Strategic National Risk Assessment 2015 Risk Summary Sheet Instructions and Template

Strategic National Risk Assessment 2015
Technical Requirements

Draft v. 1.0
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FEMA

Note: This document will be revised as the 2015 SNRA project progresses, to address specific challenges encountered by data providers.

How to Write an SNRA Risk Summary Sheet

The findings of the 2015 SNRA will be summarized for public dissemination in a product similar to the seven-page overview of the first SNRA published in December 2011. As we will be revising the publicly disseminated findings of a scientific assessment which has not yet received peer review or public scrutiny, we must accomplish this task with great care and an exceptional degree of transparency.

In addition to the small summary of findings, we anticipate that **the full unclassified technical and explanatory documentation** necessary to validate and substantially reproduce the 2015 SNRA, and the 2011 SNRA upon which it is based **will be closely scrutinized** by responsible leadership, reviewers in the U.S. risk science and policy communities, and state, local, tribal, and territorial planners and emergency managers. This is for three reasons:

1) FEMA's Whole Community orientation;[1]
2) U.S. Government standards;
3) Quality control.

Requirements

The 2015 Strategic National Risk Assessment (SNRA) will be used as the risk-based analytic foundation of the National Preparedness Goal. Its findings will be disseminated to the public. For these reasons, the 2015 SNRA will follow FEMA and U.S. Government information quality standards for highly influential scientific assessments of risk to health, safety, or the environment which are used to inform public policy.[2,3,4,5,6,7,8] In the absence of the institutional capabilities for robust technical review which ensured a defensible assessment in 2011, the 2015 project will rely upon the peer and public review requirements of these standards as the primary means to ensure quality control for all material used to supplement, update, or revise the quantitative evidence base established by the 2011 SNRA.

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[1] Fugate, Craig (2013, April 1). Administrator's Intent. At http://www.fema.gov/media-library/assets/documents/31808?id=7252.

[2] Obama, Barack H. (2009, March 9). Scientific Integrity: Memorandum for the Heads of Executive Departments and Agencies. At http://www.whitehouse.gov/the-press-office/memorandum-heads-executive-departments-and-agencies-3-9-09.

[3] Office of Management and Budget, Office of Science and Technology Policy (2007, September 19). Updated Principles for Risk Analysis: Memorandum to the Executive Branch; at http://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/m07-24.pdf.

[4] U.S. Department of Homeland Security (2011, April). Risk Management Fundamentals: Homeland Security Risk Doctrine. At http://www.dhs.gov/risk-management-series#1.

[5] Information Quality Act. Section 515, Consolidated Appropriations Act for FY 2001 (Public Law 106-554). At http://www.fws.gov/informationquality/section515.html.

[6] Office of Management and Budget (2002, February 22). Guidelines for Ensuring the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies; Notice; Republication. *Federal Register* 67(36) 8452-8460. At http://www.whitehouse.gov/sites/default/files/omb/assets/omb/fedreg/reproducible2.pdf.

[7] FEMA Information Quality Standards. At http://www.fema.gov/information-quality-standards.

[8] Office of Management and Budget (2004, December 16). Final Information Quality Bulletin for Peer Review. At http://www.whitehouse.gov/sites/default/files/omb/assets/omb/fedreg/2005/011405_peer.pdf.

Data providers should expect that the risk summary sheets documenting the source data and analysis supporting their top level estimates will be scrutinized by the public, experts in the U.S. risk technical community, and state, local, tribal, and territorial planners and emergency managers. Risk summary sheets that are accepted and used to inform the publicly disseminated short findings summary will be reproduced as an update/corrigenda section alongside the SNRA 2011 Unclassified Documentation of Findings, as opposed to incorporating them into a revised form of the 200+ page circulation draft. This is to make clear the distinction between the two assessments, and allow reviewers to assess the analytic choices of the 2015 project team by comparing its data and documentation with the material it supplemented or replaced.[9,10]

U.S. Government risk assessment standards state that agencies should employ the best reasonably available scientific information to assess risks to health, safety, and the environment,[11] and that the depth or extent of the analysis should be commensurate with the nature and the significance of the decision.[12] In particular highly influential risk assessments, such as the SNRA, that are conducted to inform policy and doctrinal decisions on the scale of the National Preparedness System should favor quantitative methods where available data permits.[13]

Risk assessment is not a monolithic process or a single method. Because so many judgments must be based on limited information, it is critical that all reliable information be considered.[14] These include information derived from qualitative analysis. The methods used in a risk assessment should be broad enough to inform the range of policy decisions for risk reduction for which they are used, and should be selected for what best informs those decisions.[15,16]

However, if important judgments conflict with empirical data, that information should be discussed.[17] This document is provided to ensure the appropriate and transparent documentation of all SNRA 2015 data, particularly but not limited to quantitative data, that will add to or alter the currently existing quantitative evidence base of the SNRA.

Risk Summary Sheets

The quantitative evidence base of the 2011 SNRA is documented in threat and hazard-specific **Risk Summary Sheets**. Risk summary sheets contain known information about the frequency of the national-level threat or hazard occurring and its potential impacts if it were to occur. Risk summary sheets may leverage already produced risk and threat assessments, data from the

[9] This is to comply with USG information quality standards and basic standards of conduct. The integrity of the SNRA 2011 documentation will be ensured by review of the draft Unclassified Documentation of Findings by the original project team prior to public dissemination. OMB (2002) 8460 V.4; U.S. Department of Homeland Security (2011, January 11), DHS MD 10500: Research Misconduct; at http://www.dhs.gov/xlibrary/assets/foia/mgmt_directive_10500_research_misconduct.pdf.

[10] "The more important benefit of transparency is that the public will be able to assess how much an agency's analytic result hinges on the specific analytic choices made by the agency." OMB (2002) 8456 col.3.

[11] OMB (2007) 5.

[12] OMB (2007) 4.

[13] OMB (2007) 5-6. This guidance refers to influential risk assessments by the definition (source footnote 28) which encompasses the SNRA or alternative analysis cited as the basis for public policy decisions on the scale of the NPS. The wording is paraphrased because the source refers to risk 'characterizations' as a term of art, but which has a different meaning as used within DHS.

[14] OMB (2007) 3, 5, citing National Academies.

[15] OMB (2007) 5.

[16] DHS (2011) 20-21.

[17] OMB (2007) 8.

historical record, or model and simulation data, as appropriate. Details of the origins of these data are also incorporated into each sheet, so that the risk summary sheet is more than a collection of numbers.

All risk summary sheets added, updated, or revised as part of the 2015 SNRA will

1) Provide quantitative estimates of frequency, as occurrences/year, and at least one impact measure. Uncertainties will be explicitly represented for each measure as low, best, and high estimates.[18] Although the most appropriate methods for deriving frequency and impact estimates will vary between hazards, these estimates must have the same meaning as and be directly comparable to those in the current SNRA.[19]

2) Provide the unclassified data, analysis, and models used to derive the top level numbers from publicly accessible cited sources.[20]

3) Describe the analytic judgments used in the selection and analysis of the data, including assumptions, defaults, and uncertainties; the rationale for these judgments; and the influence of these judgments, and other limitations, upon the top level numbers.[21]

This information must be documented in sufficient detail that an independent reanalysis could be undertaken by a qualified member of the public.[22] Data providers should expect that the full documentation for the derivation of any estimates used to inform the updated SNRA findings and the revised National Preparedness Goal will be published along with the full unclassified SNRA 2011 documentation.[23]

Detail

Unless indicated otherwise, page references in the following refer to the draft Unclassified Documentation of Findings, distributed to you with this information packet.

Risk summary sheets will

1) **Provide quantitative estimates of frequency, as occurrences/year, and at least one impact measure. Uncertainties will be explicitly represented for each measure as low, best, and high estimates. Although the most appropriate methods for deriving frequency and impact estimates will vary between hazards, these estimates must have the same meaning and be directly comparable to those in the current SNRA.**

    a. Different methods of determining the top level estimates will vary by data and model availability between events. Some will be based upon historical incident data, some upon models, some upon subject matter expert estimates.

[18] OMB (2007) 11-12.

[19] OMB (2007) 5. Uniformity of meaning across measures is a threshold requirement for meaningful risk comparisons and prioritizations to be possible, *ibid.* p. 13 no. 1.

[20] OMB (2002) 8460, V.3.b.ii.B.i, ii.

[21] OMB (2007) 8.

[22] OMB (2002) 8460, V.3.b.ii.B.

[23] OMB (2007) 13. Although some estimates will not themselves be possible to publish because of classification or other security sensitive reasons, a full description of the methods used to derive these estimates will be. OMB (2002) 8460 V.3.b.ii.B. Example, draft SNRA Unclassified Documentation of Findings, adversarial events pp. 166-182 and appendices A-F, M.

b. The impact estimates themselves will have standardized meanings identical to the consequence[24] definitions of the 2011 SNRA (pp 66-111).

2) Provide the unclassified source data, analysis, and models used to derive the top level numbers, in sufficient detail for a qualified member of the public to independently replicate those numbers.

a. Example: Hurricane risk summary sheet, pp. 133-136. This includes citations to publicly available sources (footnotes and Bibliography); the final data sets used, Tables 2-3, p. 134; description of how the data sets were derived from the cited sources, pp. 133-134; and description of how the top level numbers in Table 1 were derived from those final data sets, pp. 133-134.

b. Example: Dam Failure risk summary sheet Table 1, p. 157. This data table replicates a portion of a data table in a public USG document for which the citation is provided (footnote 33 p. 156). However, including this table in the risk summary sheet allows for the top level numbers to be directly replicated, makes clear which data were used to derive those numbers, and ensures the data will be available when the link to the original reference changes or when the original reference becomes difficult to find.

c. Note: Wikipedia is not an acceptable source.

3) Describe the analytic judgments used in the selection and analysis of the raw data, including assumptions, defaults, and uncertainties; the rationale for these judgments; and the influence of these judgments, and other known limitations, on the top level numbers to the extent you are aware of them.

a. These are the caveats you would want a critical reader to see when they turn to your risk summary sheet to find out the sources for your numbers.

i. Don't think too hard on this one. Most or all of the caveats that are specific to your analysis will be obvious to you.

b. Examples:

- **Assumptions:** Radiological Substance Release Assumptions/Fatalities and Illnesses/Injuries, p. 158; Armed Assault Assumptions/Health & Safety and Economic Loss, p. 168.
- **Defaults:** Biological Food Contamination fatality and illness multipliers, Assumptions/Fatalities and Illnesses, p. 146; Earthquake injuries/fatalities multiplier (23.5), p. 123 col. 2 paragraph 2.
- **Uncertainties and limitations:** Interpretation of SNRA Results, pp 19-20; Significant Risks May Be Masked By Limited Data, page 24; Caveat box on bottom left corner of Figure 3, page 25; Psychological Distress appendix, Limitations section pp. 101-102.

[24] 'Impacts' as used in the 2015 SNRA correspond to the meaning of 'consequences' as used in the 2011 SNRA.

c. Any caveats, limitations, or uncertainties that are common to the 2011 SNRA as a whole (stated in the body or appendices of the main report) do not need to be discussed in detail, because your risk summary sheets will be published alongside the 2011 documentation (either bound in a single very large PDF, or in a clearly labeled 'volume 2'). Only discuss in detail those caveats, limitations, or uncertainties that are specific to the data and analysis that you are providing.

Threats and Hazards in the Current SNRA (Unclassified Documentation of Findings, Risk Summary Sheets)

Natural Hazards

Accidental/Technological Hazards

Adversarial Events

Risk Summary Sheet Walkthrough[25]

Description of the threat/hazard[26] which clearly defines its scope. If defined by a threshold ($100 million, $1 billion, one or more fatalities) this should be stated here, similar to SNRA 2011 event definitions (Table 2, p. 11[27]).

Data Summary

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities	A[28]	B[29]	C[30]
	Injuries and Illnesses	Number of Injuries or Illnesses	D[31]	E[32]	F[33]
Economic	Direct Economic Loss	U.S. Dollars	G[34]	H[35]	I[36]
Social	Social Displacement	People Displaced from Home for 2 or More Days	J[37]	K[38]	L[39]
Psychological	Psychological Distress	Calculated from other metrics	**Not needed (automatically calculated)**		
Environmental	Environmental Impact	Constructed scale	**Not needed (will be elicited from environmental SMEs)**		
LIKELIHOOD	Frequency of Events	Number of Events per Year	X[40]	Y[41]	Z[42]

The Data Summary table (referred to in this requirements document as 'the top-level data') is the basic requirement a risk summary sheet is intended to fulfil. The numbers are the output of the risk summary sheet.

The rest of the summary sheet explains how those numbers were calculated. It also typically includes nice things to know about the threat/hazard like qualitative descriptions, overview, narrative, potential mitigating factors… These add useful information, but they are not essential

[25] The actual risk summary sheet template is provided at the end of this document (page 29).

[26] SNRA 2015's current designation for what SNRA 2011 termed "National-level Event". Because this template adapts prior written materials, 'threat/hazard' is used interchangeably with 'event' in the following description.

[27] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

[28] Source for estimate A.
[29] Source for estimate B.
[30] Source for estimate C.
[31] Source for estimate D.
[32] Source for estimate E.
[33] Source for estimate F.
[34] Source for estimate G.
[35] Source for estimate H.
[36] Source for estimate I.
[37] Source for estimate J.
[38] Source for estimate K.
[39] Source for estimate L.
[40] Source for estimate X.
[41] Source for estimate Y.
[42] Source for estimate Z.

for documenting the one thing the risk summary sheet needs to produce: **numbers**. And the information needed to replicate them.

The risk summary sheet provides

1) Numbers in the Data Summary table;
2) Extended discussion of how you determined those numbers – sufficient documentation for anyone to replicate it from the sources you cite; and
3) Context.

General

- The best estimate frequency and the best estimate impacts **should match each other**, and match the definition of the threat or hazard at the top.
- Impacts represent the impact of a single event, not annualized impacts.
- However, with rare exceptions, a scenario cannot be used to represent a threat or hazard in the SNRA.
    - Example: A New Madrid magnitude 7.7 earthquake scenario, by itself, gives no information of the likelihood, relative likelihood, or impacts of earthquakes of other magnitudes or impacts in the United States as a whole.[43]
    - Example: Scenarios were initially considered for many SNRA 2011 events. However, with the exception of Pandemic and Animal Disease (pp. 130, 121) their specificity prevented a defensible generalization to national risk as a whole. Volcanoes and tsunamis are represented by scenarios in the 2011 SNRA (pp. 139, 141) but were treated only qualitatively, and are not depicted in the charts or discussed in the detailed findings.
    - Additional description of when and how scenarios can and cannot be used in the 2015 SNRA is provided on page 26 of this document.
- Uncertainties in frequency and each impact must be represented by low and high estimates, in addition to a best estimate.
    - These will be tied to the choice of event definition and thresholds.
    - Inclusion of the data table(s) or the distribution(s) from which the low/best/high estimates were obtained will permit the selection of other thresholds from the same data by other users.
- In general, estimates provided using methods of lower evidential value will not replace existing 2011 SNRA estimates obtained from methods of higher evidential value.

[43] In some circumstances modeled scenarios can be used to provide factors or multipliers to bridge data gaps (see p. 25 of this guide).

- The primary criterion of evidential value in the 2015 SNRA is transparency, to permit scrutiny and replication.
- Peer-reviewed and U.S. Government sources are strongly preferred over other sources (page 24 of this guide).
- Events which currently have no data, no useable data, or no publicly communicable data – cyber, space weather, tsunami, volcano, adversarial events, quantitative data gaps for other current SNRA events, and threats and hazards not currently present in the SNRA – offer greater latitude for adding data of 'lesser' evidential value than comparatively data-rich events like hurricanes.
- Unclassified, fully unrestricted data is preferred over classified and FOUO data.
- Additional description of evidential value for data in the 2015 SNRA is provided on page 25, this guide.

Event Background

The sort of description and qualitative discussion that would be found in a well-researched non-quantitative survey of hazards goes here.

- Example: Explosives Terrorism Attack Event Background (pp 180-181[44]). The discussion in this section is a lightly adapted version of a qualitative overview of explosives terrorism in a fact sheet for the public written by DHS and the National Academies.[45]
- Example: Space Weather Event Background (p 141). Because this risk summary sheet is largely qualitative analysis, much of the remaining content would also be suitable for incorporation into the Event Background section if defensible quantitative estimates could be determined in this SNRA cycle.

Assumptions

Frequency (pp 66-73[46])

When estimating frequencies, the key question is 'Frequency of *what*?'

The frequency must correlate with the impacts. In other words, if the frequency represents the annual average frequency of occurrence of a range of impacts for a particular hazard, the worst case or highest impact credible scenario in that range should not be represented as having that frequency.

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[44] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

[45] National Academies and U.S. Department of Homeland Security (2004), IED attack: improvised explosive devices. Retrieved from http://www.dhs.gov/ied-attack-fact-sheet. The FOUO-marked content it replaced also came from a qualitative comparative overview of terrorist attack types (Potential Terrorist Attack Methods: Joint Special Assessment", DHS & FBI, 23 April 2008).

[46] See footnote 44.

The best estimate frequency should correspond to the occurrence of an incident having equal or greater impacts than the minimum threshold of impact that is specified in the event definition. In most cases, the minimum threshold will correspond or be close to the low estimate of the impact measure defining the event.

- Example: The SNRA considered hurricanes causing $100 million or greater of direct economic damage within the United States.[47] Data for 78 hurricanes which exceeded this threshold in a forty year period were collected, and used as the data set from which the top level estimates of frequency, fatalities, direct economic loss, and injuries were calculated (Hurricanes, pp 138-139).
    - The best estimate frequency, the average frequency of occurrence of the set as a whole, was about two per year (p. 138; figure 3, p. 27). The fatality best estimate in the SNRA is 26 fatalities, the average of the set, because multiplication of the average fatalities by the best estimate (average) frequency gives the annualized risk of the set.
    - The reasonable worst case scenario in the set was Hurricane Katrina, causing 1,200 direct fatalities.[48] It would not be accurate to represent hurricanes in the comparative analysis of the SNRA as an event expected to cause 1,000-2,000 fatalities and which occurred on average two (1.9) times per year.
    - The risk of hurricanes causing fatalities on the scale of Katrina could be represented using the SNRA base data set, but it would be represented by the highest one incident of those 78 incidents, having a likelihood of 1/78 × 1.9 = 0.024/year or a return period of 40 years.

For all events, the SNRA assesses the frequency and impact of threats and hazards occurring within the next 3-5 years within the United States. For events with limited data, historical frequency of occurrence outside the U.S. may be used if 1) it is representative of U.S.-only frequencies after being normalized (adjusted for total U.S. risk exposure relative to the rest of the world), and 2) if the fraction for normalization is reasonably clear and uncontentious. The fraction of relative risk exposure will be different from one hazard to another. Some possibilities include:

[47] Adjusted to present-day dollar values and risk exposure.

[48] The data source used reported fatalities directly caused by the storm, as opposed to fatalities caused by indirect or subsequent events, which is why the figure of 1,200 fatalities is lower than other figures (1,833) frequently cited.

U.S. share, relative to world, of	Fraction
Population:	0.0444[49]
GDP:	0.224[50]
SCADA IP addresses exposed to the Internet:	0.282[51]
Military spending:	0.394[52]
Terrorist attacks, 1980-2012:	0.00356[53]
Terrorist attacks, 1991-2012:	0.00252[54]
Terrorist attacks, 2001-2012:	0.00126[55]
Agnostic fraction (midway between 0 and 100%):	0.50

Historical incidents occurring outside the United States may be used as proxy data if they, and their relative distribution, are judged to be reasonably representative of present U.S. conditions. Data providers need to be extremely careful when broadening a historical data pool to include non-U.S. examples.

- For example, the Armed Assault (p. 168) and Explosives Attack (p. 176) events leverage world historical terrorist attack data from the START Global Terrorism Database for fatality and injury information. This is based upon an assumption that the relative distribution of fatalities and injuries from attacks meeting the criteria described in these risk summary sheets is similar between the U.S. and the world, within the order of magnitude precision of the SNRA.

- Mass casualty natural disasters and industrial accidents from the entire world are generally not sufficiently representative of conditions in the present-day United States. In particular, world statistics are dominated by disasters in the developing world, which generally cause substantially higher fatalities and lower property damage in dollar figures than in the U.S.

[49] World Bank (2014). World population. At http://data.worldbank.org/indicator/SP.POP.TOTL/countries (retrieved 12 October 2014).

[50] World Bank (2014). Gross Domestic Product [GDP] (current US$). At http://data.worldbank.org/indicator/NY.GDP.MKTP.CD (retrieved 12 October 2014).

[51] Infracritical (2014, October 1). Project SHINE Findings Report. Project SHINE (Shodan Intelligence Extraction). At http://www.slideshare.net/BobRadvanovsky/project-shine-findings-report-dated-1oct2014 (retrieved 11 October 2014).

[52] Table 'Constant (2011) USD', column '2012', and table 'Regional totals', column '2012', 'World total (consistent data release)'. Stockholm International Peace Institute [SIPRI] (2014, June 27). SIPRI Military Expenditure Database [data file] [2014 database, version 2]. At http://www.sipri.org/research/armaments/milex/milex_database (retrieved 8 October 2014).

[53] Counts of U.S. (including Puerto Rico and U.S. Virgin Islands) terrorist attacks causing fatality or injury to persons other than the attacker, no other filters or aggregation applied, relative to all world attacks. Counts include 1993, for which START GTD includes only partial coverage. Counts using the online GTD interface will differ somewhat due to these differences, as will counts pulling data with other combinations of parameters. START Global Terrorism Database (GTD) (2013, December 13). National Consortium for the Study of Terrorism and Responses to Terrorism (START). Global Terrorism Database. Primary database 'gtd_201312dist.zip'; 1993 file 'gtd1993_1213dist.xlsx'; correction file (7 April 2014) 'nhostkid supplement.xlsx' [Data files]. From http://www.start.umd.edu/gtd (retrieved 26 December 2013).

[54] Ibid.

[55] Ibid.

Any use of historical data requires the assumption that the observation period and location are representative of likely U.S. conditions in the next 3-5 years. The same judgments noted above that are needed before using historical data from outside the United States are also necessary before using historical U.S. data from time periods which may not be generalizable – in terms of the frequency and impacts of the hazard being studied – to the present day.

Frequency should be provided in units of # of events per year (e.g., 1 event per 10 years or 0.1 events per year). The best estimate of frequency should correspond to a best estimate of how often the event, as defined, occurs. The high estimate of frequency should represent uncertainty regarding how frequently the event, as defined, occurs. The low estimate of frequency should represent uncertainty regarding how infrequently the event, as defined, occurs.

Low, best, and high estimates of frequency can be determined in different ways, depending on whether they are derived from historical incident data, a modeled distribution, direct subject matter expert judgment, or subject matter expert judgments taken from the literature.

Historical Incident Data

- The best estimate of frequency represents the historical average frequency of recurrence of incidents over a set time period.
    - Example: There were 5 events over a 20 year historical record, so the best estimate of frequency is the average number of events per year, 0.25 events per year or 1 per 4 years.
- The high estimate of frequency should be the maximum number of events occurring in a single year.[56]
    - If no more than one incident occurs in any one year, the high estimate should be the inverse of the shortest interarrival time in the data set (the shortest number of years that two incidents are spaced apart).
- The low estimate of frequency should be calculated from the inverse of the longest interarrival time – the longest gap in years between any two incidents in the data set.
    - If every year in the data set is represented by one or more incidents, then the low frequency estimate is the smallest number of incidents occurring in any one year.
        - If every year in the time period studied has at least one incident, that may be an indication that the minimum impact threshold defining its scope may be too low to capture the *exceptional* incidents of a catastrophic level which the SNRA is intended to capture.

[56] Frequency uncertainties in the SNRA are intended to capture our limited knowledge of the frequency of the threats and hazards that the Nation will actually experience, and to capture that uncertainty from a preparedness perspective. Although a natural process with a constant underlying frequency will naturally result in long gaps between events and many events in one year (Poisson clustering), it is that variability of occurrence that communities and emergency responders will actually experience and need to be prepared for, as opposed to the long-term statistical average.

Modeled Frequency Distributions

- The best estimate of frequency should typically correspond to the mean of the distribution.
- The high estimate of frequency should typically be represented by the 95th percentile of the frequency distribution.
- The low estimate of frequency should typically be represented by the 5th percentile.

Subject Matter Expert Judgment

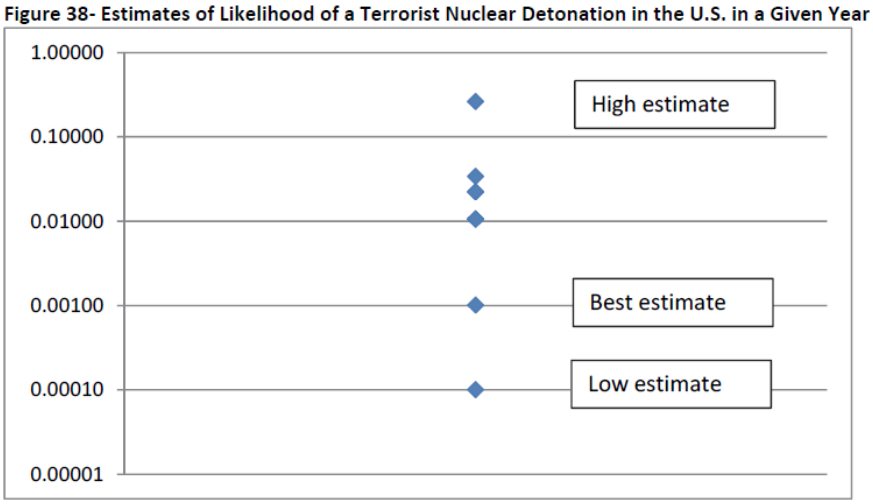
To have the same meaning as best estimate likelihoods for other hazards in the SNRA, the best estimate frequency for a hazard should represent the expected average frequency of occurrence of all incidents of that hazard falling within the scope defined by its thresholds and other measures.

- This means that the best estimate frequency should represent the estimated frequency of an incident having impacts corresponding to the low measures of impact, or greater, to occur in the U.S.
- For example, the best estimate frequency for the Animal Disease event of 0.1/year means that an animal disease outbreak in the U.S. having direct economic impacts of $2.3 billion or greater (Data Summary, p. 121) is estimated to have an approximately 10% chance of occurring in any given year. This is made explicit in the risk summary sheet (Additional Relevant Information, p. 122, describing the examples of outbreaks in other countries in terms of their economic impacts and stating that the SNRA best estimate frequency is the estimated likelihood of an incident of similar or greater severity occurring in the U.S.).
- Subject matter expert (SME) judgment is best suited for hazards such as the SNRA 2011 Animal Disease event, where the occurrence of a hazard is a rare but well-defined event which can be expected to surpass at least some minimum level of impacts, given occurrence. In principle, such hazards define their own impact thresholds (which is why the Animal Disease definition does not need to specify an explicit numerical threshold).
    - However, it can also be used for hazards with continuous impacts, such as floods or non-nuclear terrorist attacks which can have impacts as low as zero given occurrence – so long as the SME explicitly specifies that the best estimate frequency is the expected frequency of occurrence of incidents exceeding the minimum threshold of the event definition.
- The low frequency estimate may represent fundamental (epistemic) uncertainty in the return period of the event as in the Animal Disease event (Additional Relevant Information, p. 122), an estimated or observed variability of recurrence for a hazard having a known return period, or a mixture of both (Pandemic low and high frequencies, derived from historical observation but representing epistemic uncertainty, pp. 130-132).

- The high frequency estimate may also represent fundamental (epistemic) uncertainty in return period, estimated or observed variability of recurrence, or a mixture of both.

No estimate, including low estimates, can have a frequency or probability of zero since this implies certainty regarding an uncertain event. Likewise no estimate, including high estimates, can have a probability of 100% since this also implies certainty and also corresponds to a frequency that is infinite.

Figure 1: Example: Frequency Estimates from the Literature[57]



Estimates from the Literature

Multiple point estimates from the literature – which for rare events or events without historical precedent, may come from non-peer reviewed literature (with caution) – may be combined to represent the range of expert opinion (figure 1).[58] For numerous point estimates spread over at least an order of magnitude (a power of ten), the uncertainty will represent the range of expert opinion. The low and high estimates will ordinarily represent the low and high of the set of point estimates.

- For estimates provided by an analyst who is not him/herself a content area expert, the transparency of this method may make it a more defensible approach than other options. If the 'raw data' are taken from public sources, given a description of how it was derived the resulting estimate can be replicated from the data and the data themselves can be scrutinized.

[57] Lundberg (2013) p. 195. Lundberg, Russell (2013, September). Comparing Homeland Security Risks Using a Deliberative Risk Ranking Methodology. Dissertation, RAND Pardee Graduate School. At http://www.rand.org/pubs/rgs_dissertations/RGSD319.html (retrieved October 2013).

[58] Examples of this approach done well may be found in Lundberg (2013), from which figures 1 and 2 in this document are reproduced. Figures 38 and 40 pp 195, 198, representing the spread among judgments found in the literature for the frequency (multiple estimates) and consequent fatalities (multiple modeled scenarios) for a terrorist nuclear attack in the U.S. Lundberg, Russell (2013, September). Comparing Homeland Security Risks Using a Deliberative Risk Ranking Methodology. Dissertation, RAND Pardee Graduate School. At http://www.rand.org/pubs/rgs_dissertations/RGSD319.html (retrieved October 2013).

- A major limitation of this approach is that the resulting estimates can be strongly skewed by availability or selection bias. That is, the analyst's resulting estimate depends upon what s/he happens to find.
    - However, a large number of independent estimates may have value in aggregation by using their average, geometric average, or median for a best estimate ('wisdom of the crowds').
- A second limitation is that 'expert' estimates of frequency (and impact) are often skewed high. For a rare event with too little information or mainstream political interest for many rigorous or objective studies to have been conducted, the experts who shout the loudest often are those who believe the risk is greater than commonly understood.
    - A corollary to this is the 'Cassandra effect': Probability judgments can be biased high by the magnitude of judged impact – the vividness of the impacts should an event occur infects judgment of probability as well. Frustration can unconsciously increase the subjective judgment of probability of an especially catastrophic hypothetical event, the longer the advocates for addressing the danger of a risk unaddressed by society spend 'in the wilderness'.
- A third limitation is 'incestuous data':[59] multiple sources cite what is ultimately the same estimate, sometimes circularly.[60] The evidential value of this estimate could be considered to be proportional to the number of times it is cited, because each writer who cites it goes on the record as endorsing it themselves. However, the writers repeating the estimate are usually not subject matter experts in the field, and the multiple citation of the estimate may be driven by the effect of it being a number in an area of contention without many numbers.
- Use of multiple point estimates from the literature for frequency (or modeled scenarios for impact) was NOT considered to have sufficient evidential value to be used in the 2011 SNRA. Potential use of this method for some provisional estimates of the 2015 SNRA represents a departure from the 2011 standard.[61]

Because likelihood and impacts are essentially paired in the SNRA, general notes on impacts will be given next.

Impacts (General)

The most important thing is to make sure the impacts represent the impacts of a single event, as defined, given that it occurs.

[59] Sandia National Laboratories (2003, September). Page 4-15, Handbook of Parameter Estimation for Probabilistic Risk Assessment. NUREG/CR-6823, SAND2003-3348P, for U.S. Nuclear Regulatory Commission: at http://pbadupws.nrc.gov/docs/ML0329/ML032900131.pdf (retrieved 5 February 2014).

[60] CENTRA Technologies, for DHS Office of Risk Management & Analysis (2011, May). Geomagnetic storms: an evaluation of risks and risk assessments. Risk Management Issue Brief, DHS: at http://www.dhs.gov/xlibrary/assets/rma-geomagnetic-storms.pdf (retrieved 2 February 2015).

[61] This is one reason why 2015 results will be documented in accompaniment to the results of the original 2011 SNRA, rather than replacing them in the documentation.

Uncertainty and variability are represented by low and high estimates, in addition to a best estimate (pp. 114-117).

As with frequency, any use of historical data from other countries or time periods requires the assumption that the observation period and location are representative of likely U.S. conditions in the next 3-5 years. A burst dam in China or a typhoon in Bangladesh may cause hundreds of thousands of fatalities. It is possible that an accidental or natural disaster in the present-day United States could cause fatalities on this scale, but it is far less likely.

Best estimate impacts have two meanings in the SNRA depending on whether they originate in a) historical incident data or modeled distributions, or b) subject matter expert estimates.

Historical Incident Data

- The best estimate should be interpreted as, given that an event occurs that meets the definition (or threshold), *on average*, what are the impacts?
- The high estimate should be interpreted as the maximum impacts per event, from the historical record.
- The low estimate should be the lowest impacts per event, from the historical record.
- Examples: Wildfire (pp. 144-145), Biological Food Contamination (pp. 146-147).
- Examples: Fatalities and injuries for Aircraft as a Weapon (pp. 166-167), Armed Assault (pp. 168-169), Explosives Attack (pp 176-178). Although the low, best, and high fatality and injury estimates are U//FOUO, they were derived from public data.

Modeled Distributions

- The best estimate should be interpreted as, given that an event occurs that meets the definition (or threshold), *on average*, what are the impacts?
    - This has the same meaning as it does for historical incident data. However, it is calculated differently, as a weighted average (p. 113).
- The high estimate should be the 95th percentile of impacts.
    - One way of relating this to historical data based SNRA analysis is that the maximum impacts from a historical record of 20-100 years will also roughly correlate to a 95th percentile. (That math is not exact, but it helps conceptually.)
- The low estimate should be the 5th percentile of impacts.
- Example: [Accidental] Radiological Substance Release, pp. 158-160.
- Most examples of modeled distributions in the 2011 SNRA are the CBRN events which leveraged data from the Integrated CBRN Terrorism Risk Assessment (ITRA).[62]

[62] DHS Directorate of Science & Technology (2011), Integrated CBRN Terrorism Risk Assessment (reference is SECRET//NOFORN).

However, the ITRA and its component assessments adapted a probabilistic risk assessment (PRA) method originally developed for the nuclear power industry and other complex technological systems, so it is possible that additional accidental hazards in the unclassified SNRA could be modeled in this way.

The 5th/95th percentiles are conventional choices for capturing a standardized confidence or credible interval (90% central interval) from a modeled distribution. However, their selection for reporting purposes in an assessment such as the SNRA is ultimately a normative and policy decision, and different decision-makers may be interested in different percentile levels. Additionally, these percentiles are conditional on the choice of lower threshold of impact or impact that is used to define the scope of the event in the first place (pp 114-117).

To allow for current and future flexibility to investigate different thresholds and percentiles, please report the underlying distribution in sufficiently granular data to do so (half-order of magnitude bins have been used by the SNRA project in the past, but more granular data are welcome). This will allow different users in different contexts to select different thresholds and percentiles than those that will be reported in the static charts and top level data tables of the 2015 SNRA.

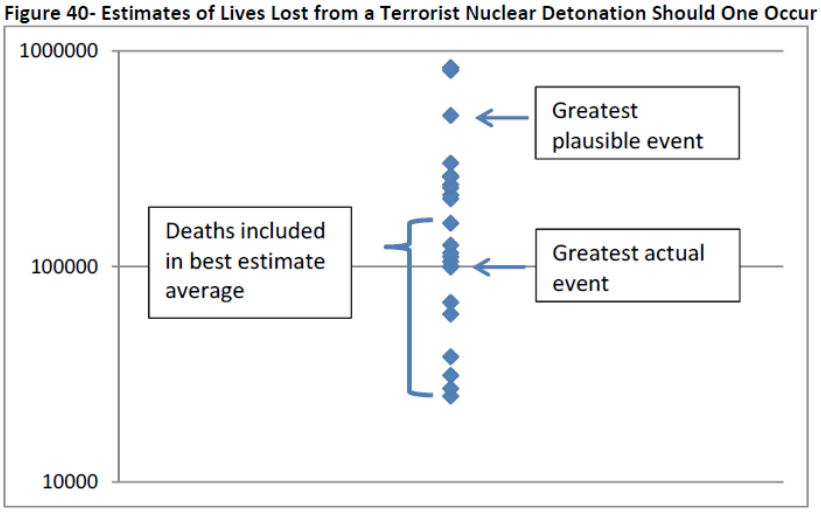
Subject Matter Expert Judgment

- The best estimate may, in principle, be provided as meaning an average. However, it is generally difficult for people to provide an accurate average, even with the aid of sophisticated elicitation techniques. People are usually much more accurate in estimating percentiles, in particular the median (50th percentile), or the mode (most likely value).
    - Subject matter experts should estimate:
        - Given event occurrence, what would be the most likely outcome (mode) in terms of the given impact measure?
        - Alternatively, given event occurrence, what would be the 'middle of the range' outcome (median)?
- The low estimate should be the *de facto* threshold of the event. Given event occurrence (the best estimate likelihood is the best estimate of this), what would be the lowest impacts possible/reasonably likely to occur?
- The high estimate should be the "reasonable worst case scenario".

Estimates from the Literature

The same notes apply as for frequency (figure 2).

Figure 2: Example: Fatality Estimates from the Literature[63]



Health and Safety (pp 74-87[64])

Fatalities are fairly straightforward. They are usually the most definite or unambiguous impact measure, and are frequently the measure chosen for visual depictions of risk. They are also usually the easiest statistic or estimate to find.

Injuries and illnesses can be trickier. They are not always as easy to find as fatalities, and the lack of a definite natural threshold dividing "ill" or "injured" from "well" makes data difficult to compare across data sources. Even those data sources with a definition or threshold for the injuries or illnesses they count are often very incomplete.

The SNRA lumps all injuries and illnesses together. This is a major limitation, because by mixing injuries of all levels of severity it makes comparisons across hazards difficult. However, it can be useful for estimating hospital surge needs. A biological, chemical, or radiological terrorist attack may cause thousands of 'walking well' to flood area hospitals, while an earthquake can cause thousands of serious injuries requiring medical care. Both burden hospitals with thousands of patients needing triage and evaluation in the hours following an emergency.

If you *do* have a breakdown of injuries or illnesses by any measure of severity (in particular, numbers hospitalized) please provide it because that will help us in the future when we improve this metric. If you are not using a standard measure of some sort (e.g. having a definition that is posted somewhere), please provide your definition of severity level so we can translate it into other standard measures in the future.

If you are not providing a breakdown by severity level, please provide a definition of threshold severity for the illnesses and/or injuries you are including in your count.[65]

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[63] Lundberg (2013) p. 198.

[64] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

[65] Example: Footnote 7, Pandemic risk summary sheet (p. 134).

Injuries and illnesses, being a less rigorous measure in the current SNRA, can be estimated using a proxy multiplier (proportional to fatalities) if no good data source is available. Such a multiplier should come from one or more historical data points, or modeled scenarios, which are judged to be reasonably representative of other catastrophic occurrences of that hazard.

Direct Economic Impact (pp 88-95[66])

Economic impacts are frequently the most challenging measure in the SNRA for external analysts to assess.

Economic costs are calculated and represented in the literature in all sorts of incomparable ways. The most significant thing to avoid is:

Do not include Value of Statistical Life (VSL), lifetime lost wages or income, or other dollar-valued impact equivalencies in your economic estimates.

- VSL values differ from study to study, agency to agency, writer to writer. FEMA Benefit-Cost Analysis uses one measure, DHS is attempting to standardize another across the Department, while other agencies use measures of their own. Including them in reported direct economic impact numbers makes the numbers impossible to compare across studies and hazards, which undermines the purpose of conducting a comparative analysis in the first place.
- They create double counting – but only for some hazards and not others. Their influence on the economic numbers compared across hazards is invisible to the final reader.
- They conveniently align fatality and economic costs between disasters by padding economic costs with a portion proportional to fatalities. This obscures the real variation in direct economic impact between and within hazards, removing useful information.
- They impose a value judgment and an equivalency between impacts which belongs to the end user of the assessment, not the analyst. This is especially critical for a national risk assessment, which must make comparative judgments of national risk across many contexts for many decision-makers and many stakeholders having a diversity of values.

Please scrutinize all economic estimates obtained from literature sources to ensure that all economic figures attached to fatalities are removed.

The SNRA does report a cost per fatality of $42,500 for one year lost spending.[67] However, we can apply this on our end.

[66] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

[67] This figure originated from the economic model of the 2008 Bioterrorism Risk Assessment (BTRA 2008), which used a uniform distribution over the $35,000-$50,000 median family income bracket as defined by U.S. Government economic statistics. As the mean of a uniform interval is its midpoint and the tails of the distribution become insignificant for disasters causing more than a handful of fatalities, the midpoint of $42,500 was adopted as a point estimate for the 2011 SNRA. The 2008 BTRA and many events in the 2011 SNRA also apply a figure of $6,000 for funeral spending, but as this adjustment is inconsistently applied across events and rarely makes a significant difference on the order of magnitude precision of the SNRA, it may be neglected for the purposes of the 2015 iteration. DHS Directorate of Science and Technology (S&T) Bioterrorism Risk Assessment 2008, Appendix E2.7: Economic Consequences, p. E2.7-34. (Appendix reference is UNCLASSIFIED//FOR OFFICIAL USE ONLY; Extracted information is UNCLASSIFIED.)

Direct economic losses as currently defined by the SNRA include decontamination, disposal, and physical destruction costs, lost spending due to fatalities, medical costs, and business interruptions.

- Indirect economic impacts include costs incurred by the suppliers and vendors in the associated expenditure sectors for the industries impacted by the direct costs.
- Induced costs include those incurred due to reduced spending by households with members employed in any of the directly or indirectly affected industries.
    - Induced costs can also include substitution effects or likely transfers of economic activity from one set of sectors to another set, such as avoidance of air or other travel or altered transportation mode preferences to other sectors following an attack on the commercial air transport sector.

The current SNRA methodology compares only direct costs. Information on indirect and induced costs are welcome as they will be needed to improve the SNRA in future iterations, but direct costs are what the 2015 SNRA needs. As defined in the SNRA, direct costs include

Decontamination, Disposal, and Physical Destruction (DDP):

- Property damage (including building contents)
    - Including utilities, roads, other government sector
- Decontamination costs (for buildings not demolished)
- Disposal costs for debris
- Crop damage

Business Interruption:

- Lost sales, wages, other business costs directly caused by the event
- Example: 2013 Boston Marathon bombing. The $10 million lost business costs for the 500 businesses within the 12 block immediate impact area which was restricted for approximately one week of investigation would be direct business interruption costs.[68] The lost economic activity from the 1-2 day citywide lockdown would not be included.
- Business interruption costs may be substantially reduced by the increased use of telework in recent years.

Medical Costs:

- The first SNRA did not establish a consistent definition for medical costs across hazards. However, fully reporting your sources and assumptions, including any injury severity level assumptions or data for the illnesses or injuries you report, will allow a more consistent harmonization in the future.

[68] Luna, Taryn (2013, April 27). Back Bay businesses affected by bombings are eligible for federal loans. Boston Globe [Boston.com]: at http://www.boston.com/business/news/2013/04/26/back-bay-businesses-affected-bombings-are-eligible-for-federal-loans/BRSPuC0GboxQWAACCycGgI/story.html (retrieved 7 September 2014).

- A good source for cost numbers are statistics provided by the HHS Agency for Healthcare Research and Quality (AHRQ). Please ensure that the counts to which you apply any cost estimates correspond to the type of estimate (e.g. apply inpatient costs only to numbers hospitalized, not all injuries/illnesses).[69]

One Year Lost Spending from Fatalities:

- $42,500 per fatality.[70]

Please err on the side of reporting more detail rather than less. This will enable harmonization of costs in the present and future iterations of the SNRA. Additional information on potentially finer-grained measures of economic impact – jobs lost, homes destroyed, critical infrastructure damage – will also be valuable for expanding the impact measures in future iterations of the SNRA, so please provide them as well if they are readily available (but don't waste effort obtaining them if they aren't).

In many cases, it will be clear that one or more components of the SNRA direct economic measure will dominate other components to an extent that they can be neglected, within the order of magnitude precision of the SNRA. For example, business interruption costs for the Wildfire event were judged to likely be insignificant in comparison with property and crop damage (Economic Loss, pp. 148-149). **All such assumptions must be explicitly stated.**

Please specify the year of the dollar value you are providing.

Social Displacement (pp 96-102[71])

The SNRA measure of social displacement is the number of people who are forced to leave their home for a period of two days or longer. This does not include hospital stays, as that would represent double counting with the injury/illness measure.

The measure of social displacement used in the SNRA does not capture the significant differences between short-term evacuation and long-term permanent relocation, which is a limitation of the current analysis. Like injuries and illnesses, the SNRA displacement metric rolls up multiple levels into one metric. If you can provide additional detail on people made homeless, homes destroyed, or different evacuation durations, these may be very helpful for the 2015 National Preparedness Goal revision and will be very helpful for future iterations of the SNRA when this metric is revisited.

Displacement numbers may be provided by literature data sources. For some events, the USAID funded international disaster database EM-DAT may provide useful displacement numbers. If a judgment can be made that numbers of people displaced are likely to be far greater than numbers

[69] Agency for Healthcare Research and Quality, U.S. Department of Health and Human Services. H-CUPnet: at http://hcupnet.ahrq.gov/ (retrieved 5 February 2015). Determination of

[70] See note 67.

[71] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

of people injured (this will be true for some threats/hazards but not for others), EM-DAT's 'Total Affected' measure may be used as a reasonable estimate for social displacement.[72]

Please attempt to provide some estimate (low, best, and high) for displaced (2+ days) persons, however rough. This may include a judgment that displacement is expected to be minimal or zero for most incidents of the threat or hazard for which you are providing data, if that judgment seems reasonable. Displacement estimates, along with fatality and injury/illness numbers, are needed to calculate the psychological distress metric of the SNRA.

Psychological Distress (pp 103-109[73])

The SNRA psychological distress measure does not need to be separately estimated by data providers, since it is automatically calculated from the fatalities, injury/illnesses, and persons displaced according to a formula (p. 105). The formula includes a multiplicative factor that was elicited from SMEs for the events in the first SNRA. However, as the factor ranges only from 1.0 to 1.3, the results are not very sensitive to an inappropriate selection.

The set of factors elicited for the 23 events of the first SNRA follow a regular pattern, which in lieu of a new elicitation we will likely apply to new events as provisional estimates pending future review by subject matter experts.

Provisional Assignment of Event Familiarity Factors for Candidate National-level Events

Event Characteristic		EFF (C_{EF})
	CBRN terrorist attacks	1.3
	Conventional terrorist attacks other than gun attacks (Explosives, Aircraft as a Weapon)	1.2
	Conventional terrorist attacks primarily using firearms (Armed Assault)	1.1
	Unintentional disasters of human origin, involving toxic substances evoking special dread, such as poison gas (Chemical Substance Release, Radiological Substance Release)	1.1
	Other unintentional disasters of human origin (Biological Food Contamination, Dam Failure)	1.0
	Earthquakes	1.1
	All other natural hazards, including disease	1.0

[72] Centre for Research on the Epidemiology of Disasters (2011). EM-DAT: The OFDA/CRED International Disaster Database. [Data file]. Brussels: Université Catholique de Louvain. Available from http://www.emdat.be.

[73] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

Environmental Impact (pp 110-114[74])

Environmental estimates will likely be elicited for all events as a group from a panel of environmental SMEs, similar to the first SNRA.

For the purposes of the SNRA, environmental risk is defined as the potential for adverse effects on living organisms associated with pollution of the environment by effluents, emissions, wastes, or accidental chemical releases; energy use; or the depletion of natural resources.[75]

Environmental effects within urban areas and all human health effects are not included within the scope of this environmental impact measure, because these impacts are already addressed separately in the other impact measures for the SNRA.

[74] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

[75] This definition is aligned with the EPA's definition of environmental risk. Accessed at: http://www.epa.gov/OCEPAterms/eterms.html.

Additional Notes

Requirements for Use of Data and Experts in the SNRA

The 2015 SNRA is likely to be one of FEMA's most scrutinized analytic products. More importantly, it is going to be used to drive and support important decisions related to national preparedness. To this end, given the extreme timelines and data-gathering requirements, great care must be taken with all information (both quantitative and qualitative) used in, and output from, the SNRA.

To meet the standards for both policy and scientific defensibility, the SNRA must rely on credible data and expert judgment for all quantitative information. The SNRA will rely on the best available estimates of frequency and impact from peer-reviewed literature and/or other government assessments. Risk summary sheets will contain comparable and credible data sources which meet the following criteria:

1. Relevance (i.e. the source must provide direct and unambiguous support for any quantitative and qualitative characterizations);

2. Technical expertise and reputation of the author (i.e., the author is a subject matter expert according to the criteria below, e.g. education, training, published research, awards, recognition, and leadership of relevant societies);

3. Evidence of peer-review (i.e. the publisher verifies the accuracy of the information by checking the citations, references, footnotes, and bibliography); and

4. Timeliness (i.e. the information is sufficiently recent that it is not outdated and unsuitable for use).

Some threat/hazard areas are characterized by deep uncertainty and strong divergence of opinion between subject matter experts (SMEs), such that use of subject matter expertise may not narrow or shift the range of opinion elicited from or provided by non-experts. These divergences can equally affect models dependent on SME input to fill key knowledge gaps. In these instances, a collection of multiple estimates (even point estimates) from a diversity of sources may provide more informational value than a single model or expert.[76]

Where sufficient and appropriate data sources are not available in the literature, the SNRA will accept estimates of frequency and impact from contributing partners that are elicited by defensible standards and defensible selection of subject matter experts. Effective and defensible expert elicitation requires criteria for the identification of, and access to, a sufficient number of appropriate specialists and generalists who can provide meaningful expertise. The criteria for subject matter expertise are as follows:

1. Strength of technical knowledge in the event type domain or impact category (i.e., education, training, and published research);

[76] Use of multiple point estimates from the literature for frequency (or modeled scenarios for consequence) was NOT considered to have sufficient evidential value to be used in the 2011 SNRA, for which the majority of the other text of this section was originally written. Potential use of this method for some provisional estimates of the 2015 SNRA represents a significant departure from the 2011 standard.

2. Work experience in the event type domain or impact category (e.g. years of experience working in relevant federal agencies and/or academic departments);

3. Reputation in the event type domain or impact category (e.g. demonstrated by awards, recognition, and leadership of relevant societies);

4. Ability to provide quantitative and/or qualitative analysis or judgment on the frequencies and/or impacts of the event (threat/hazard) the providing agency is providing data to replace or add.

To meet the standards for both policy and scientific defensibility, data and expert judgment (numeric and non-numeric) will only be used in the SNRA for those events that meet the criteria above. Events for which neither credible data nor credible expertise exist that meet the criteria above cannot be characterized in the SNRA, and will be handled in some other fashion to meet PPD-8 requirements.

Evidential Value

In general, estimates provided using methods of lower evidential value will not replace existing 2011 SNRA estimates obtained from methods of higher evidential value.

- The primary criterion of evidential value in the 2015 SNRA is transparency, to enable public scrutiny, communication with the primary stakeholders of the SNRA and the National Preparedness System, and effective peer review.
    - Subject matter expert estimates will be given equal evidential value to the outputs of models, if the models cannot be scrutinized and replicated by Federal analysts or other peer reviewers. Both are essentially 'black box' estimates for which the derivation can be traced back only to the point where it came out of the expert's brain or the model.
        - This is primarily an issue with proprietary models.[77]
        - However, estimates and factors derived from proprietary models can be used as corroborating or supporting evidence for estimates derived by transparent methods. Additionally, estimates from multiple <u>independent</u> proprietary models may be used in combination as a basis for primary estimates provisionally used in the 2015 SNRA.
    - Unclassified, non-FOUO estimates will be given preference over classified and FOUO estimates, unless the latter estimates have a clear record of substantially stronger evidential value as documented by the public reports of independent

[77] "National policy should not be based on methods not fully available to the government." JASONS, for DHS Directorate of Science & Technology (2011, November). Impacts of Severe Space Weather on The Electric Grid, pp. 2, 7. MITRE report JSR-11-320: at http://www.fas.org/irp/agency/dod/jason/spaceweather.pdf (retrieved June 2012).

external peer reviews[78] and meet the substantial reproducibility standards of U.S. information quality guidelines for influential scientific assessments.[79]

- This means comparable evidential value sufficient to answer the question being asked. In the case of the 2015 SNRA that means low/best/high triplets for frequency and measures of impact.[80]

- The 2015 SNRA will use the best available data and analysis to inform its estimates.[81] This means that there is more latitude for adding new or replacement estimates to events which currently have no data, or no data which can be used for the primary functions of the SNRA.
  - For events which currently have no useable paired frequency and impact data (cyber, space weather, tsunami, volcano) or data that can be communicated to and validated by public stakeholders (CBRN events and adversarial event frequencies), data obtained by any method which can be traced back to its origin and validated in a transparent fashion is very likely to be useable – as proxy estimates for stakeholder communication, at a minimum[82] – in the 2015 SNRA. Filling these data gaps will increase the utility of the 2015 SNRA for informing the revision of the National Preparedness Goal.

Regardless of the degree of uncertainty we may have about them as analysts and data providers, likelihood and likely impact judgments will be applied to each and every event in the SNRA. If the SNRA does not provide them, the decision-makers using the SNRA will.

Likelihood and impact judgments in the SNRA are made explicit in a way that stakeholders, political leadership, and technical reviewers can scrutinize, and which are expressed in quantitative terms having the same, unambiguous meaning for all audiences.[83] Where the SNRA leaves gaps in key variables which it is too cautious to assess, the decision-makers who use the SNRA will base the decisions which they do not have an option not to make upon their own implicit and unarticulated risk judgments in a non-transparent, undocumented, and ambiguous way.

[78] OMB (2002) 8459-60, V.3.b.ii. Agency-sponsored peer reviews that are employed to help satisfy the objectivity standard of information quality for data and analysis which cannot itself be directly disclosed to the public are to be conducted in "an open and rigorous manner." OMB (2002) 8459-60, V.3.b.i.

[79] OMB (2002) 8456-57.

[80] Classified risk analyses are expected to be used to inform the more detailed information needs of discussions informing Prevention and Protection Core Capabilities, in particular setting quantitative targets, as part of the larger Goal revision effort. These will be documented in a classified annex to the 2015 SNRA.

[81] OMB (2007) 9.

[82] As used in the terrorism risk assessment method of the RAMCAP J-100 standard. Pp 103-110, American Society of Mechanical Engineers (ASME) (2011, December 20). A regional resilience/security analysis process for the Nation's critical infrastructure systems. ASME Innovative Technologies Institute: at http://www.wbdg.org/pdfs/asme_resilience_infrastructure_dec2011.pdf (checked 6 February 2015).

[83] 'Quantitative risk assessment methodology'. Risk Steering Committee (2010, September). DHS Risk Lexicon, 2010 edition. At http://www.dhs.gov/xlibrary/assets/dhs-risk-lexicon-2010.pdf.

Scenarios

- With rare exceptions, a scenario cannot be used to represent a threat or hazard in the SNRA.
    - Example: A New Madrid magnitude 7.7 earthquake scenario, by itself, gives no information of the likelihood, relative likelihood, or impacts of earthquakes of other magnitudes or impacts in the United States as a whole.[84]
    - Example: Scenarios were initially considered for nearly all SNRA events. However, with the exception of Pandemic and Animal Disease (pp. 130, 121[85]) their specificity prevented a defensible generalization to national risk as a whole. Volcanoes and tsunamis also represented by scenarios in the 2011 SNRA (pp. 139, 141) were treated only qualitatively, and are not depicted in the charts or discussed in the detailed findings.
- If the risk is dominated by a single, fairly compact and generic scenario, that scenario can represent the best estimate of impacts.
    - Example 1: Human Pandemic Outbreak (pp 130-132). The pandemic scenario of 25% attack rate (25% of the U.S. population becoming ill) is inherently generic enough to be representative of influenza pandemics in the U.S. in general. It is not tied to a specific location, attacker, weather pattern, or time of day.
        - Note that "ill" is specifically defined, footnote 7 p. 130. This is very important because it defines the scope of the event.
        - The one way it is not generic is its magnitude. It was chosen as a reasonably most likely scenario by subject matter expert judgment.[86]
    - Example 2: Animal Disease Outbreak (pp. 121-122). This was based upon a specific modeled scenario from the literature of a large outbreak in California. However, this scenario was judged to be representative of all moderately-large

[84] In some circumstances modeled scenarios can be used to provide factors or multipliers to bridge data gaps. For example, the data sources the SNRA leveraged for the Earthquake national-level event provided normalized historical incident frequency, fatality, and direct economic damage loss, but not injuries. The injury distribution was constructed as a proxy measure by multiplying the distribution of fatalities by 23.5, the ratio of (Level 1-3) injuries to (Level 4 injury) fatalities in the New Madrid scenario (SNRA unclassified documentation of findings p. 123).

Use of factors in this manner

1) Should be sparing;

2) Must be informed by SME judgment that the impact measures are reasonably correlated, and that their relation in the scenario is representative of other incidents of that hazard (the relation between fatalities and injuries in the New Madrid scenario may be representative of earthquakes elsewhere in the United States, but the relation between fatalities and direct economic damage would not be); and

3) Should not be used to construct measures for fatalities or direct economic damage from other measures with limited data, because of their greater interest to stakeholders (an assumption used to construct a measure of secondary interest may be acceptable to stakeholders, but an assumption used for a measure of primary interest may not be). See OMB (2007), footnote 33.

[85] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

[86] It is actually one of two base scenarios, the 'Moderate' scenario discussed in the National Planning Scenarios pandemic scenario. A second scenario, which SMEs recommend be used in planning factors together with the 'Moderate' scenario, is a 'Severe' 1918-scale scenario causing 2 million fatalities in today's U.S. population. This higher scenario may have been an appropriate choice as well.

outbreaks, whether originating in California, Texas, or some other state. The scenario in the literature was used as a proxy, not as the actual National-level Event. Why this is significant:

- The estimated likelihood of occurrence of an outbreak of that magnitude anywhere in the U.S. is 1 in 10 years (best estimate frequency).
- The likelihood of occurrence of an outbreak of that magnitude in California is some fraction of that.
- The SNRA is intended to assess risk to the U.S. as a whole, so it is the likelihood of the first bullet which needs to be determined.

- If the risk from a hazard cannot be reasonably determined to be dominated by a scenario which is attached to a particular region or context smaller than the national scope of the SNRA, a scenario cannot be used to represent the total risk to the Nation from that hazard.
  - Example 3: The Tsunami national-level event (pp 142-143) is represented by a specific scenario, a 15 meter maximum height Cascadian Subduction Zone tsunami affecting the Oregon coast. The SNRA project team were unable to determine how representative this scenario was of the total tsunami risk to the Nation, in terms of the fraction of national risk presented by Oregon tsunami risk, earthquake-induced tsunamis, or 15 meter height events. Although the numbers for this specific scenario are reported in the risk summary sheet and data tables (Appendices B-G, K), they were not included in the comparative analysis of the SNRA or depicted in the charts because there was insufficient information for a comparison (Risks Requiring Additional Study/Tsunamis and Volcanoes, p. 36).
  - Example 4: The Volcano national-level event (pp 145-147) also represents a specific scenario, an eruption of Mount Rainier in Washington State. The fraction of total risk to the Nation from destructive volcano eruptions represented by this scenario also could not be determined, and so volcanoes could not be included in the SNRA's comparative analysis or charts.

- If a consequence scenario[87] is suspected to represent a dominant fraction of the total risk to the Nation from that hazard but its frequency cannot be determined in a defensible fashion, it cannot be assessed in the SNRA.
  - Example 5: A chemical accident causing 4,000-20,000 fatalities comparable to the 1984 chemical plant disaster in Bhopal, India is a scenario of concern to many policy makers, and one which a national risk assessment would be expected to focus upon. However, the single point estimate of frequency located by the SNRA project team (Figure 1 and text, p. 154) was judged insufficient to assess a defensible likelihood for the occurrence of this scenario in the United States. Only the smaller-scale accidents reflected in defensible (authoritatively sourced

[87] In this context a "consequence" model or scenario has a different technical meaning as a generic risk modeling term, than "impact scenario" which is used as a descriptor of asteroid impact consequence scenarios in particular.

and recent enough to be representative of present-day risk) U.S. historical data (p. 158) were capable of being assessed and represented in the SNRA.

- Example 6: U.S. policy makers who are concerned about space weather risk tend to be relatively focused on the catastrophic $1-2 trillion economic damage scenario consequent to the destruction of hundreds of key electric transformers (Space Weather Economic Impacts/Effects on Electricity Supply, p. 141). This gives the SNRA a fairly well defined, compact scenario to investigate. However, as the SNRA could not determine defensible estimates of the likelihood of that scenario, it could not be assessed in comparison with other hazards in the 2011 SNRA (Highly Uncertain Risks, pp. 35-36).

- The key question which the SNRA attempts to answer is the likelihood of different hazard scenarios with different impacts. Because of the maturity and sophistication of computational disaster modeling, any number of disaster scenarios can be modeled in great detail in a rigorous fashion. However, consequence-only models usually do not give information on the relative likelihood of different levels of impact for a disaster, which is necessary for determining what scale of disaster dominates the national risk from that hazard for different measures of risk. Without this information, not even the most sophisticated consequence models of threat or hazard scenarios of concern can be compared against other threats and hazards in a comparative risk assessment such as the SNRA.

How to Evaluate an SNRA Risk Summary Sheet (Checklist)

1. Event definition.
    a. Is it clear, concise, and analytically meaningful?
    b. Do the frequency and impact data match the event definition?

2. Frequency.
    a. Is frequency provided in units of # of events per year? (e.g., 1 event per 10 years or 0.1 events per year)
    b. The best estimate of frequency should correspond to a best estimate of how often the event, as defined, occurs. This could be derived from a historical average over a set time period, or subject matter expert judgment.
        i. Example: There were 5 events over a 20 year historical record, so the best estimate of frequency is the average number of events per year, 0.25 events per year or 1 per 4 years.
        ii. Example: Where there is a model that outputs a frequency distribution, we have incorporated the mean of that frequency distribution as the "best estimate".
        iii. Example: Subject matter expert judgment should provide the estimated frequency of occurrence of incidents resulting in impacts at or above the minimum threshold of the impact defining the scope of the event.
    c. The high estimate of frequency should represent uncertainty regarding how frequently the event, as defined, occurs.
        i. Example: One could look at the inverse of the shortest interarrival time, or the maximum number of events per year over a historic record.
        ii. Example: Where there is a model that outputs a frequency distribution, we have incorporated the 95th percentile of that frequency distribution as the "high estimate".
        iii. Example: Subject matter expert judgment may represent uncertainty in the true frequency, or estimation of how many times the event, as defined, might occur in one year (a particularly bad year).
    d. The low estimate of frequency should represent uncertainty regarding how infrequently the event, as defined, occurs.
        i. Example: One could look at the inverse of the longest interarrival time, or, the fewest # of events per year over a historic record.
        ii. Example: Where there is a model that outputs a frequency distribution, we have incorporated the 5th percentile of that frequency distribution as the "low estimate".
        iii. Subject matter expert judgment may represent uncertainty in the true frequency, or (the inverse of) an estimation of how many years could go by between two succeeding occurrences of the event – the reasonably longest 'dry spell' or gap between successive occurrences.

3. Impacts.
    a. The most important thing is to make sure the impacts represent the impacts of a ***single*** event, as defined, given that it occurs.
    b. The best estimate should be interpreted as, given that an event occurs that meets the definition (or threshold), ***on average***, what are the impacts?
        i. For events leveraging subject matter expert judgment for their estimates, the best estimate may represent the 'most likely' (mode) outcome or the median (50-50) value outcome, given occurrence of the event as defined.
    c. The high estimate should be interpreted as either:
        i. The maximum impacts per event, from the historical record.
        ii. The 'reasonable worst case scenario', from literature estimates and/or subject matter expert judgment.
        iii. The 95th percentile of impacts, from a model/simulation (the idea is that the max impacts from a historical record of 20-100 years will also roughly correlate to a 95th percentile – but obviously that math is not exact).
    d. The low estimate should be interpreted as either:
        i. The lowest impacts per event, from the historical record.
        ii. The 5th percentile of impacts, from a model/simulation.

4. Other quirks.
    a. Pay attention to how fatalities, injuries/illnesses, and economic impacts are defined.
        i. Are latent fatalities included? (e.g. cancer)
            1. We do not have a consistent way of counting these, but if this applies to your event please document them in the risk summary sheet (whether or not you include them in its top level estimates) for differential treatment in a future iteration of the SNRA.
        ii. What counts as an injury/illness?
        iii. What was included in direct economic impacts? If direct and indirect are included together, they need to be separated for comparability to SNRA events.
        iv. Direct economic impact numbers will use the definition pp 20-21 of this requirements document.
    b. Make sure all data sources, citations, and other needed information are provided so that the analysis can be replicated.
        i. Wikipedia is unacceptable as a data source.[88]
        ii. U.S. Government sources are preferable.
        iii. Peer-reviewed sources are also preferable.

[88] However, Wikipedia is highly recommended as a research starting point to find citable data sources.

Threat/Hazard Name

Description of the threat/hazard which clearly defines its scope. If defined by a threshold ($100 million, $1 billion, one or more fatalities) this should be stated here, similar to SNRA 2011 event definitions (Table 2, p. 11[89]).

Data Summary

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities	A[90]	B[91]	C[92]
	Injuries and Illnesses	Number of Injuries or Illnesses	D[93]	E[94]	F[95]
Economic	Direct Economic Loss	U.S. Dollars	G[96]	H[97]	I[98]
Social	Social Displacement	People Displaced from Home for 2 or More Days	J[99]	K[100]	L[101]
Psychological	Psychological Distress	Calculated from other metrics	**Not needed (automatically calculated)**		
Environmental	Environmental Impact	Constructed scale	**Not needed (will be elicited from environmental SMEs)**		
LIKELIHOOD	Frequency of Events	Number of Events per Year	X[102]	Y[103]	Z[104]

Event Background

The sort of description and qualitative discussion that would be found in a well-researched non-quantitative survey of hazards goes here.

[89] Unless indicated otherwise, all page references in the following refer to the draft (28 January 2015) SNRA 2011 Unclassified Documentation of Findings which was distributed to you with this information packet.

[90] Source for estimate A.
[91] Source for estimate B.
[92] Source for estimate C.
[93] Source for estimate D.
[94] Source for estimate E.
[95] Source for estimate F.
[96] Source for estimate G.
[97] Source for estimate H.
[98] Source for estimate I.
[99] Source for estimate J.
[100] Source for estimate K.
[101] Source for estimate L.
[102] Source for estimate X.
[103] Source for estimate Y.
[104] Source for estimate Z.

Assumptions

Frequency

Describe the sources and methods used to obtain the low, best, and high estimates of frequency. Use footnotes or endnotes.

Health and Safety

Describe the sources and methods used to obtain the low, best, and high estimates of fatalities and illnesses or injuries. Use footnotes or endnotes.

If your injury/illness data have a more granular breakdown (more/less severe, Hazus Level 1-4), please provide those numbers in a table here.

Direct Economic Loss

Describe the sources and methods used to obtain the low, best, and high frequency background here. Use footnotes or endnotes.

Please provide the breakdown of your direct economic estimates by component:

- **Decontamination, Disposal, and Physical Destruction (DDP):**
  - Property damage (including building contents)
  - Decontamination costs (for buildings not demolished)
  - Disposal costs for debris
  - Crop damage
- **Business Interruption:**
  - Lost sales, wages, other business costs directly caused by the event
- **Medical Costs**
- **One Year Lost Spending from Fatalities**
  - $42,500 per fatality[105]

If your direct economic loss figures have a granular breakdown (homes destroyed, jobs lost), please provide those numbers in a table here.

Social

Describe the sources and methods used to obtain the low, best, and high estimates of persons displaced for 2 or more days. Use footnotes or endnotes.

If your displacement data have a more granular breakdown (short term, long term, homeless), please provide those numbers in a table here.

[105] Note 67, this document.

Psychological

The estimates will be calculated from the fatality, injury/illness, and displacement estimates using a pre-defined formula (Appendix G). However, please feel free to write qualitatively about the psychological impacts of your threat/hazard.

Environmental

The estimates will be elicited from subject matter experts. No text is required here.

Potential Mitigating Factors

Please describe potential mitigating factors, as desired (see SNRA 2011 risk summary sheets for examples[106]).

Additional Relevant Information

Please provide additional relevant information, as needed. Large data tables may go in this section, or under a previous section. If you do provide large data tables here, switch this section with the References/Bibliography. Alternatively, the data tables could be put in an annex/appendix.

References/Bibliography

If complete citations are provided in the footnotes, this section is not necessary. It is recommended, however, to keep references straight.

It can also be used to list 'References consulted but not cited', in order to show that you've covered the bases/done your homework and didn't just pick the first references Google turned up. This can be very helpful later, so that other experts don't waste their (and your) time sending you references which they hadn't realized you had already examined.

[106] Draft Unclassified Documentation of Findings appendix J.