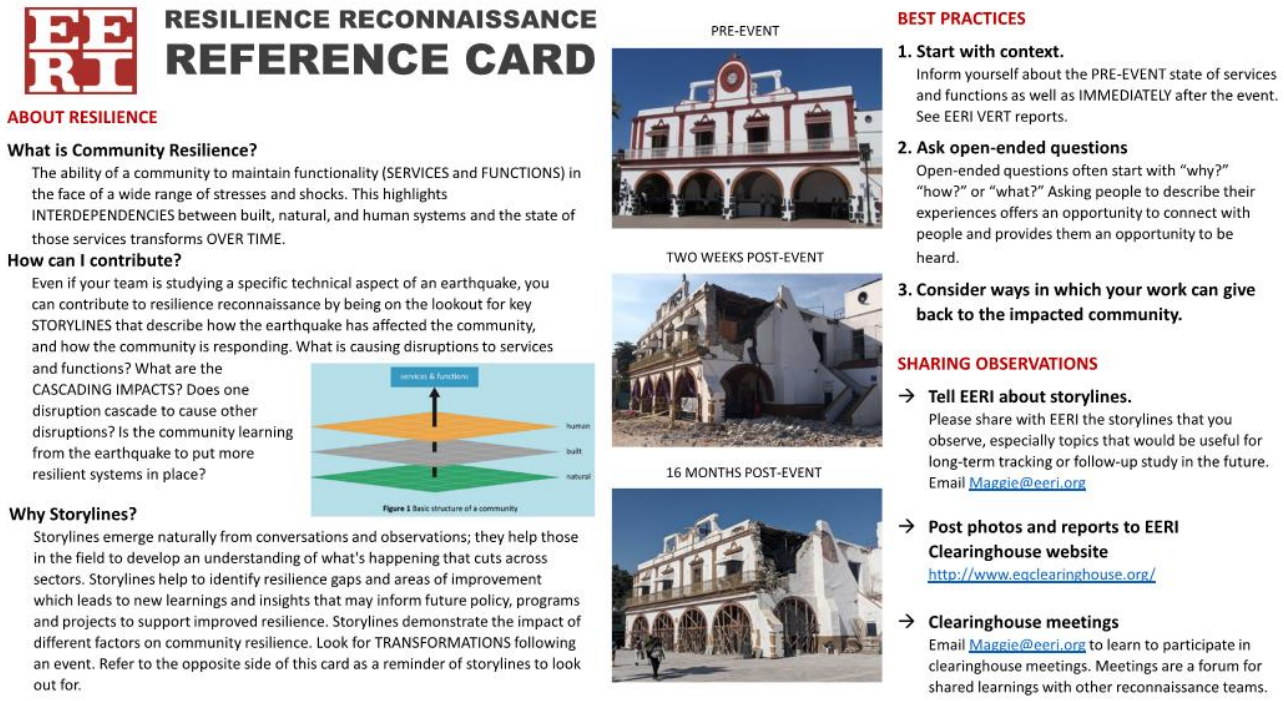


Figure 4: Resilience Reconnaissance Reference Card

5.1 Future Work

We designed the tools discussed herein in the hope that they will live beyond the limited duration of our Housner Fellows project. EERI is evolving how it supports reconnaissance, acting as both the conductor (guiding topic areas for study, coordinating teams) and coordinator (linking lessons learned, building relationships with other organizations). Our goal is for these products to be integrated into the LFE Program, to help refine the reconnaissance approach advocated by EERI, and for LFE and VERT to continue to improve upon them to help advance our understanding of community resilience through earthquake reconnaissance. Our recommended next steps for advancing these tools within the existing EERI structure follows:

1. Potential for Integration into existing EERI Programs

- VERT prepares the ***Context Packet*** one to six weeks after the earthquake event (VERT's "Phase 3"). This is when VERT prepares information in support of EERI and other teams planning to go to the field. See Figure 5 for a summary of the VERT timeline following an event.
- LFE shares the ***Primer*** & ***Reference Card*** with teams or organizations preparing to conduct reconnaissance, such as through the Travel Study Program, to introduce them to resilience reconnaissance concepts.
- The ***Context Packet*** findings are posted to the Earthquake Clearinghouse website, and findings from reconnaissance are organized around the concepts and themes presented in the ***Primer***.

2. Field Testing

- EERI provides the ***Context Packet***, ***Reference Card***, and ***Primer*** to all teams that EERI is aware of that are deploying to conduct reconnaissance along with other information that the teams may specifically request in line with current VERT practices. Teams are encouraged to provide feedback to EERI on the ease of use and applicability of the tools in the field to aid their ongoing refinement.

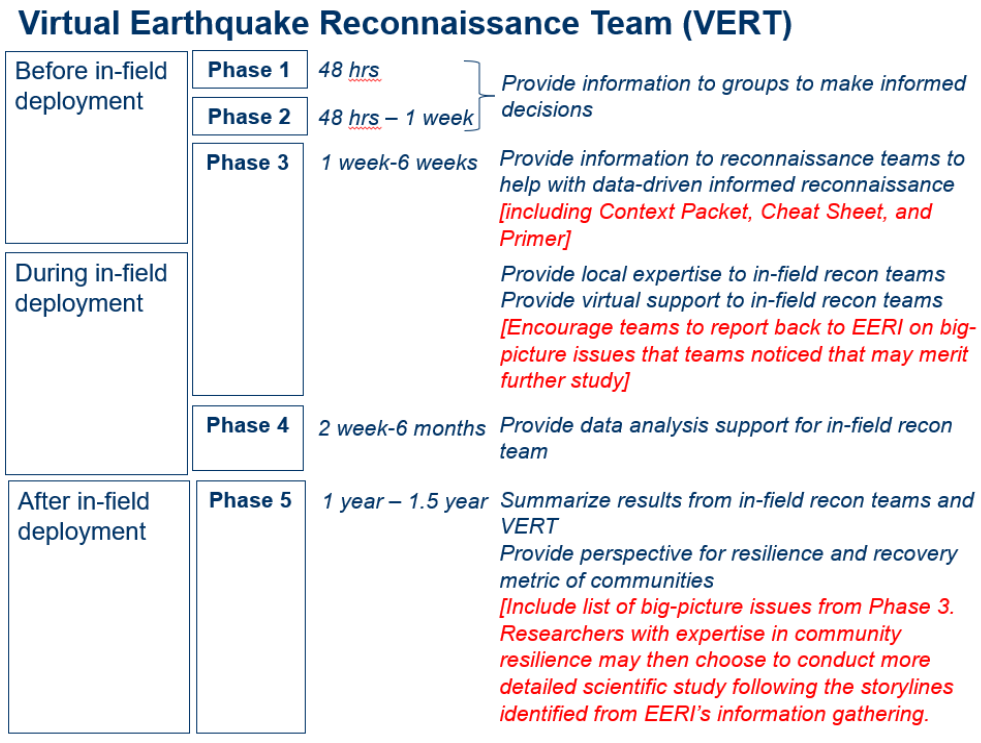
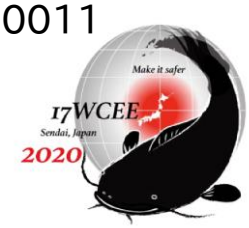


Figure 5: Suggestions for incorporating the newly-developed tools for resilience reconnaissance into existing and developing practices by EERI's LFE and VERT programs. Blue text adapted from slides presented by VERT at the 2019 EERI Annual Meeting. Red text added by Housner Fellows to identify opportunities for incorporation of resilience reconnaissance tools.

6. Conclusions

It can be difficult to make connections around what people see and learn in the field following an earthquake. Observations are influenced by our personal experiences, expectations, random chance (e.g., in making connections in the field), government actions, timing, and many other factors. We believe that continuing to refine an approach to resilience reconnaissance will contribute to advances in reducing earthquake risk by identifying interconnected and significant issues that may not be apparent through more traditional earthquake reconnaissance methods. We assert that a critical component to effective resilience reconnaissance is finding the themes or stories that underlie more readily observable issues; essentially, effective resilience reconnaissance should aid in revealing the iceberg underneath the visible tip. Making and articulating these connections is critical for learning how to sustainably reduce risk in the future. Additionally, we believe that, over time and over a wide geography, we will see common themes that may trigger better tools through practice and policy that reduce these risks.

Over the past several years, EERI has evolved its leadership role in reconnaissance, from an active participant to both active participant and facilitator of larger reconnaissance efforts. We believe that there is an amazing opportunity for EERI to lead and facilitate the practice of resilience reconnaissance and connect the findings to a much wider audience, to include local research institutions, municipal governments, and citizens of the affected communities. We hope that our suggested tools will assist in guiding earthquake risk reduction and contribute positively to EERI's longstanding history of and leadership around earthquake reconnaissance.



7. Acknowledgements

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8. Copyrights

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