sociological science

Collaborative Practices in Crisis Science: Interdisciplinary Research Challenges and the Syrian War

Fiona Greenland,[a] Michelle D. Fabiani[b]

a) University of Virginia; b) University of New Haven

Abstract: Crises present the scientific community with unusual demands, including the need for rapid solutions. This can translate into a greatly compressed time frame that curtails data collection and analysis procedures used in "normal" science. Researchers cope with these demands, while maintaining professional standards and a personal commitment to producing reliable work, by engaging in what we call performed separations. These are practices that allow people to adopt an ethical epistemic position while operating within constrained and urgent research situations. We distill the core features and effects of performed separations in the case of experts working to study archaeological looting in wartime Syria. We look specifically at how different practices of control allow for varying degrees of separation and the production of knowledge claims. By extension, performed separations facilitate making ethical claims about one's role in the production of research and use of findings.

Keywords: crisis science; research reliability; performed separation; conflict archaeology

Crises have wide-ranging impacts on science, including research practices, data sharing, resource allocation, collaboration structures, and communication networks (Fortun 2001; Knowles 2014; Lindee 2016; Rotolo and Frickel 2019). As "focusing events," they can put unusual pressure on scientists when the public demands prompt and durable solutions to disasters (Birkland 1998 on focusing events; Crow, Albright, and Koebele 2021; Vaughan 2016). In 2020, researchers from biological, physical, social, cultural, and engineering disciplines mobilized to address the worldwide COVID-19 pandemic (Cassata 2021). The rapid development of the COVID-19 vaccines by infectious diseases specialists was one outcome of this. It demonstrated the most optimistic scenario of collaborative crisis science, as well as the entrenchment of science in a competitive framework of nationalist and private sector interests (Krige and Leonelli 2021; Leonelli 2021). Science studies scholars have long argued that science is a form of knowledge production structured by strategic sites of work and organization (Knorr Cetina 1995; Owen-Smith 2001; Wylie 2018). The scientific response to the health crisis reinforced this point even as it sparked public discussions about why some sites of work and organization were apparently more effective than others in generating research that was timely as well as reliable.

The ability of scientists to collaborate quickly and in intensely stressful working conditions raises a number of questions about how practitioners balance rigor with urgency (Fortun and Frickel 2012). In particular, the internal dynamics and team management of crisis science projects have been understudied (Colwell and

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Machlis 2019). Analyzing a case of crisis science through interviews, observations, media coverage, and scientific publications, we examine the production of reliable research under urgent conditions. Three literatures anchor our inquiry. The body of work on crisis science supports our position that crisis science is not a diluted version of regular science but rather has its own methodological and epistemic characteristics (Fortun 2001; Machlis and Ludwig 2014; cf. Tierney 2007).[1] Sociology of knowledge informs our understanding of reliability in research findings, and we build on key insights into research quality and epistemic differences within multidisciplinary projects (Lynch 1985; Mårtensson et al. 2016; cf. Ioannidis 2005) and on the significance of hierarchies and project structure in shaping overall research outcomes (Greenland 2013; Knorr Cetina 1995; Shrum, Chompalov, and Genuth 2001). Finally, we draw on translational criminology to analyze the process whereby the scientists' research was turned into actionable information for policy makers (Laub 2012; Laub and Frisch 2016; cf. Crow, Albright, and Koebele 2021). This process is a staple of crisis science, yet our informants expressed ambivalence about its ethicality and epistemic soundness. The issue goes beyond the organizational goals of coordination and communication and into the routine tasks of translation within work sites.

Ultimately, we identify three practices of effective crisis science, which are detailed below. These practices capture the theoretical model that best represents the findings from our case study as well as the wider literature. Our case study concerns *conflict archaeology*. This term has been used in conjunction with the material study of historical violence and battlefields (Carman and Carman 2006). By contrast, we develop it in the sense of "the archaeological study of recent and modern conflicts" (Moshenska and González-Ruibal 2015:2) and the ethics of archaeological practice during, and as an outcome of, war (Kersel 2008). In this article, conflict archaeology refers to the technicians, basic researchers, and policy makers who studied archaeological looting during the Syrian civil war (2011 to 2018) (Al Quntar et al. 2015; Lawler 2014). Conflict archaeology was a temporary interdiscipline: "hybridized knowledge fields situated between and within existing disciplines" (Frickel 2004:269). Some conflict archaeologists worked full-time on the crisis response, but the majority were part-time. This fact, along with the researchers' distribution across different institutional types, impacted perceptions of reliability among the conflict archaeologists. After highlighting the war's profound disruptions to archaeologists, anthropologists, and other researchers, we introduce the structure of the conflict archaeology crisis response. Drawing on our interview data, we then map our informants' crisis science location on a grid of high or low reliability—a self-perceived assessment of the quality of the data and analysis output of the overall project. Next, we introduce the term *performed separation* to describe a repertoire of epistemic, methodological, and emotional practices that researchers use to establish strategic positioning within the crisis science collaboration.[2]

The concept of performed separation shares features with *boundary work*, "purposeful individual and collective effort to influence the social, symbolic, material or temporal boundaries, demarcations and distinctions affecting groups, occupations and organizations" (Langley et al. 2019:704; cf. Barth 1969; Bechky 2003; Fournier 2000; Gieryn 1983, 1999; Lamont and Molnár 2002). In the realm of professions, boundary work can be competitive, collaborative, or generative of new configurations of groups (Bowker and Star 1999; Frickel 2004; Langley et al. 2019). Performed separations, too, reinforce individuals' alignment with professional groups and shared epistemic standards and can be classified under configurational boundary work. But there is a key aspect of performed separations that is not readily reflected in the boundary work concept. Occupation-based boundary work is "a thoroughly mundane performance, carried out in the background and pre-reflexively without being foregrounded and thematized in terms of long-term calculation" (Langley et al. 2019:728). As our informants described them, performed separations were consciously performed actions designed to signal specific epistemic commitments. Importantly, performed separations also have an intra-individual dimension because they give researchers a sense of agency within different sets of personal relationships and professional obligations (Nippert-Eng [1995] 2008). For these reasons, we regard performed separations as a subset of boundary work but substantively distinctive enough to warrant different terminology.

From this case study, and drawing on our knowledge of the wider literature on crisis science, we identify three main hallmarks of effective crisis science, all of which are, to the extent that they promote that effectiveness, practices of performed separation:

1. *Temporal control*: the ways that people grappled with, and ultimately reconciled themselves with, greatly compressed time frames to generate results.
2. *Scope control*: how people "saw" and interpreted limited evidence.
3. *Responsibility control*: distributing credit and blame among researchers and the non-scientist stakeholders who coordinated the work.

We pay close attention to why, when, and how researchers used these practices. Overall, we found that basic researchers who worked full-time in the crisis response were less likely to feel confident in the reliability of the overall research output the closer they got to the policy makers' and intelligence officials' translational research process. By contrast, the part-time crisis scientists who worked closely on translational research were confident in the output. However, researchers who described employing one or more performed separations were more likely to have high confidence in output reliability regardless of their work location within the crisis science response. A major difference between the groups was that the part-time crisis scientists continued to be active in their home disciplines. They did not romanticize the scientific process as pure or unblemished but instead remained fully aware of the errors and compromises that characterize regular science. These findings have implications for making crisis science effective and robust, specifically by attending to collaborative structures, relational ties, and personal support resources.

The Case: Conflict Archaeology

At the height of the Syrian civil war (2011 to 2018), government agencies and media outlets sounded the alarm about systematic looting at archaeological sites in Syria and Iraq (Al-Azm, Al Kuntar, and Daniels 2014; Harmanşah 2015). The Islamic State in Iraq and Syria (ISIS) was said to have generated significant income by looting and smuggling archaeological materials and to have used the proceeds to carry out violent acts against civilians (Greenland et al. 2019). Looting became an urgent policy matter for U.S. national security. Officials wanted to know the size of the revenue flow, the scope of the trading network, and the spatial parameters of the market for "blood antiquities," as ISIS's looted artifacts came to be known (Di Giovanni, Goodman, and Sharkov 2014; Howard, Prohov, and Elliot 2015; Shabi 2015). Archaeologists and anthropologists who would not normally seek out policy-related collaborations told us that they were motivated by moral outrage and a sense of shared ethical responsibility to work on the looting and smuggling response.

Their scholarly disciplines were enduring massive exogenous shocks. The war prevented foreign archaeologists from traveling to the region to conduct summer fieldwork—previously a routine and expected annual process for collecting data (cf. Pollock [2016:216] on wartime disruptions to archaeology in western Asia). The war also destroyed research infrastructures. Networks of local collaboration were broken up as Syrian archaeologists, along with the local people who staffed and supported excavation projects, were forced to flee the country or stay behind and try to survive amid constant threat of violence. One of the country's most prominent archaeologists, Khaled al-Asaad, former Director of Antiquities at Palmyra, was publicly murdered by ISIS in August 2015 (Hassan 2015). Civilians made homeless by the war sought refuge in archaeological ruins (Abdulkarim 2014). War zone violence damaged hundreds of archaeological sites, resulting in the loss of inestimable data (Casana and Laugier 2017). Additionally, the archaeological profession, along with the broader field of cultural heritage conservation, was said to have failed in its mission to protect archaeological sites and materials (Al Quntar 2018; cf. Meskell 2010 on "expert failure"). The war, in sum, radically altered the scientific conditions of Near Eastern archaeology. The old paradigms of understanding were dissolved as researchers watched state and non-state actors launch successive waves of attacks on sites and objects once considered sacred to science.

With few opportunities to observe the trade on the ground, policy makers and scholars analyzed from a distance (Casana and Panahipour 2014; Cunliffe 2014). Because it was too risky to visit archaeological sites to assess damage at close range, satellites were deemed the safer tool for making such assessments. From 2014 through 2017, the U.S. government awarded contracts to researchers and independent organizations to study the issue. Thousands of satellite images were analyzed by computer scientists, satellite engineers, archaeologists, anthropologists, and counterterrorism experts (Danti 2015; Lawler 2014). Archaeologists trained to use satellite images as secondary sources now relied on them for primary observations and sensory devices (Danti, Branting, and Penacho 2017; Tapete, Cigna, and Donoghue 2016). Among the outcomes of this effort were Congressional hearings, a bipartisan bill restricting antiquities imports, and multiple estimates of income streams from the illicit trade in antiquities.

Archaeologists had used satellite imagery for similar research inquiries prior to the war. The war did not introduce the core methods or principles that characterized conflict archaeology. What the war did do was create new configurations of collaborators, give researchers unprecedented access to classified satellite data, and routinize urgency. Conflict archaeology work was distributed across university labs, federally funded scientific agencies, nongovernmental organizations, and federal departments and agencies. Archaeologists and legal scholars had previously engaged with government bodies to intervene in warfare to protect cultural heritage (Gerstenblith 2009). The government–university relationship is familiar to many academic researchers, but the crisis intensified the relationship, and, for many conflict archaeology crisis respondents, it was their first foray into the domain of policy advisors and intelligence officials. That domain is the site of *translational research*, where research is stripped to its essential components, translated for non-experts, and compared with other information sources. Researchers' position relative to translational research emerged as a recurrent theme. We will return to these positions and their relationship to performed separations in the section on empirical and methodological orientations.

The Structure of Crisis Science

Crisis science. Key characteristics of regular (i.e., non-crisis) science are incremental progress, iterative analysis, and deliberative processes (Colwell and Machlis 2019:3). The primary objective is to publish findings in journals that pass rigorous, often lengthy, peer-review tests. Yet, in the context of a crisis, those practices may not be possible or desirable. The characteristics of crisis science, by contrast, are problem-solving inquiry, decisive analysis, and reduced data access (Machlis and Ludwig 2014). As such, crisis science has implications for researchers' standards for reliability and robustness in knowledge production. Crisis science, furthermore, is noteworthy for the increased interest by a broad set of stakeholders. Media, private industries, citizens, and policy makers may seek to influence the scientific process through their scrutiny, questions, and public discussions (Lindee 2016). Instead of being "outside" stakeholders looking on the scientists, policy makers are interlocutors woven into the entire process (Stampnitzky 2013). In her work on terrorism studies, Lisa Stampnitzky (2013) notes that U.S. policy makers' and think tank experts' deployment of specific vocabularies influenced the way political scientists talked and thought about terrorism. Particularly during the aftermath of 9/11, terrorism experts put themselves into constant crisis mode and eventually generated "facts" about terrorism that aligned with the non-critical rhetoric and political agendas of counterterrorism officials. The line between basic research and policy-making was blurred as "translation" became a one-way stream of data points and models from politics to academic departments, conferences, and journals (Jackson 2015).

Translational work. This blurring of lines reflects the interactive relationship between policy makers and social scientists during periods of crisis as a form of translational science. In non-crisis settings, this concept has been used as the foundation for facilitating policy-making that uses evidence-based research (Laub and Frisch 2016). The three main goals of translational criminology are relevant here. It aims to merge the research and policy spheres to facilitate the integration of scientific evidence into policy decisions through collaboration, communication, and trust (Laub 2012). When not in a crisis, the divide between basic research and policy implementation is clear. During a crisis, the need for interaction among multiple disciplines and stakeholders makes translation more common. Yet, whether in crisis or not, investigations of the role of interpersonal dynamics in this translation process are scarce (see Pesta et al. 2019).

One of the translational challenges for conflict archaeologists was to generate findings that were pertinent for immediate policy use without being misleading or illusory. An illusory finding is any research outcome that asserts causality where none exists, overstates the explanatory power of observed phenomena, or is otherwise misleading. Such cases can indicate contrasting standards of data processing and analysis—contrasts that exist in regular science but take on different consequences during crisis. Crisis, then, may introduce new anxieties about the quality of the science. Expectation dynamics are always a key component of the scientific process, varying in form and intensity across different disciplines (Borup et al. 2006). The flip side of the "hype" that propels crisis science to prominence is anxiety (i.e., Brown 2003). In the case of conflict archaeology, hope for a new method of quantifying cultural heritage and insurgent threat was accompanied by fear of terrorism and massive cultural loss.

Archaeologists were aware of these twin expectations and worked tirelessly to manage anticipation—their own and other stakeholders' (Clarke 2009 on anticipation dynamics). Prior work has productively mined the phenomenon of expectation dynamics and its impact on science but has had less to say about how scientists respond to urgency in the mundane practices of their research. In the case of looting and cultural violence in the Middle East, the work of archaeologists was broadcast in real time, accelerating the pace of scholarly discussion in such a way that existing standards of research and data evaluation had to be rethought and recalibrated to the immediate tasks (Cerra et al. 2016). Ensuring reliable research outcomes sometimes took a back seat to managing outside stakeholders' expectations, with the result that conflict archaeologists expressed ambivalence about the prevailing reliability of public statements about the group's work as a whole.

Structure and position. These and other epistemic issues shift analytical attention from organizational structure to the microsocial factors of individuals' perceptions and performance (Knorr Cetina 1995). In crisis science the usual methods for generating trust and building routines are bracketed in favor of rapid setup. Relationship-building that might take years in a lab during regular science is compressed (Lynch 1985; Shrum 2010). Researchers must navigate that uncertainty in addition to other uncertainties about their own performance and how they will be judged. As one of our study participants put it, "Am I supposed to do my regular job but much faster? Or is the expectation that I'm actually a different kind of scientist, given the circumstances?" This concern was bound up with another: that what they were doing was regarded as *research*. Research is "a *Conscious Action* that aims for *New Knowledge*, emanates from one or several *Questions at Hand*, studies one or several *Contexts*, builds upon *Existing Knowledge*, uses one or several *Scientific Methods*, is documented in one *Described Procedure*, requires *Transparency* and relates to one or several *Systems of Rules*" (Mårtensson et al. 2016:597). Although we sometimes use the terms *research* and *science* interchangeably, we note that the latter typically refers to a broad space of thought and practice, whereas the former corresponds to specific knowledge-formation endeavors. Our informants also interchanged the terms, evidently sensitive that flawed conflict archaeology research findings could damage the credibility of their respective sciences.

Against the widespread assumption that urgency forces downward pressure on standards—as seen in "vaccine hesitancy" that questions the quality of COVID-19 vaccination research (Remmel 2021)—we found that scientists involved in conflict archaeology work were acutely attuned to the research standards of their disciplines. Entering the project did not mean that they became a different kind of scientist. They did their "regular jobs" by keeping one foot in their primary research institutions and the other in the crisis work. They adapted to the greatly compressed time frame on data analysis results by deploying interpretive methods that were epistemically acceptable to them, and they effectively filtered out the politicized aspects of the conflict they were working on. Performed separation, in this light, is not a coping mechanism to isolate oneself from unfamiliar researchers and agendas. It is an integrative practice, vital to keeping scientists working as *scientists* who produce robust and reliable findings even as they wear the "crisis respondent" hat in the short term.

Empirical and Methodological Orientations

We conducted semi-structured, in-depth interviews with individuals who performed different tasks within the conflict archaeology research process. There were three general categories of specialist:

1. *Detectors*: Scientists who operated computers, codes, algorithms, and detection equipment and thus generated satellite and remote sensing data.
2. *Analysts*: Scientists who took the processed spatial data and compared or interpreted them (e.g., through satellite imagery and georeferenced coordinates).
3. *Decision Makers*: Policy professionals who interpreted and applied the Detectors' data and the Analysts' interpretations to policy-oriented reports and documentation efforts.

The first stage (*Detectors*) represents machines and people as they build and conduct the sensory apparatus and data calibration. The computer codes, algorithms, and equipment adjustments of technicians and programmers directly affect the spatial data production process and the fusion of data into images legible to the human eye. The second level (*Analysts*) represents the reception of satellite data, often in the form of images. In the case of conflict archaeology these actors include archaeologists, anthropologists, cultural policy specialists in think tanks and universities, and foreign affairs scholars. We found that these actors have varying levels of training in remote sensing technologies. The third stage (*Decision Makers*) comprises Congressional officials, international nongovernmental organizations such as UNESCO, and the National Counterterrorism Center (among other empowered actors) who create policy and security procedures based on the Analysts' findings. These categories of specialist factored into our analysis of their temporal contributions and spatial locations in the crisis science response. The figure in the online supplement presents a schematic rendering of the process.

Data Collection: Semi-structured Interviews

To ensure that our investigation accounted for both the collaborative and autonomous elements of crisis science, we designed an integrated approach that accounts for links between researchers' decisions, policies, and values. For example, in designing the sampling strategy, we sought out individuals who worked across the schematic boundaries above to facilitate discussions of how uncertainty could intervene in these liminal spaces. We also looked for at least one Analyst and Detector from each major lab that conducted work on archaeological looting for counterterrorism from approximately 2014 to 2018. We then supplemented this sample with labs focusing on the production or processing of satellite, remote sensing, and geospatial data as well as with Decision Makers in both cultural heritage and counterterrorism working nationally and internationally. In total, we conducted 35 interviews (out of 41 requests): 21 with Analysts (60.00 percent), nine with Detectors (25.71 percent), and five with Decision Makers (14.28 percent). Of those interviewed, 17 (48.57 percent) indicated that they operated across multiple domains. Most of the nonresponses were from Detectors and Decision Makers. The table in the online supplement shows the breakdown of our interview participants across categories.

Questions covered a range of topics relevant to uncertainty and mitigation, including how robustness and reliability were defined and operationalized in respondents' work, how they defined standards of excellence in their area, how they decided to publish, and which journals or outlets were considered appropriate outlets for their work. Our assessment of the strength of individuals' reliability confidence was based on their perceptions of the validity and robustness of research outputs—theirs and other conflict archaeologists'. We did not attempt a statistical verification or replication study (which would entail a very different study of reliability and require access to data that are largely unpublished). Those with technical expertise were asked to give an example walkthrough of how they would do certain tasks (e.g., orthorectification, correcting satellite imagery, identifying looting pits). The focus of each conversation was to examine the processes involved in each person's specific research or workflow. For Detectors, this could include how they knew when to stop processing an image. For Analysts, this could include how they knew their findings were robust or reliable—what measures they took to make sure their results were defensible. For Decision Makers, this could involve how they determined whether a particular document or piece of evidence was sufficient to be used in support of their end goal.

The time elapse from involvement in the conflict archaeology crisis to interview ranged from less than a year to two years. As such, there is variation in the amount of time that our participants had to process and reflect on their crisis science work. Accordingly, the questions were designed to encourage the informants to describe their analytical practices and strategies as they saw fit. Each interview transcript was then qualitatively coded for examples of when and what types of uncertainty existed in their work and how they addressed them. To code individuals' positions within the crisis science response, we assessed their answers to our questions about employment, institution type, and research/analysis activities. (Coding protocols are available by request from the authors.) In the interest of confidentiality, we refer to all of our informants by unique identifiers indicating their contribution type within the conflict archaeology crisis response, and we use the nongendered pronouns they/them/their. Some excerpts were lightly edited for clarity.

Findings: Performed Separations

Across the full spectrum of knowledge production, from Detectors to Decision Makers, we identified three main mechanisms for performed separation that took shape depending on the participant's role in the knowledge-production process: (1) temporal control, (2) scope control, and (3) responsibility control. Table 1 reviews each in more depth.

Each of these separations reflects a different challenge to producing robust and reliable research under the pressures of scientific urgency. To adapt to the severe time restrictions imposed by policy makers, Analysts played with time by speeding up processes that would ordinarily require months to complete but slowing other processes (e.g., recording and publishing metadata) that they insisted could not be rushed. Conflict archaeology was a high-pressure undertaking for reasons beyond tight deadlines and politicized findings. The specifics of the empirical case—including horrific violence against people—took an emotional toll on the researchers. Some participants shared that although they were able to maintain perceptions of professionalism and thoroughness in the workplace, they endured nightmares, psychological breakdowns, and strained family relationships as a result of working long hours. Creating emotional distance served as a necessary psychological and ethical coping mechanism for producing basic science under urgent conditions (Pickersgill 2012).

Similarly, researchers had to contend with unfamiliar data sets, models, and technologies. The work time frame was too compressed to allow full technical training for everyone. In embracing black boxes and strategic technical ignorance, Detectors, Analysts, and Decision Makers were able to navigate dilemmas of robust and reliable science processes while producing usable findings under short time frames. This was particularly true with satellite data interpretation—the central objective of the project. Some Detectors and Analysts expressed misgivings about performing research tasks that would be converted into actionable intelligence for counterterrorism agencies. To separate their domain from that of intelligence and federal policy, Detectors and Analysts insisted that their visual interpretations of the satellite data were impartial and unrelated to the policy requests. This performance of separation is essential to understanding the success of urgent science in conflict archaeology.

Our coding decision *Embedded/Adjacent* is scaled on the amount of focus individuals contributed to conflict archaeology work. This variable factors in time commitment (full- or part-time) and the direct relevance of an individual's work to

Table 1: Mechanisms for performed separation

	View of time frames and deadlines	Actions of separation
Temporal control	Viewed as discipline-specific Basic researchers often expressed skepticism that high-quality data and analysis could be produced in the short time frames demanded by policy makers	To make truncated timelines morally and epistemically palatable: • "Borrowing" time by slowing down non-consequential workflow processes • Operating on "academic time" through researchers' basic science projects
Scope control	Time frames did not allow for full training of everyone involved	To maintain robustness and reliability of research using new products under urgent conditions: • Embracing black boxes and strategic technical ignorance, reliance on trusted individuals • Satellite images were visually assessed differently by Detectors and Analysts • Each practice used by Detectors and Analysts signified an ethical stance
Responsibility control	Researchers expected Decision Makers to shoulder blame for any illusory findings resulting from condensed time frames	To gain trust sufficient to generate findings under compromised conditions: • Mutual recognition of limitations and importance of being "up front" • Shared duty to amalgamate epistemologies • Rejecting "cherry picking" protected researchers from reliability dilemma

conflict archaeology. For example, individuals could be described as Adjacent if they worked full-time on the satellite remote sensing instruments that collected data for conflict archaeologists, but did not analyze the data themselves. We found that researchers who were more embedded in the crisis science response and worked closely with Decision Makers tended to express higher certainty about the reliability of the work they helped produce. (Note the *Embedded* end of the x axis in Figure 1.) But we also found that individuals who were less embedded and did not work closely with Decision Makers also expressed high certainty about the reliability of the findings they helped to produce. Performed separations help explain this counterintuitive finding.

Our coding decision *Near* or *Far* is scaled on process steps removed from crisis policy-making. Detectors were typically far removed from translational research efforts by their instruments and tasks. They tended to describe their roles as limited to metadata, algorithms, orthorectification processes, and satellite calibrations, all of which made possible the user-ready images required by Analysts and Decision Makers. Analysts typically worked on processes situated between the Detectors and Decision Makers. Lacking detailed technical expertise in the production of satellite images, Analysts moved those images from the domain of algorithms and

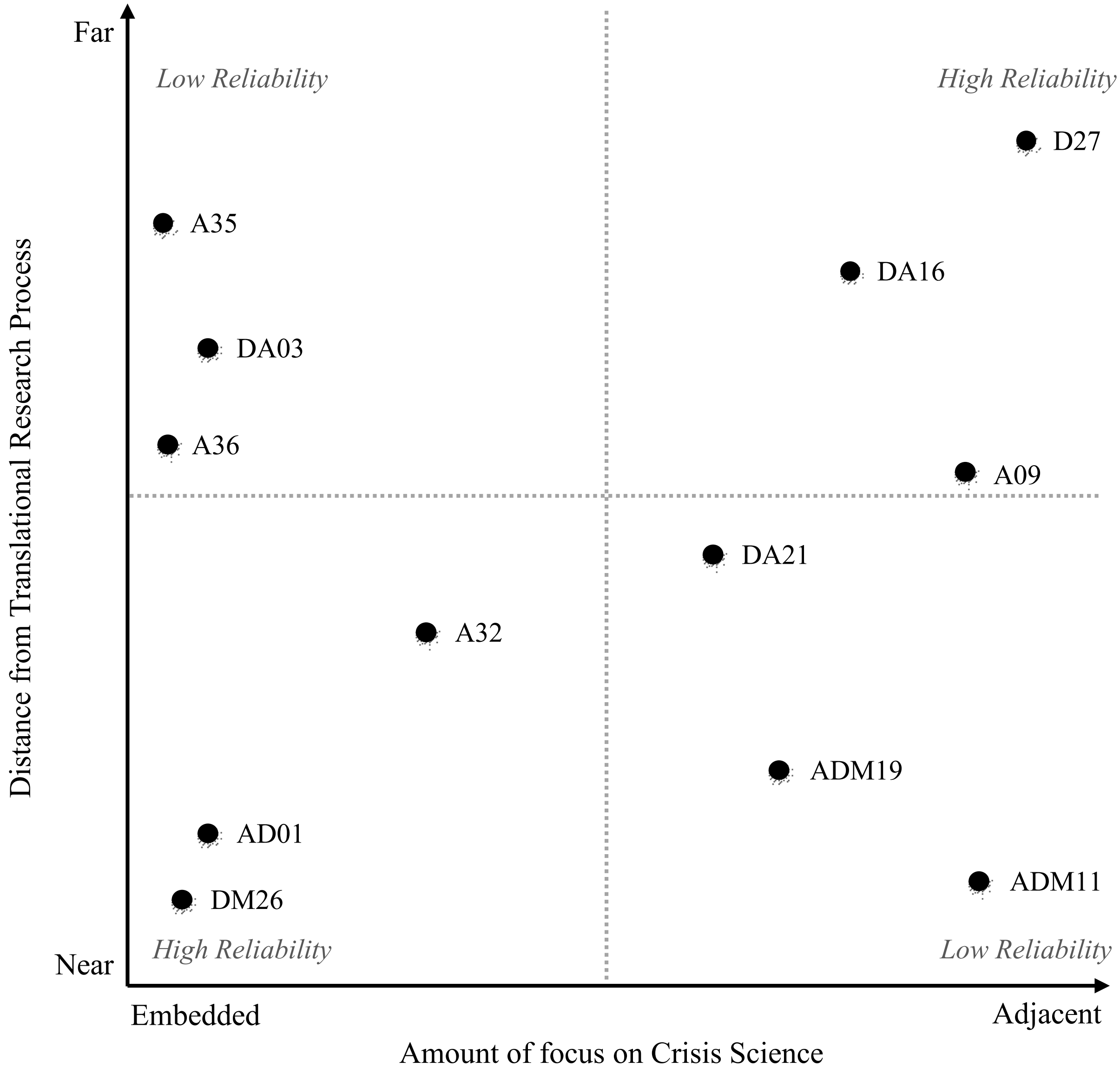

Figure 1: Plot describing how an individual's position in crisis science and their distance from the translational research process influence their view of the reliability of the final research output. Highly embedded researchers who are also near to the process are more likely to view the output as having "high reliability" (e.g., DM26, AD01).

remote sensing and into the sociopolitical domain of conflict and destruction. Some participants performed hybrid tasks, and we refer to them as Analyst–Detectors or Detector–Analysts—the first term suggesting more work in that area. DA21 (*Adjacent/Near*), for example, was a data scientist with archaeological training and was a part-time contributor to a short-term, rapid-turnaround study of looted artifacts in Syria. Decision Makers worked primarily with Analysts but received information from multiple sources and triangulated several Analysts' interpretations. Below we discuss each separation practice on its own and then return to the idea of how individual positions constituted the broader system of performed separations.

Temporal Control

These are ways that researchers show themselves to be professional and thorough—or normatively "good" researchers. Part of what they do is perform "long time," or the time cycle required to complete a project. Researchers have to engage with a project long enough that it seems plausible to have done an adequate job, but not so long that they seem unproductive or lazy. Time serves as a signaling device. Performances of "long time" extend to *non*-research activities, including time lapse in e-mail returns, requests for meeting extensions, and turnaround time on reviews and administrative documentation. Sometimes, academics are "slow" because they are incentivized to be. It is part of the culture.

Detector 27 (D27) is a Detector with 12 years' experience in computer science and satellite engineering. They participated in conflict archaeology through their lab, a university-based unit that specialized in remote sensing technologies to support natural disaster interventions. We coded them *Adjacent/Far* (Figure 1). The conflict archaeology work proceeded at a pace much faster than what they were used to. Normally, they told us, if a project is considered "urgent" it would be "something that they [the funders or primary investigators] need within a year or two. So, it's not an immediate turnaround for most of this stuff" (D27). By contrast, conflict archaeology presented pressure for results in days or even hours. The tight deadlines meant that the same data processing lags that were acceptable during regular science were now untenable. During the conflict archaeology work, they said,

> We have had a lot of issues with slowness [. . .] because we are relying on somewhere else to provide [data], so we can pull it down and then do what we need to with it. So, that's definitely been one of the biggest issues, recently, with getting that. We have to write our software to anticipate failure with downloading things. (D27)

D27's direct involvement in writing that software and ensuring that it worked was, for them, suggestive of high reliability throughout the conflict archaeology crisis response. Another *Adjacent/Far* informant was Detector–Analyst 16 (DA16), who vividly conveyed what it is like to do research with the crisis-moment demands of "very quick turnaround." We asked them whether those demands have an impact on how research standards are incorporated into the project:

> DA16: Yes, I think it would. Sometimes you're not doing it [research] so much to answer a research question so much as to just provide information. So, a lot of times when you need a quick turnaround it's just to provide the quickest information you can get your hands on. So instinctively follow the same type of process, scientific process that you would otherwise but sometimes not, sometimes you just do it as fast as you possibly can. [. . .] the science doesn't get completely left at the door but I mean if you only have two days, you only have two days, so.

> Michelle D. Fabiani: In those cases, would you say that it's more than just being transparent about what can be said with the data or the information that you're providing? Sort of providing some boundaries around how it should be interpreted?
>
> DA16: Yes, for sure. [. . .] We may say, "Well we can't exactly answer that question because of this or we might be able to answer that question but it's harder to say because we would need to do this, this, and this in order to know for sure"—that kind of thing.

DA16 expressed overall confidence in the crisis science research. They had to negotiate regular science's processes with crisis science's demands. One strategy for doing so was to turn research questions into "information" questions. Research questions became information requests, scientific processes became instinctual shortcuts, and boundary-setting normalized the translation process. This internal translation was a common theme among our interviews with Analysts. As Analyst 32 (A32; *Embedded/Near*) points out below, some viewed this shift as a form of triage where the time constraints forced a shift in perspective and one that was only possible through borrowing time.

> A32: One big change was the rapidity of information exchange. That was a massive shift to nearly real-time tracking of the situation. The fundamental questions were about ethics, disclosure, and the staffing arrangement of our triage process. There was no efficient way of processing data from site to site. We were a cohesive group of people, working conflict to conflict.

In cases where borrowing time was not possible, those we interviewed highlighted attempts at maintaining their "instinctual" approaches or "standard methods" with varying degrees of success. By attempting to exert temporal control, Detectors and Analysts were able to meet the information demands of the crisis. At the same time, these adaptations were not without consequence. Restrictions on time led to internal translations in the types of knowledge that could be produced and the role of methods in creating reliable and robust science. The process by which this translation occurs reflects how Detectors, Analysts, and Decision Makers each "saw" and interacted with the satellite imagery.

Scope Control

Conflict archaeologists focused a large share of their work on identifying and measuring looters' pits, or the indentations in the ground left by digging activity (Contreras and Brodie 2010). A looter's pit is not a naturally occurring feature, like a riverbed or a dust devil (Stone 2008, 2015). It is a socially constructed feature freighted with assumptions about human activity including motives, morals, and money (Kersel and Hill 2019). The looter's pit on the satellite screen is at once a scaling tool and claims-making device (Cunliffe 2014). One of our informants explained that prior to the Syrian conflict, non-archaeologists showed little interest in looters' pits. The traditional methods for documenting them were unrecognizable to non-specialists. Satellite imagery, our informant suggested, bridged the expertise gap with its powerful visual message: "Today everyone it seems, at least everyone we've been dealing with in the U.S. government and in law enforcement, are much more familiar with this [looters' pits] and don't need to be convinced it's credible" (Decision Maker 26 [DM26]; *Embedded/Near*). To make meaning of the holes takes years of study at sites. Archaeologists can (most of the time) distinguish between a hole made by erosion, by an animal, and by the force of a human-held tool. Non-archaeologists might be able to apply the generic label "hole" to many different features at an archaeological site but lack the nuanced knowledge of the terrain and matrix necessary to make further distinctions. The practice of *ground truthing* means visiting a site in person to inspect things up close, but even this is not fail-proof (Jaton 2017; Stone 2015). When archaeological sites are exposed to year-round natural and human forces, there are shifts and collapses and everyday wear and tear, all of which alter the soil profile. The work is difficult, even for seasoned archaeologists working in normal scientific conditions.

At issue is how to look at the remote sensing data (Lawrence 2020). To paraphrase one of our informants, there are always going to be multiple interpretations of what a data point shows, especially when that data point seems readily interpretable, as with satellite images. But what a lot of people miss is that there are also multiple interpretations of what a satellite image *is* and does. Because of that ambiguity there are meanings that exist independent of the image and the way it frames, consolidates, and re-produces the real-world truths that they are assumed merely to record and represent. Conflict archaeologists pointedly described many of their research activities as visual: looking, seeing, scanning, pointing and clicking, monitoring, and so forth. They draw boundaries separating these activities from other activities: talking, coding, measuring, classifying, writing code, compressing images, and so forth (cf. Vertesi 2015). These boundaries and descriptions show satellite images as both a source of quantitative information and a visually rich data environment that requires ethical position-taking in relation to interpretation (Elwood 2010:402). Detectors characterized themselves as primarily involved in the technical aspects of satellite image processing—work described by one informant as the "nitty gritty" of conflict archaeology. In doing so, they could separate their area of work from potentially compromised areas elsewhere in the conflict archaeology crisis science collaboration.

Related to this were expressions of discomfort with the use of technology to make swift interpretations that carried potentially dramatic consequences. Analyst–Detector 01 (AD01), who worked full-time in the conflict archaeology crisis response for nearly a year (*Embedded/Near*) was blunt about the propensity for error via point-and-click visual practices:

> AD01: It could be pretty scary [. . .] Even at 1 meter [resolution], seeing this kind of stuff is hard, that's one reason that people didn't recognize looting that had happened earlier. [. . .] You can't really see a hole very well—they kind of blend together. Because a hole may be as big as this table and that's like one pixel, so it doesn't really show up.

What was "scary" for this researcher was the necessity of making interpretations based on suboptimal resolution that would then inform Decision Makers' reports to intelligence and policy-making officials. A similar concern was raised by Analyst 36 (A36; *Embedded/Far*): "You're contending with a lot of different potentials and errors and inaccuracy. [...] You can see [looting evidence] everywhere. But sometimes it's really hard to differentiate damage that comes from long-term neglect versus damage that results from active looting. We are making a lot of assumptions about intent when we talk about those patterns." AD01 did, nevertheless, express a high degree of confidence in the data and analysis produced by their team. They maintained scientific standards, such as presenting all analytical outcomes, even those that did not necessarily align with policy makers' views: "My stance was unwavering in that I was unwilling to compromise on this basic thing which I thought was fundamental to what we do as academics—trying to find out what was going on and telling people about it" (AD01).

Seeing holes incorrectly, without a sociocultural schematic, carried the risk that Decision Makers would fail to envision the nuances of human activity. A32 sought to maintain that nuance by sticking to standards of research consistent with non-crisis work:

> A32: Conflict brings unusual activity. We had to figure things out without ground truthing. And, given the urgency of the situation, we knew that people were looking over our shoulder. We kept to standard coding procedures, but the data didn't always fit. [...] We had to figure out how to shift our standard methods and coding procedures into the policy/crisis paradigm. We had to show how our work intersected with their mandates.

Note that even though A32 and their colleagues tried to maintain standard coding procedures, the data they were given did not necessarily fit those procedures in light of the new mandates. Federal agencies wanted specific information: how much the antiquities were worth. This is not, A32 reminded us, what Near Eastern archaeologists are trained to study. On the contrary, they are taught that market prices are irrelevant to artifacts' scientific value. That value is captured by studying artifacts' archaeological context in situ. Given the dangers of the conflict zone, this was not possible. A32 demonstrated high confidence in the reliability of conflict archaeology without ground truthing. But Detector–Analyst 03 (DA03; *Embedded/Far*), who worked far from decision-making, cited ground truthing as the "Gold Standard criterion" against which their remote sensing conflict archaeology would be judged. For them it was difficult to imagine valid and reliable knowledge without it, and they expressed low confidence in the ability of the data to do anything more than model hypothetical scenarios.

Finally, Analyst 35 (A35; *Embedded/Far*) conceded that the technology now makes it possible to identify looting from satellite pictures but questioned the point to doing so:

> A35: For us archaeologists, the goal of utilizing satellite imagery is mostly to be able to find sites easier. [...] Now, what is the idea of saying yeah, this site is heavily looted? Is that to basically alert authorities in a place to just go and stop it? That is very difficult in places like Egypt for example. It's impossible in Syria and Libya. I don't think [the question

> is whether] identifying looting is possible. It *is* possible. It's just, what is the end goal of that?

A35 was embedded in conflict archaeology work during the crisis, but their work location was several process steps from Decision Makers. Accepting the technical accuracy of the satellite data while questioning its applicability to fixing the crisis was an indicator of their low confidence in the robustness of the research being produced.

Negotiated Responsibilities

Decision Makers interacted directly with elected officials, policy advisors, and federal agency staff and were expected by these stakeholders to deliver timely and comprehensible information about developments in Syria. It was common in our interviews to hear about tight deadlines and the expectation by federal agencies that their specific questions be answered within hours. Decision Makers described spending significant time on the phone with Detectors and Analysts to cajole them for solid information, fast. Part of this coordination effort involved "shaping" the scientists' findings into forms that federal policy makers could use. One of the most common and effective methods for doing this was to render the remotely sensed entity describable and interpretable.

> Decision Maker 22 (DM22; *Embedded/Near*): Is the data that's being interpreted and these maps that are being produced, is this at a level that is useful? Like can my colleagues deal with this or are the data too complicated? None of us in [FEDERAL AGENCY REDACTED] are experts in interpreting satellite imagery or in GIS [geographic information systems], so I trust that the lab is using the best methodology they can. We do look at the outputs and we keep going back to the question: are these outputs going to be useful for policy makers?

"Useful" is not the same as "user-ready." "Useful" here means specifically and readily applicable to tasks, conversations, and targets of the government. This was the line between information and intelligence, and it was a source of discomfort for many Analysts and Detectors.

Analyst 09 (A09; *Adjacent/Far*) used a term of opprobrium for it: "cherry picking." It was problematic, they insisted, that Decision Makers were lifting stylized facts when "they aren't familiar with the context in which the data was generated [. . .]." Policy makers and talking heads would just "cherry pick what seemed to correlate with their expectations and then ignore all the other bits [of data]." DM26 rejected the allegation of cherry picking and reframed their work as translational research:

> DM26: I think the big bar to getting policy makers to use academic research is it's lengthy and written for a different audience. So, what we have done is *translated* for lack of a better word. You know, pulled out the talking points and relevant images and tried to make it easy for someone that has two minutes to look at a document.

Whereas the academic scientists' goal is to provide reliable data, the Decision Maker tries to bracket reliability in favor of usefulness. Only in the context of what value can it add to the whole picture, to help Decision Makers better understand, is the researcher's work useful.

The production of crisis science represented a constant negotiation over responsibilities. Decision Makers needed concrete information to make strategic decisions. Analysts needed to provide highly structured science that in many ways defied the standards they were taught. Analyst–Decision Maker 11 (ADM11; *Adjacent/Near*) worked part-time on conflict archaeology: "on-again, off-again" alongside other, non-urgent projects. They had extensive experience with applied science and policy directives, having worked on such topics as wildlife trafficking and illicit market finances. As such, ADM11 had a unique perspective by providing scientific analysis for diverse policy needs in different settings. They stressed that the convergence of scientific and policy needs was not fundamentally problematic. However, the particularities of conflict archaeology "intentionally narrowed" the analytical picture to focus on terrorism at the exclusion of other possible causes of looting. This "distorted" the actual revenue level of antiquities and drew attention away from "other funding streams but also in general what's going on with people who are also trafficking in looting in Syria" (ADM11). For ADM11, this represented a breakdown in negotiated responsibilities. The policy directive to focus narrowly on terrorism led them to conclude that the overall work was locally reliable but not robust to general inquiry.

Analyst–Decision Maker 19 (ADM19) was also *Adjacent/Near* and had a similarly skeptical view about the knowledge value of the work, as expressed in a playful hypothetical: "The policy maker just needs to know that people with green underwear are more likely to smuggle artifacts across borders. They don't need to know why, they don't need to know how, they just need to know that they can look for people with green underwear." The negotiation required Decision Makers to take more ownership and responsibility for the science produced. Their structural location gave them an advantage for conveying the accuracy and utility of the science provided by Analysts (in this case the conflict archaeology scientists). "I provide a lot of air cover," one Decision Maker put it, referring to their willingness to take responsibility when a data point was wrong or an anticipated report was late. Related to this was Decision Makers' willingness to be the "bad cop" and issue deadline ultimatums or deliver unwelcome results to policy makers and the press. Here the Decision Maker took more ownership and responsibility for the final product than they might have in other circumstances.

In return for "cover" from Decision Makers, Analysts showed a willingness to meet the needs of the Decision Maker to the best of their ability, often involving a paradigmatic shift in what constituted "reliability" in the production of science:

> ADM19: Many policy makers are not very, I'd say *mature*, when it comes to interpreting that kind of data, and the minute you say anything to them, they'll just take it as gospel and then blame you afterwards. A lot of my colleagues have said that if you're not 100% sure about something or are 99% sure about something, don't give it to a policy maker. If I did that, I would never give anything to a policy maker because I'm never

> 99% sure about anything, so I will just sort of label something with the amount of confidence that I have and then discuss the sources of my uncertainty and what could be done to reduce that uncertainty. Often, I will say we're only marginally confident about this.

This Analyst acknowledged that pressure from Decision Makers affected how they worked, and they expressed reservations about the forced choice to ignore the full context of data. But the performance of negotiated responsibility made crisis science first feasible, then reliable.

Discussion and Conclusion

The crux of crisis science is problem-solving. When the public turns to scientists for help, it typically wants assurance and a robust solution. Researchers must balance expediency with disciplinary standards of reliability. Through the case of conflict archaeology, we find three recurring practices in effective crisis science: temporal, scope, and responsibility controls. When these controls were successfully operationalized, the result was increased confidence among the scientists engaged in answering the urgent questions posed by the crisis. As our informants described them, the controls were organic, in the sense of being deployed by the researchers on an individual or local group basis. There was no evidence in our data that top-down control mandates were in place. Organizational and disciplinary cultures, rather than employer or funding body policy, made it possible for researchers to exert temporal or scope control, for example. Future work could determine what policies or practices would generate felicitous conditions for these controls. Scientists working in urgent moments may be more likely to produce reliable research if they are allowed half-time engagement in their normal science projects and work conditions, an arrangement most likely facilitated by their employers (see Crow et al. [2021] on policy-making and crisis science).

In our case study, we found that location within the endeavor is important. Adjacency can have benefits for crisis scientists if they maintain research activity in their discipline and observe the rigorous standards of that discipline. This finding aligns with the hallmarks we identified, as this involvement reminds researchers that even regular science has imperfections, suboptimal time frames, and restricted data. In the cases of part-time crisis science participants who worked closely with Decision Makers, their continued involvement in regular science gave them a more balanced perspective on the methodological and analytical realities of crisis response. But full-time participants who were close to Decision Makers did not necessarily have sufficient perspective to see the full range of standards and the individuals involved. We explain this observation as suggesting that researchers who were full-time involved in crisis science were no longer participating in basic research. As a result, they were prone to romanticize academic research even as they lamented its awkward fit with crisis needs. Finally, we observed that those who were full-time embedded in crisis science, regardless of their proximity to Decision Makers, faced burnout, stress, and intense scrutiny. Scientists navigating crises, within the profession and outside of it, require institutional as well as intrapersonal supports (Morawski 2020).

Why are discipline-specific standards so important in crisis science? Part of the answer is the multiplicity of stakeholders and the increased scrutiny that often accompanies a crisis. When Detectors are busy with the nitty gritty, they cannot be occupied with other things—like the more controversial work of coordinating with media outlets and Decision Makers. In fact, much of their image-creation work *is* subjective and susceptible to broader pressures from professional and political interests (Sparke 2011; Vertesi 2015). Many Analysts tried to be transparent in what they could and could not speak to in their findings. In this, there are broader implications for crisis science: to the extent possible, it is beneficial to structure the work via temporary contracts for part-time, intensive bursts of activity while being transparent about the translational research process. This bolsters researchers' confidence in the reliability of the research, in a way that full-time involvement with opaque translational research does not.

The coordinating processes that we study have political advantages for researchers. They defer scientific credulity to different experts in the knowledge-production chain and paper over inconsistencies. All of this achieves epistemic stability because everyone can agree on an interpretation that does not require actual representation. Crisis science strains the production of knowledge across divergent concepts of interpretation. Some of the key things we asked about tie into *why* it is so important that Analysts serve as translators and how difficult it is to do it effectively. This includes expectations by Decision Makers in terms of timeliness and urgency, research versus intelligence, and strategic ambiguity versus credibility. To this end, further work should be done on the transformation of scientific work into intelligence. Information-to-intelligence was conceived of by our informants as a pipeline through which bits of science were systematically moved away from the scientists. We adopted this schematic in our analysis. Looked at differently, however, it was less a pipeline than a lattice of iterative interactions, in which Decision Makers were in constant communication with Analysts and Detectors. Daily check-ins and weekly team meetings were the elements that bound the lattice. The theoretical implications of this collaborative structure can be productively elaborated in future studies of crisis science.

Performed separations are not exclusive to crisis science. Indeed, one of our informants explained that keeping his work at an arm's length had become a standard operating procedure for working with outside stakeholders in general. But during crisis, these separations are especially prominent and essential. They enable people to set themselves in opposition to claims and practices that conflict with their own ideas about methodological robustness and the strength of available data. As such, performed separations—such as declaring one's work to be restricted to technical matters or disconnected from policy concerns—signal an ethical position of disinterestedness while participating in a project that has defined policy goals. These adaptations permit people to protect what they see as their scientific autonomy and distance themselves from perceptions of scientific laxity amid pressure to deliver results.

Urgent scientific collaboration during the COVID-19 trials generated praise for its suppleness and responsiveness. It also raised questions about the nature of collaboration in such projects and how standards of reliability are maintained. Crisis science is most effective when experts adjacent to the research serve as coordinators and translators (Machlis and Ludwig 2014). But we also know that coordination of communication does not guarantee a convergence of epistemic interests (Vertesi 2015). Among the reasons for non-convergence include scientists' uneasy reckoning with the role of their own disciplines in promulgating crises by reproducing risks and normalizing errors (Fortun and Frickel 2012; Vaughan 2016). Before the next pandemic, natural disaster, or war generates another crisis science moment, we can look to the example of conflict archaeology for the hallmarks of effective crisis science.

Notes

1 "Regular" science can be understood through the four norms of Robert K. Merton's ([1942] 1973) idealized "scientific ethos": communism, universalism, disinterestedness, and organized skepticism. In reality, much of non-crisis science falls short of the Mertonian ideal. Crisis may trigger further dispensations. For a broader discussion of the relationship between scientific norms and practices and disaster, see Fortun et al. (2016).

2 The authors thank James Evans for suggesting this term.

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Fiona Greenland: Department of Sociology, University of Virginia.
E-mail: fg5t@virginia.edu.

Michelle D. Fabiani: Criminal Justice Department, University of New Haven.
E-mail: mfabiani@newhaven.edu.

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Table S1. Descriptive statistics (N = 35)

	N	%	Mean	Range
Analysts—All	21	60.00		
Analyst only	13	37.14		
Analyst-Detector	6	17.14		
Analyst-Decision Maker	2	5.71		
Detectors—All	9	25.71		
Detector only	2	5.71		
Detector-Analyst	7	20.00		
Detector-Decision Maker	0	0		
Decision Makers—All	5	14.28		
Decision Maker only	3	8.57		
Decision Maker-Analyst	2	5.71		
Decision Maker-Detector	0	0		
Education	35		2.771	1-3
1. Bachelor's Degree	2	5.71		
2. Master's Degree	4	11.43		
3. Doctorate (incl. JD)	29	82.86		
Distance from Translational Work[1]	35		1.571	1-2
1. Near (2 or fewer steps)	15	42.86		
2. Far (3 or more steps)	20	57.14		
Position in the Conflict Archaeology field[2]	35		1.457	1-2
1. Adjacent	19	54.29		
2. Embedded	16	45.71		
Time commitment[3]	35		2.314	1-3
1. Less than 1 hr/week	3	8.57		
2. Part Time (1-33 hrs/week)	18	51.43		
3. Full Time (<34 hrs per week)	14	40.00		

[1] **Near/Far** is spatial. We use it to refer to a person's distance from the translational research process. Our coding decision *Near* or *Far* is scaled on process steps removed from crisis policy-making. We coded people as Near if they were 2 or fewer steps away, and Far if they were 3 or more steps away. In this context, the mean shows a relatively even split in the sample, with a slight emphasis toward Far.
[2] **Embedded/Adjacent** is temporal. We use it to refer to the amount of focus devoted to conflict archaeology. This variable factors in time commitment (full- or part-time) and the direct relevance of an individual's work to conflict archaeology. For example, individuals could be described as Adjacent if they worked full-time on the satellite remote sensing instruments that collected data for conflict archaeologists, but did not analyze the data themselves. As indicated by the mean (1.457), our sample is relatively evenly split between Embedded and Adjacent, with a slight emphasis towards Adjacent commitment.
[3] On average, over the course of the crisis science response from early 2015 through mid-2017.

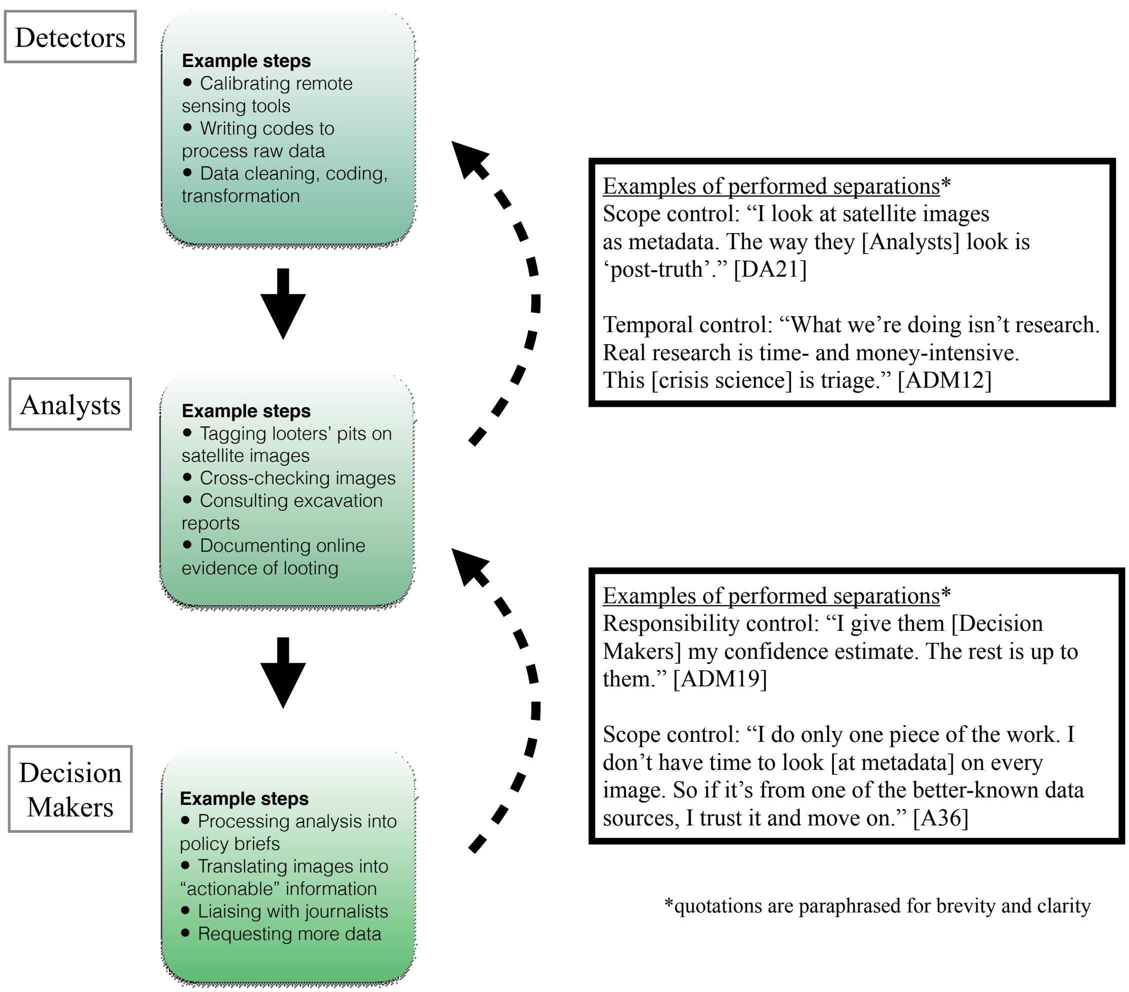

Figure S1. Production steps in conflict archaeology. Dashed arrows represent responses to crisis science reliability concerns.

Coding definitions

Figure 1 in the main text plots our respondents on a grid structured by field position, work commitment, and confidence measures. Near/Far and Embedded/Adjacent were binary coding decisions. As a result, each respondent can occupy only one quadrant. The spatial variation within each quadrant corresponds to the person's degree of confidence in the reliability of the research being produced by the crisis science response. For example, A32 was coded *Embedded/Near* because they performed crisis science analysis in close conjunction with Decision Makers ("Near"), and although they continued to perform non-crisis science research during the period in question, that other research was directly related to conflict archaeology. As such, their field position was "Embedded." Because A32 expressed moderate confidence in the overall research being produced by the crisis science response, they are plotted between High and Low Reliability (near the upper-right corner) of the *Embedded/Near* quadrant. To take another example, D27 was coded *Adjacent/Far* because they performed computational and programming tasks that were several steps removed from crisis science translational work ("Far"), and because those tasks were distributed across research projects including non-conflict archaeology projects ("Adjacent"). They expressed high confidence in the reliability of their work, and in the reliability checks performed by researchers closer to crisis science translational work. For this reason, they are plotted in the *Adjacent/Far* quadrant, in the High Reliability space. These and related coding decisions are explained at length in our data dictionary and coding analysis notes (available from the authors upon request).

Coding procedures

We performed two rounds of coding, with an inter-rater reliability (IRR) test between rounds. We used the Dedoose package for transcript storage and coding, structured by macro- and granular-level coding nodes. Two student research assistants transcribed the interview recordings, which were then checked by the authors for accuracy including technical terms and foreign language transliterations. All transcripts were de-identified and assigned a unique identifier. Macro-level nodes were established by the authors prior to Round 1 Coding, based on prominent themes in the interview schedule. Each author then coded 50% of the transcripts (randomly assigned). They first read a given interview in its entirety, then applied macro-codes, and created granular codes, during the second pass. The list of coding nodes is available from the authors upon request.

Once all of Round 1 coding was completed, the authors performed the IRR test on a 10% sample of excerpts. A stratified random sampling method with replacement was employed so that each Code received at least 2 excerpts selected. Replacement was allowed for efficiency, meaning that the same excerpt could be selected multiple times for each code. There were 35 unique codes and 1050 excerpts. 10% was 105 excerpts, which translated to exactly 3 rounds of sampling. (To see the specific excerpts attached to each ID, we created a "Round 1 Coding Excerpt Randomization" spreadsheet. This is also available upon request from the authors.)

The coding goal was not 100% agreement but rather to have sufficient overlap in coding to indicate an alignment in how the codes were being used and to ensure coding complementarity. Some divergence was expected and desirable as the coders have different backgrounds and interview experiences informing how they interpret the data. To ensure that both coders were in alignment, both coders reviewed patterns of code application with respect to three specific areas of interest and then compared them. The three areas of interest were: (1) scientific urgency, (2) structure of the conflict archaeology field, and (3) credibility and reliability in data/knowledge production. Based on the qualitative comparison, some adjustments were made to the data dictionary and coding decision rules prior to Round 2.

Round 2 coding was designed to be complementary coding rather than a full blind coding. This step relied on the coders having an IRR threshold score of at least 50%. Rather than re-reading and re-coding every interview, the coders reviewed each other's coding decisions, adding additional codes where needed and making comments where coding ideas diverged. We reviewed the Round 2 changes and reached agreement prior to analysis.

IRR equations and output are available upon request.