



Exceptional service in the national interest

RISK FORMULATION FOR NCFS

Lessons from Financial Risk Measurement and Continuity

Kevin Griffith, Sandia National Laboratories

December 13, 2023

BACKGROUND: SNL SUPPORT TO DHS

Sandia National Laboratories (SNL) has supported the NISAC program since 2004, leveraging the lab's technical understanding of risk from other disciplines, including decades of nuclear weapon research, to provide rigor and analysis to managing risk in the critical infrastructure and cyber domains.



Through the establishment of the National Risk Management Center (NRMC), SNL's support has evolved to focus on providing risk frameworks, design principles, and analysis capabilities to assess interdependent risks across National Critical Functions and critical infrastructure.

The Risk Analytic Methods and Support (RAMS) portfolio performs this work for USG in support of federal network and critical infrastructure protection.



The **National Risk Management Center (NRMC)** is the planning, analysis, and collaboration center within the Cybersecurity and Infrastructure Security Agency (CISA), leading strategic risk reduction efforts for the Nation.



The **DHS Science and Technology Directorate (S&T)** is the science advisor to the Secretary and serves as the research and development arm of DHS; conducting basic and applied research, development, testing, and evaluation activities in alignment with the DHS mission.



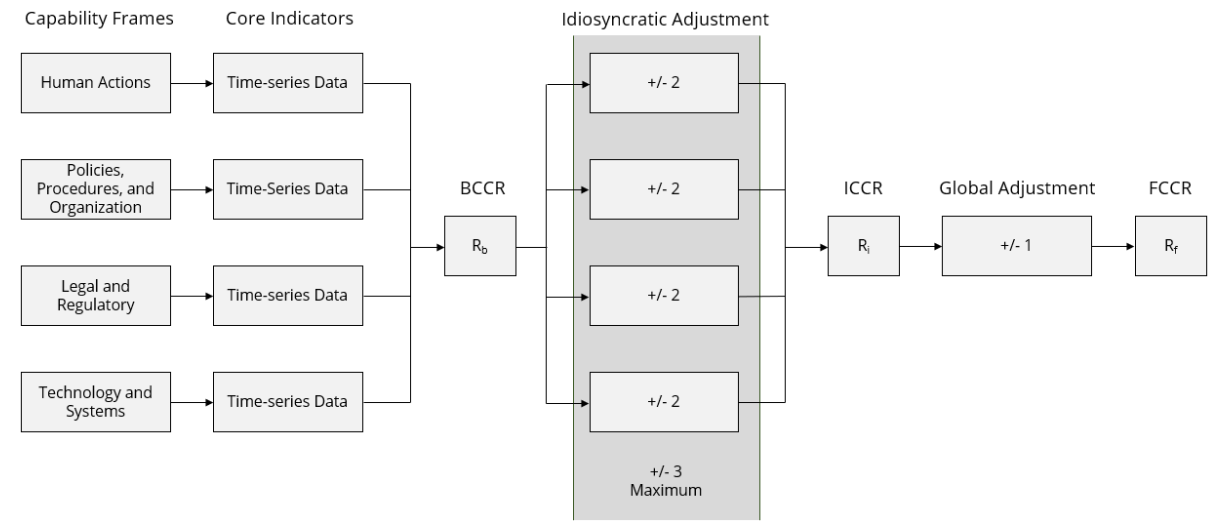
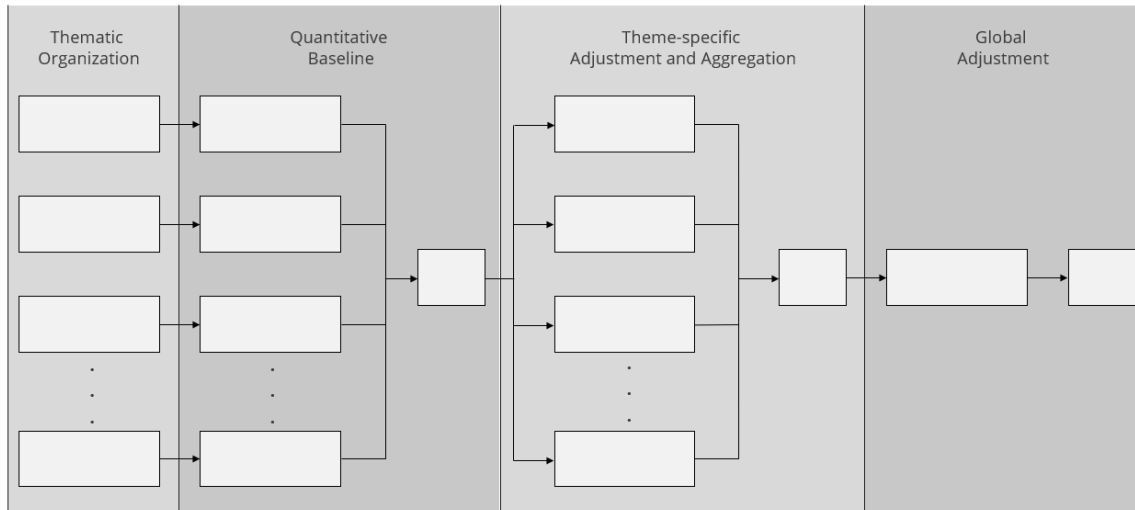
**SANDIA NATIONAL LABORATORIES
RAMS SUPPORT**

to

DEPARTMENT OF HOMELAND SECURITY

SOVEREIGN CREDIT RATINGS AND RISK

Credit ratings integrate quantitative and qualitative data per a unique structure.



SOVEREIGN CREDIT RATINGS AND RISK

Credit ratings estimate the likelihood element of the risk equation.

Example Regulatory Bodies and Agencies

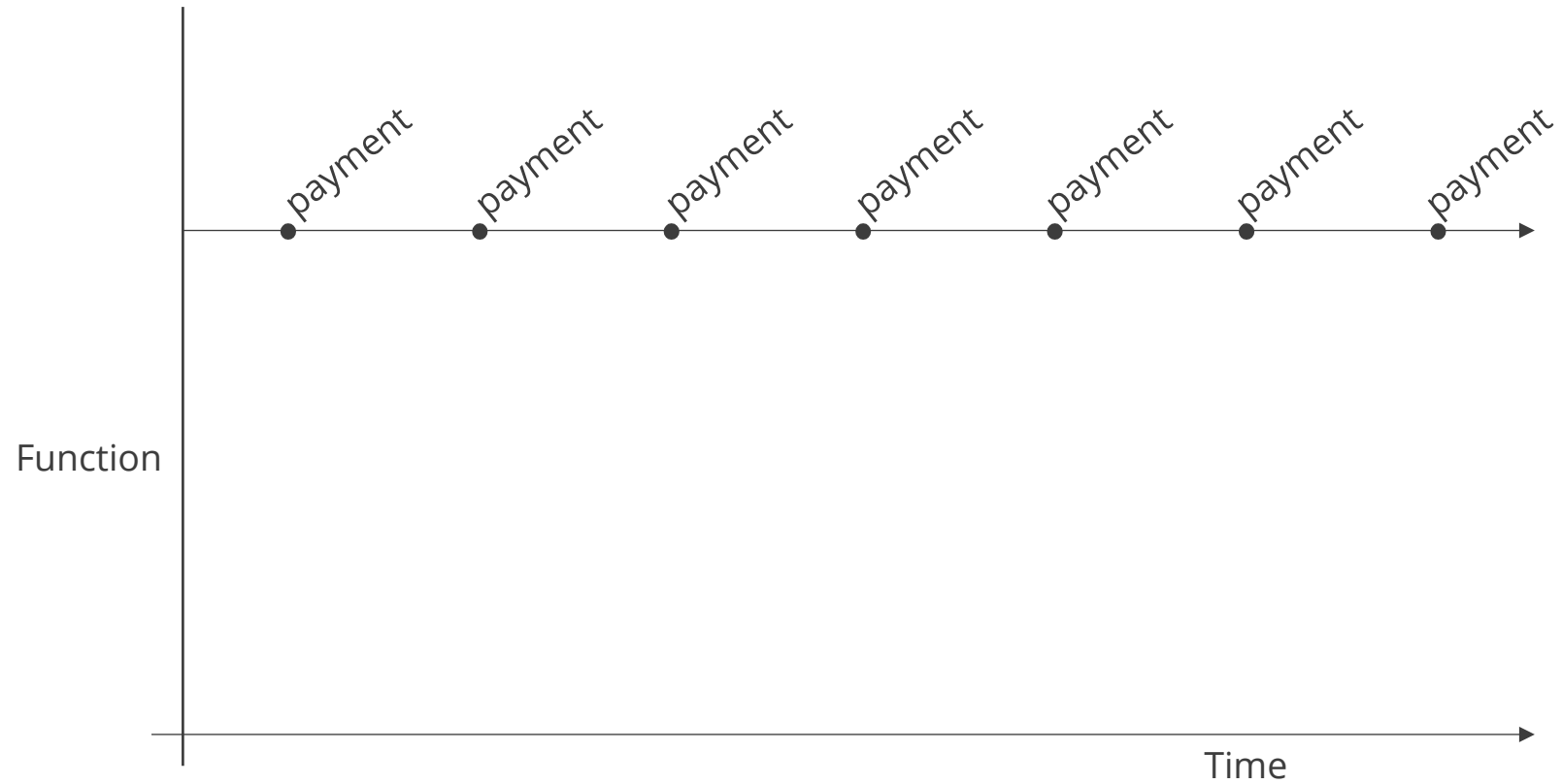
- **Securities and Exchange Commission (SEC) NRSROs**
- Fitch Ratings
- S&P
- Moody's
- KBRA
- DBRS
- HR Ratings
- **European Securities and Markets Authority (ESMA) CRAs**
- Scope Ratings
- EuroRating
- ARC Ratings
- Nordic Credit Rating

{1,0} Default: missed payment of principal or interest on a contractual obligation.

Long-run observation permits derivation of probability of default (PD) value.

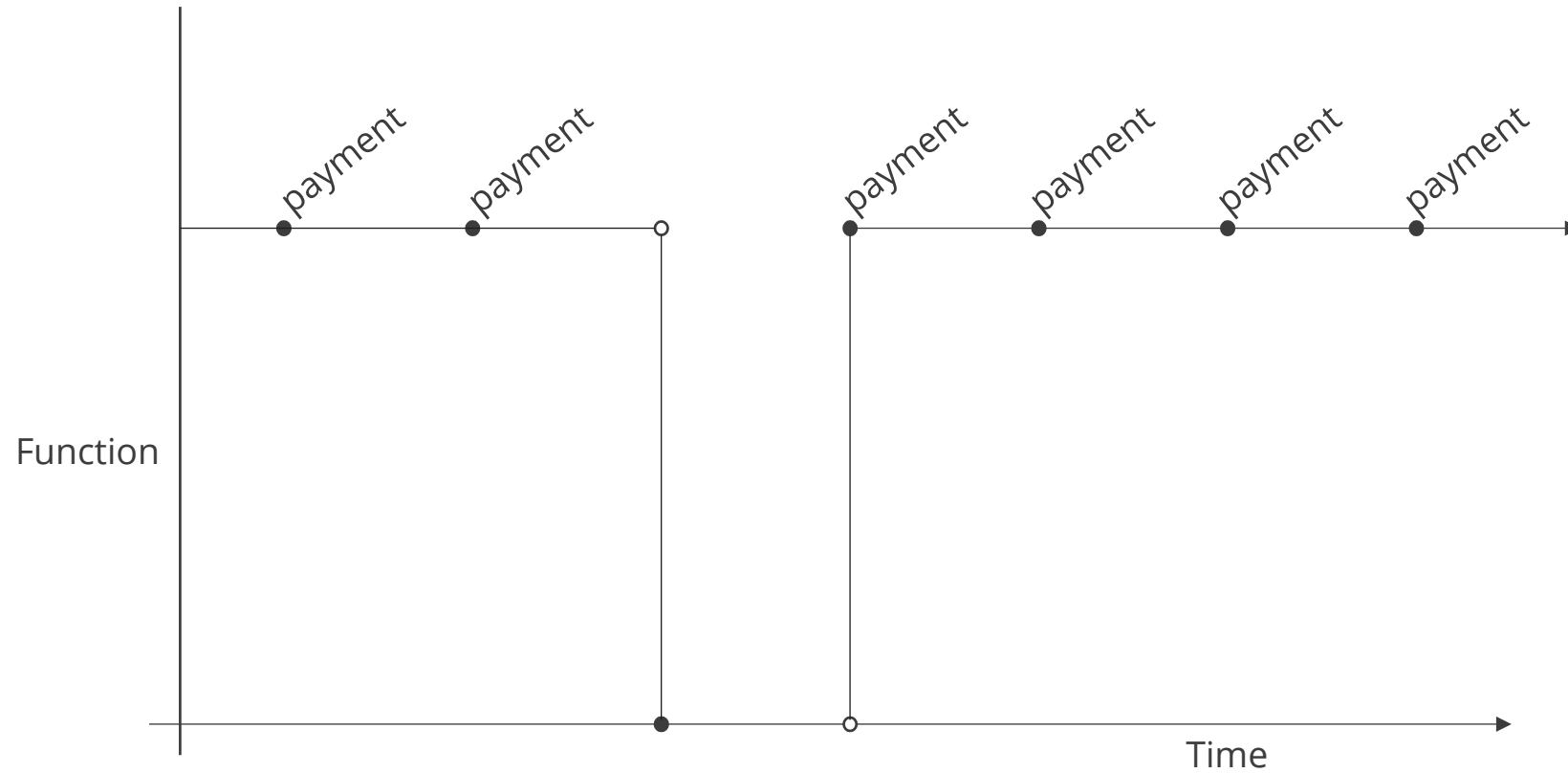
DEFAULT: GRAPH REPRESENTATION

Obligations being met over time...



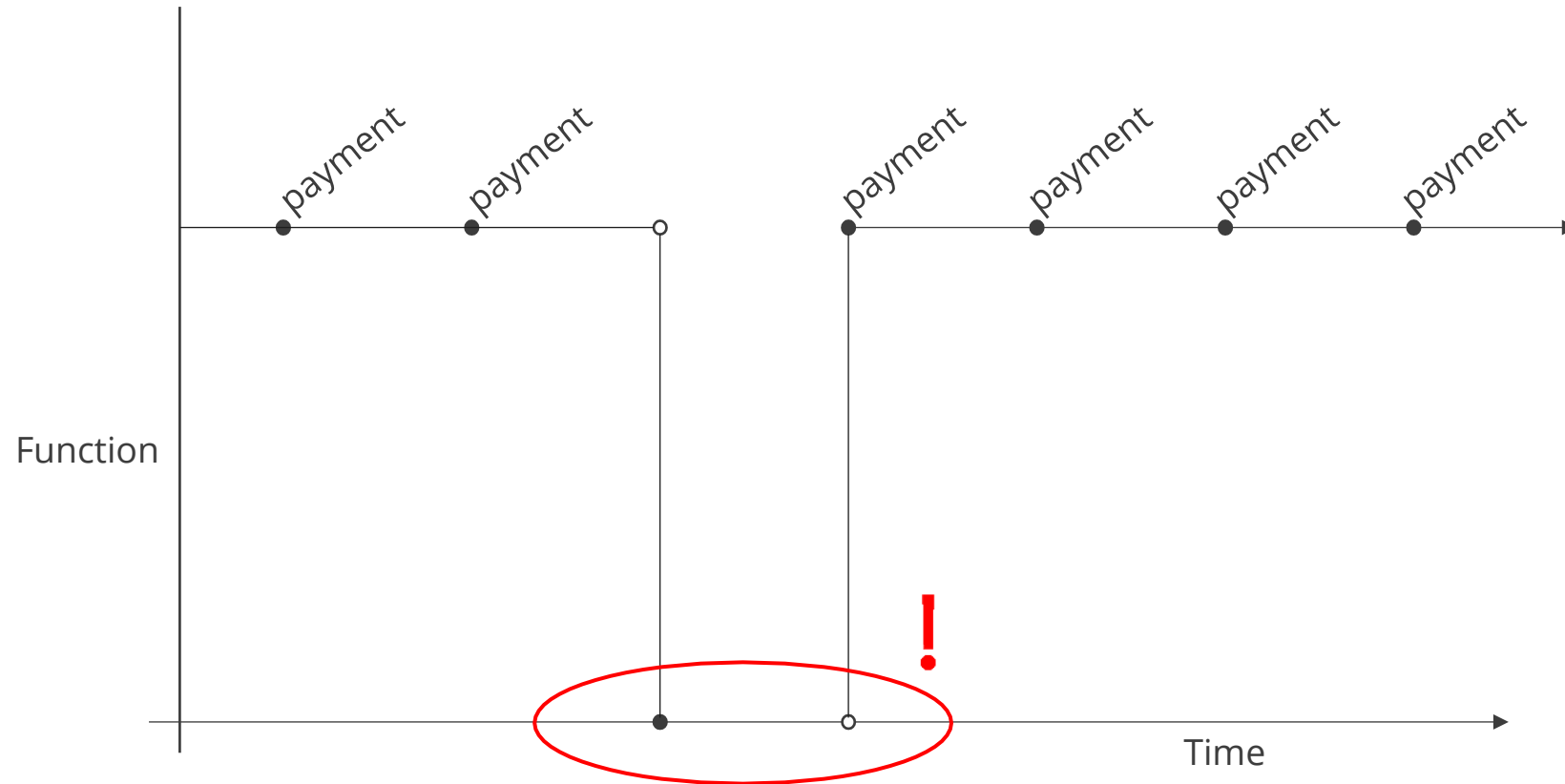
DEFAULT: GRAPH REPRESENTATION

Failure to meet obligation...



DEFAULT: GRAPH REPRESENTATION

Failure to meet obligation...



NATIONAL CRITICAL FUNCTIONS

Continuous provision of NCFs can be represented similar to default.

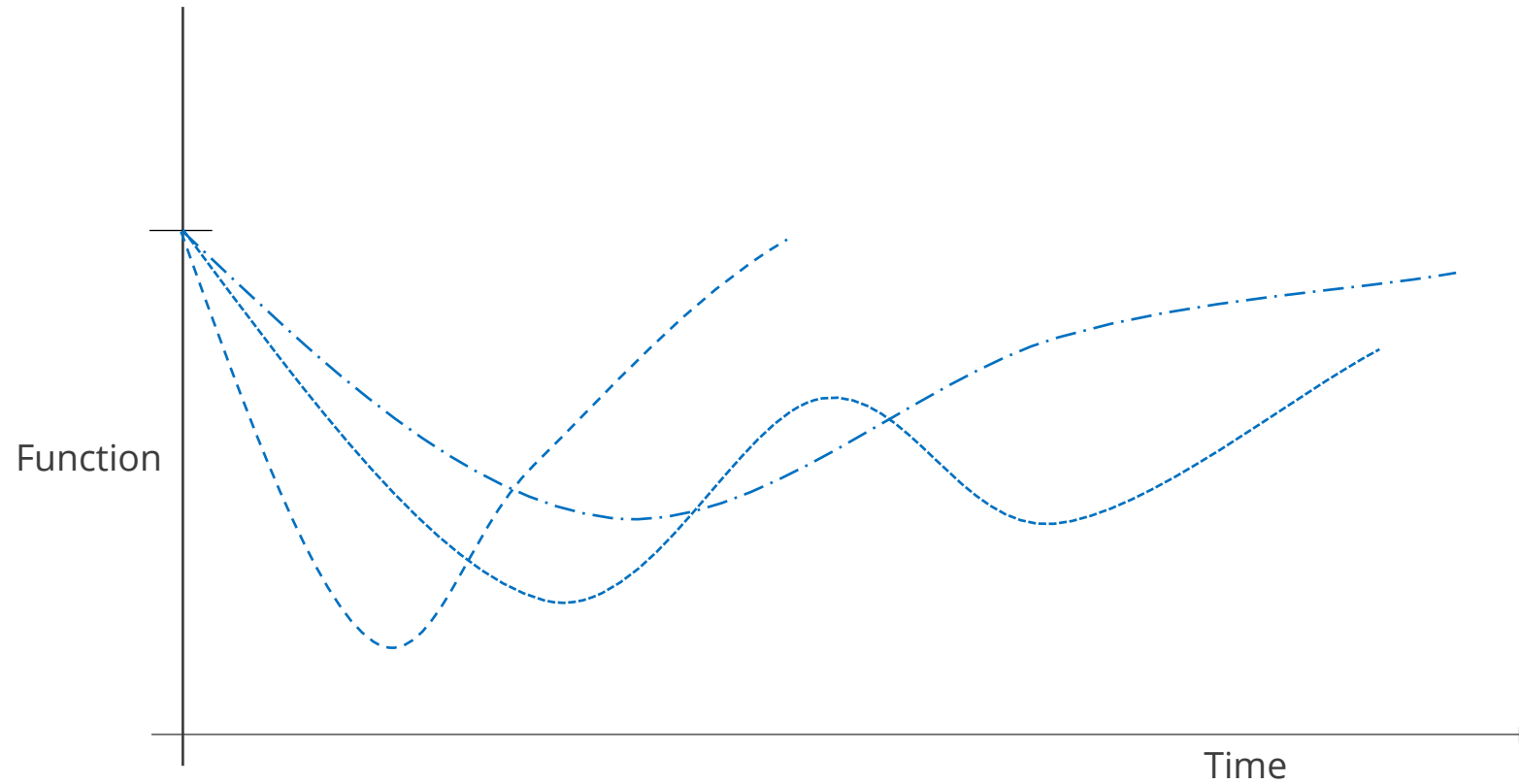
CONNECT 	DISTRIBUTE 	MANAGE 	SUPPLY 
<ul style="list-style-type: none"> Operate Core Network Provide Cable Access Network Services Provide Internet Based Content, Information, and Communication Services Provide Internet Routing, Access and Connection Services Provide Positioning, Navigation, and Timing Services Provide Radio Broadcast Access Network Services Provide Satellite Access Network Services Provide Wireless Access Network Services Provide Wireline Access Network Services 	<ul style="list-style-type: none"> Distribute Electricity Maintain Supply Chains Transmit Electricity Transport Cargo and Passengers by Air Transport Cargo and Passengers by Rail Transport Cargo and Passengers by Road Transport Cargo and Passengers by Vessel Transport Materials by Pipeline Transport Passengers by Mass Transit 	<ul style="list-style-type: none"> Conduct Elections Develop and Maintain Public Works and Services Educate and Train Enforce Law Maintain Access to Medical Records Manage Hazardous Materials Manage Wastewater Operate Government Perform Cyber Incident Management Capabilities Prepare For and Manage Emergencies Preserve Constitutional Rights Protect Sensitive Information Provide and Maintain Infrastructure Provide Capital Markets and Investment Activities Provide Consumer and Commercial Banking Services Provide Funding and Liquidity Services Provide Identity Management and Associated Trust Support Services Provide Insurance Services Provide Medical Care Provide Payment, Clearing, and Settlement Services Provide Public Safety Provide Wholesale Funding Store Fuel and Maintain Reserves Support Community Health 	<ul style="list-style-type: none"> Exploration and Extraction Of Fuels Fuel Refining and Processing Fuels Generate Electricity Manufacture Equipment Produce and Provide Agricultural Products and Services Produce and Provide Human and Animal Food Products and Services Produce Chemicals Provide Metals and Materials Provide Housing Provide Information Technology Products and Services Provide Materiel and Operational Support to Defense Research and Development Supply Water

"NCFs are the functions of government and the private sector so vital to the United States that their disruption, corruption, or dysfunction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof."

- Cybersecurity and Infrastructure Security Agency

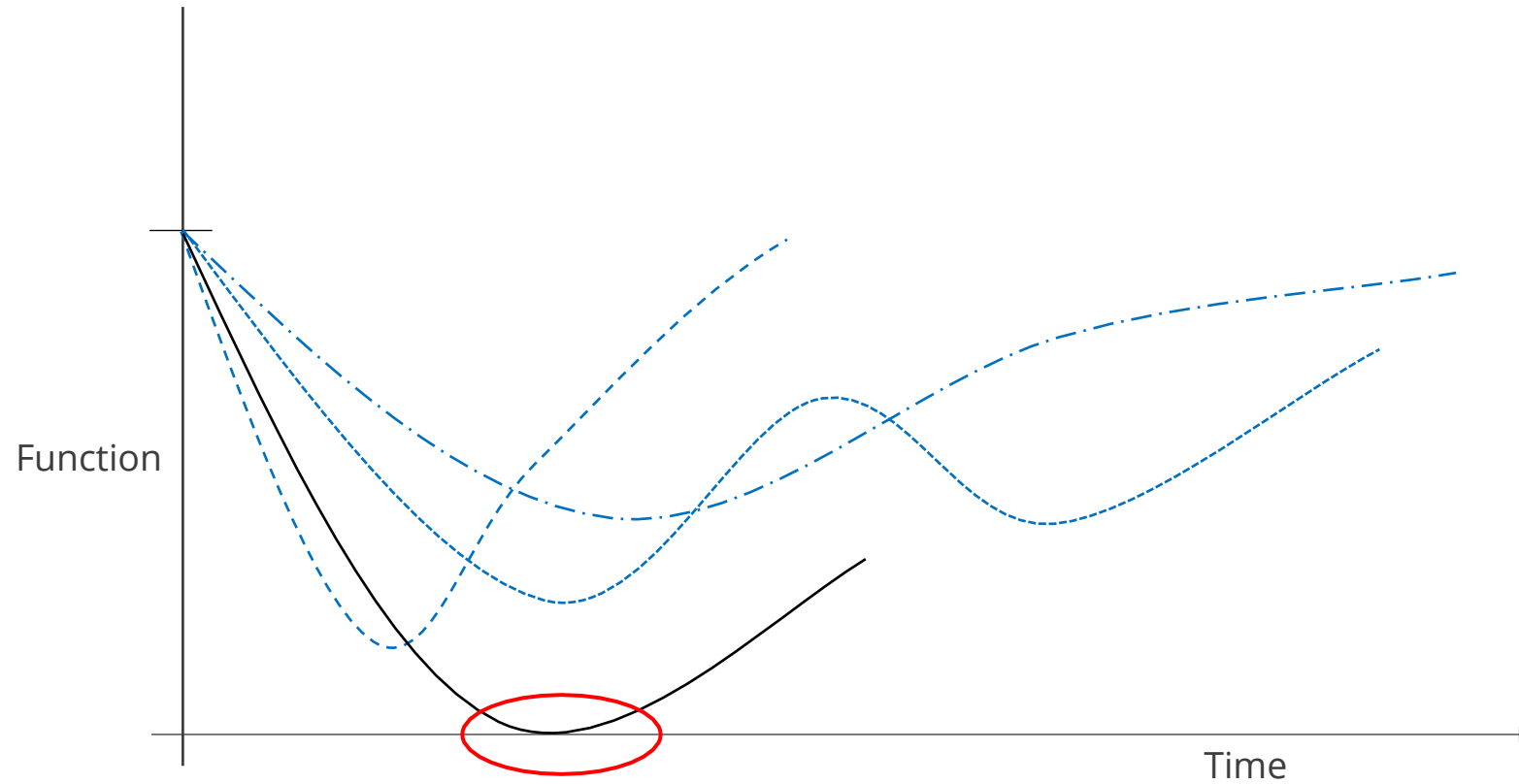
RESILIENCE: GRAPH REPRESENTATION

Resilience is often measured as functional change over time.



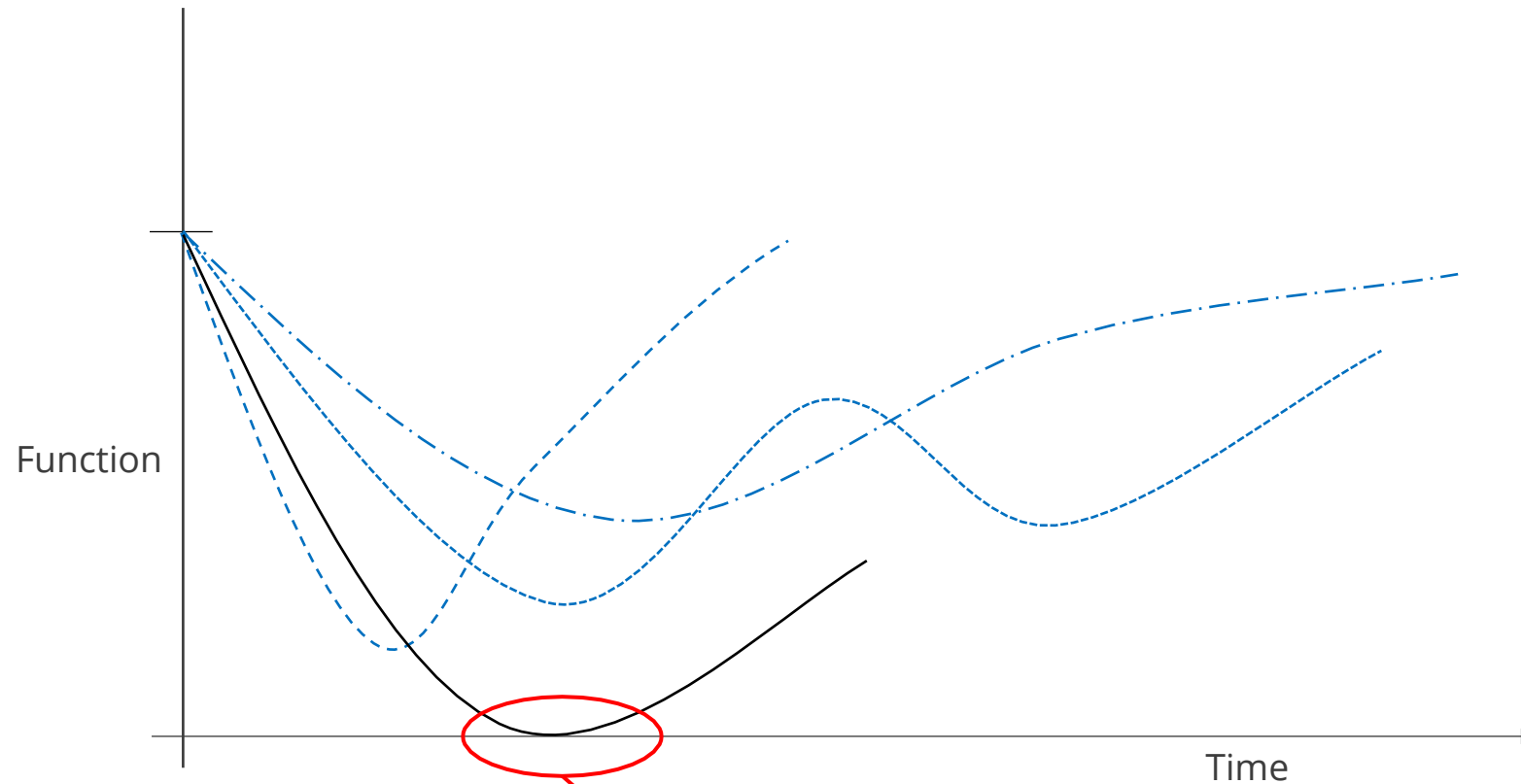
NCF DISCONTINUITY: GRAPH REPRESENTATION

Continuous provision of an NCF achieves discontinuity when function reaches zero.



NCF DISCONTINUITY: GRAPH REPRESENTATION

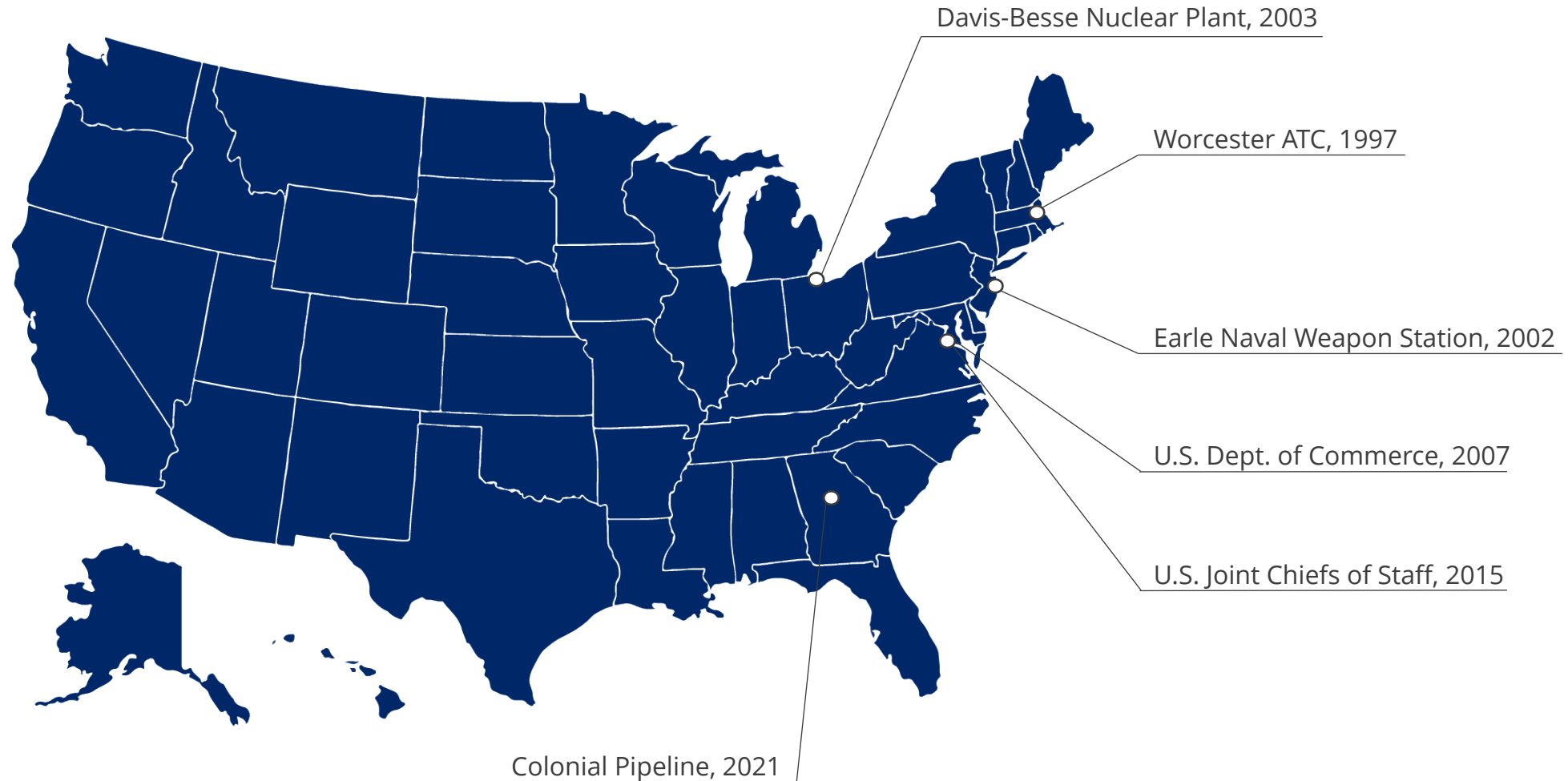
Discontinuity incidents, like default, are agnostic of time and severity.



Discontinuity in provision of an NCF across *all* operations and locations.

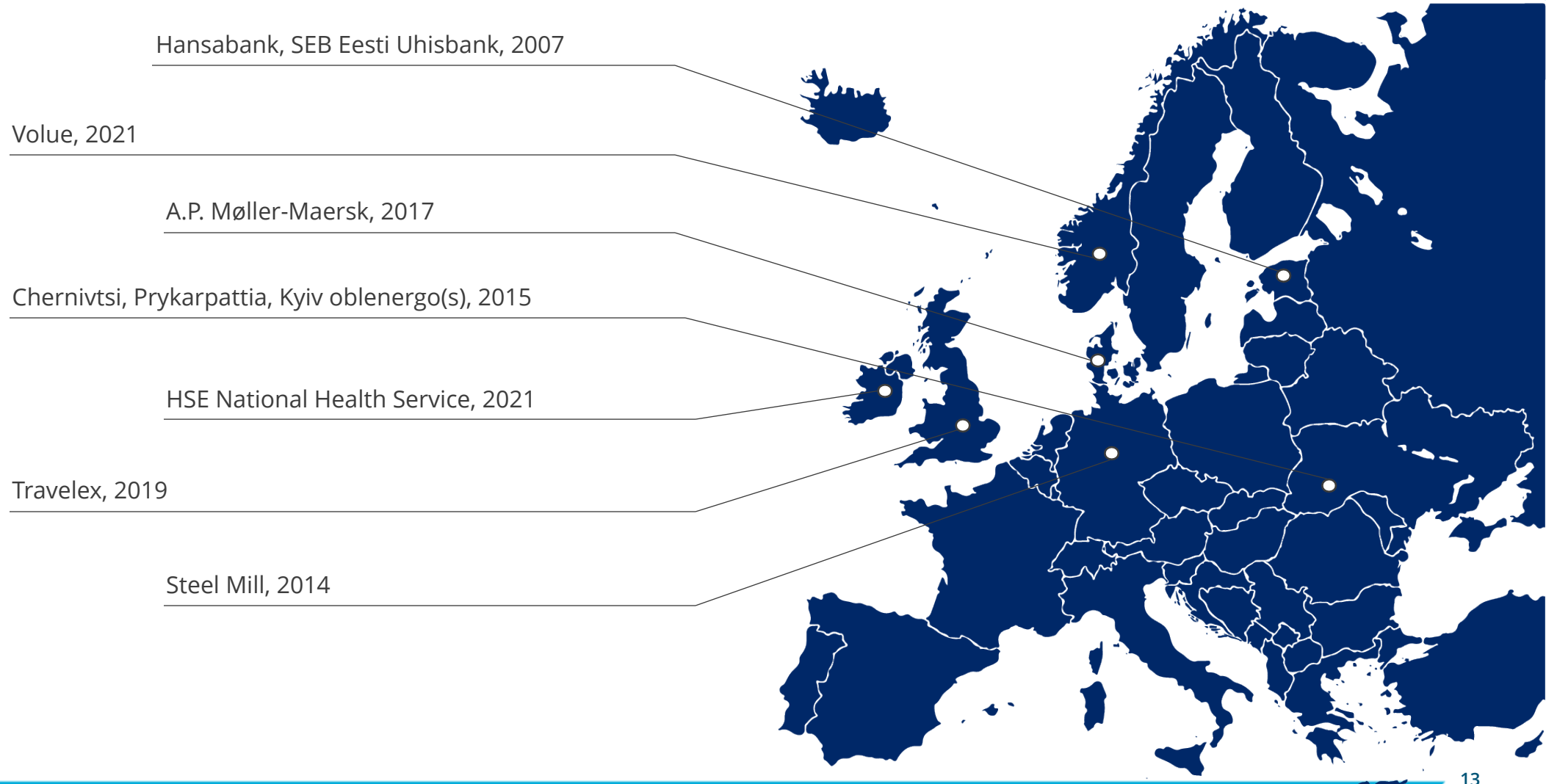
DISCONTINUITY INCIDENTS: UNITED STATES

Several examples from survey of cyberattacks, 1997 – 2022.



DISCONTINUITY INCIDENTS: EUROPE

More examples from survey of cyberattacks, 1997 – 2022.



COMPLETING THE RISK EQUATION

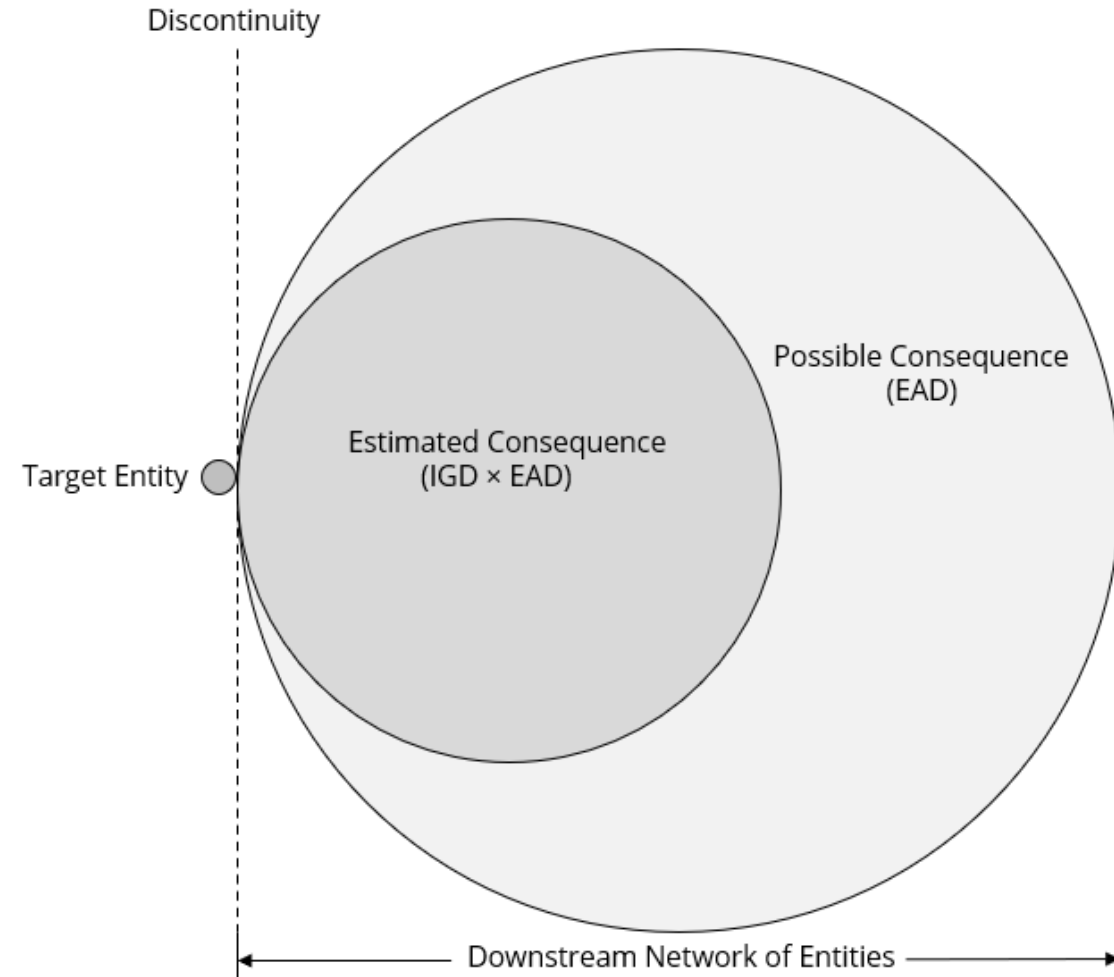
Bank for International Settlements (BIS) contributes consequence element of the risk equation.

Elements of Risk

- **NRSROs and CRAs**
- Probability of Default (PD)
- **BIS**
- Loss Given Default (LGD)
- Exposure at Default (EAD)



$$\text{Risk} = \text{PD} * \text{LGD} * \text{EAD}$$



COMPLETING THE RISK EQUATION

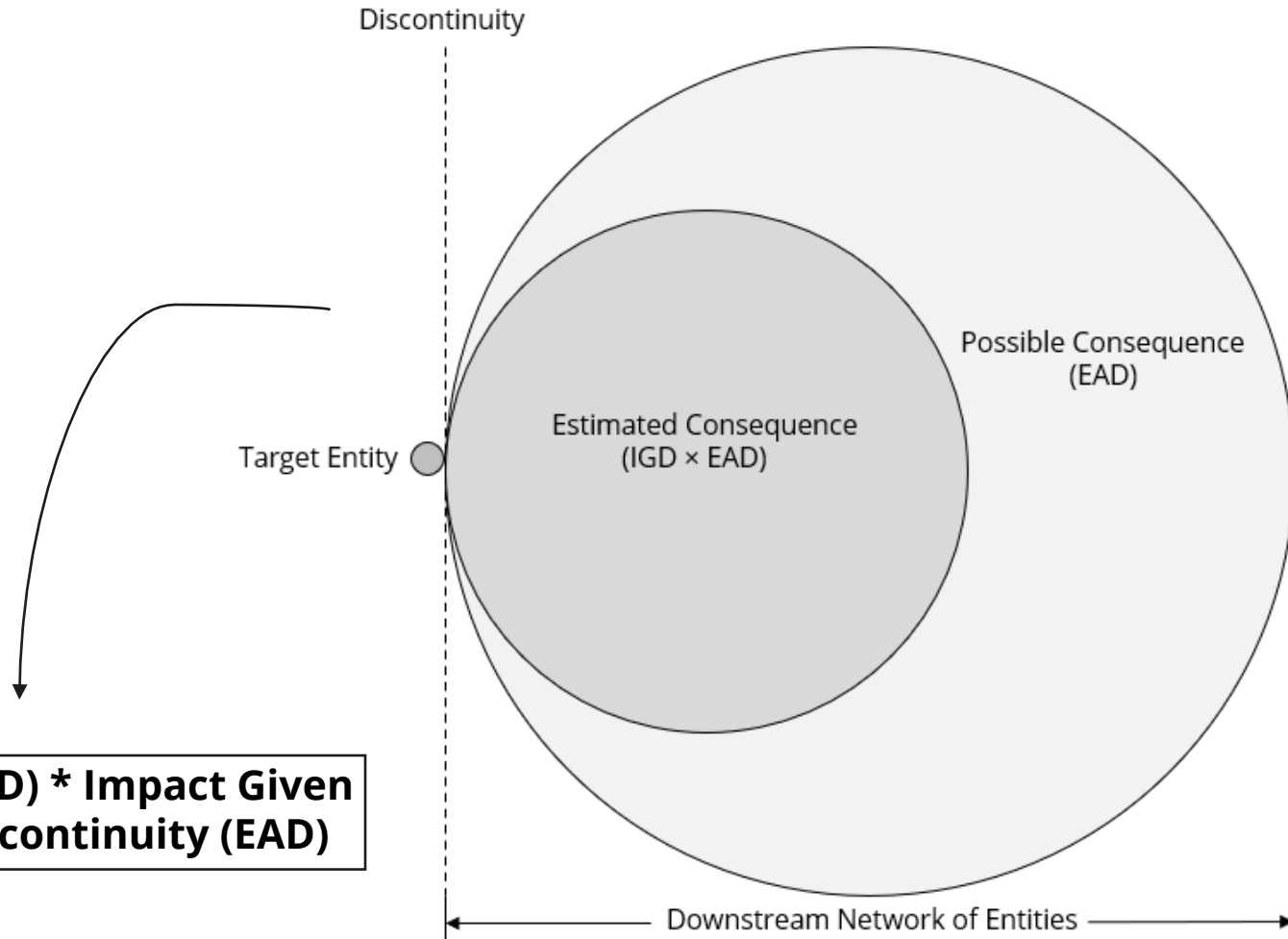
Elements can be adapted to represent discontinuity incidents.

Elements of Risk

- **NRSROs and CRAs**
- Probability of Default (PD)
- **BIS**
- Loss Given Default (LGD)
- Exposure at Default (EAD)

~~$\text{Risk} = \text{PD} * \text{LGD} * \text{EAD}$~~

$\text{Risk} = \text{Probability of Discontinuity (PD)} * \text{Impact Given Discontinuity (IGD)} * \text{Exposure at Discontinuity (EAD)}$



CONCLUSION

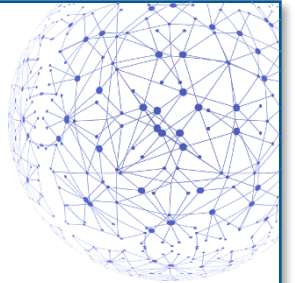
Measuring continuous provision of NCFs may be valuable to sovereign-scale risk management of targeted entities.

Potential Value

- **Integration of quantitative and qualitative data:** varied data sources and data types combined in rigorous and repeatable methodology.
- **Estimation of likelihood and consequence elements:** distinct elements can be used for prioritization and risk treatment actions.
- **Rating scales can support communication:** ability and willingness to mitigate discontinuous function due to cyberattack.

Other Assessment Domains

- Climate
- Manufacturing
- Transportation Systems
- Education
- Public Policy
- Agriculture



ACKNOWLEDGEMENTS



Sandia National Laboratories

- **PI:** Ashley Stapp
- **PM:** Noël Nachtigal
- **Technical Contributors:** Asmeret Naugle, Hayden Fears, Danielle Jacobs, Joshua Dise, Megan Nyre-Yu

Zeichner Risk Analytics

- **Technical Contributors:** John Arterbury, Nicholas Winstead