The CISR Business Process Project: Balancing the Ideal with the Pragmatic to Value Resilience Incentives

Jerry P. Brashear, Paula Scalingi and Ryan Colker

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Incentives Have the Potential to Deal with “Tragedy of the Commons”

- **Tragedy of the commons:**
  - When an investment decision benefits (or costs) both the decision-maker and the public and/or other stakeholders,
  - And the benefits to the decision-maker are insufficient to justify the investment,
  - The decision-maker declines to invest,
  - And the benefits to the public & outside stakeholders – externalities or “co-benefits” are foregone

- This accounts for much of the under-investment in resilience and security

- Incentives present the opportunity to make the investment sufficiently attractive to the decision-maker to make the investment, benefitting all
Resilience Incentives Require Risk Analysis

- Most incentives establish a grantor-recipient relationship
- Each party needs to evaluate the impacts of the incentive, respectively, from their own perspectives
- **Recipient**: Does the incentive make an otherwise rejected option acceptably cost-effective? Or is it just a “bonus”?
- **Grantor**:
  - Does the incentive induce enough **changed** behavior to justify its aggregate cost?
  - How many recipients would make the desired decisions **without** the incentives but take it anyway (“**free riders**”)?
- If the objective of the incentive is resilience, all these decisions require risk/resilience analysis
Critical Infrastructure Security & Resilience Risk Management Process (CISR-RMP) Project

✦ Project Goal: Apply business process engineering (BPE) to CISR risk/resilience management

✦ Goal of CISR-RMP: enable localities, lifeline infrastructures, other enterprises and regional communities to:

- Cooperatively assess all-hazards risk of human & financial losses & disruptions to vital services, direct & indirect;

- Rationally value & allocate available resources to options – with and without incentives – to advance CISR as much as possible under constraints; and

- Reliably evaluate the effectiveness of these initiatives in reducing risk and fragility.
Structure of the CISR-RMP Project

- Federal policy on CI & regional risk/resilience measurement & management
- Local risk/resilience processes currently used & their constraints
- Federal tools & methods for lifelines security & resilience

Objectives
- CISR-RMP design specifications
- BPE design CISR-RPM & gaps
- CISR-RPM implementation strategy
- Road map to improving CISR-RMP
Policy-Based Design Principles

NIPP 2013 and Supplement require:

- CI risk be estimated by identifying what assets are critical, accounting for interdependencies,
- Threat, vulnerability and consequences be analyzed in ways that support rational choices among action options,
- The selected options be implemented and their performance be evaluated.”

NIPP 2013 Supplement’s additions:

- Documented
- Reproducible
- Defensible

DHS Risk Management Fundamentals – DHS doctrine:

- Unity of Effort
- Transparency
- Adaptability & Practicality
- Customization
User Situation & Needs

- Little risk management at the local/regional level, e.g.,
  - “State and Federal recovery funds will always cover disasters”
  - “It’s irrational to spend 100¢ dollars on uncertain events now, not 25¢ dollars on actual events later, IF & when they happen”
  - GCs advise that “ignorance of risk” is a liability defense

- What true risk analysis is going on is
  - Largely proprietary and confidential one-offs
  - Conducted by the largest organizations, or
  - Federally stimulated and compliance-oriented, and
  - Siloed from other management processes

- None of the utilities or agencies analyzes dependencies & interdependencies, but all are acutely aware of them

- Resilience per se is not analyzed, but seen as outcome of risk reduction
Potential User Outlook

Virtually all respondents were keenly interested in an improved approach, especially if:

– Proposed/required by external authority
– Liability issues resolved, e.g., SAFETY Act extended
– Simple, free, open, provide immediate value to decision-makers
– Conducted by on-site staff with no- or low-cost technical assistance
– Common analysis & comparable data OK; common solutions are not
– One stated he was planning to integrate risk management with asset management and capital planning
Review of Federally Sponsored CI Risk Tools

- 21 federally sponsored and nominated tools examined
  - 10 were eliminated
    - 3 estimated important risk elements (e.g., future weather), but not risk or resilience
    - 7 were survey-based indicators, useful for benchmarking, but not risk-reduction option valuation
  - 11 were examined in more depth relative to their ability to support option valuation by local and regional CI and public decision-makers under budget constraints

- None was found to be complete, but a few show great promise
Review of Federal Lifeline CISR Tools
Review of Federal Lifeline CISR Tools

Design Requirements

Scales / Methods, Processes & Tools (Sponsors)

- Sort/rank by Criticality
- Rank by Risk
- Decide to Design Options
- Value Options
- Rationalize Budget
- Evaluate Performance
- Regional Depend. Anal.
- Aggregate to Reg., St., US

Key Decision Support
### Review of Federal Lifeline CISR Tools

<table>
<thead>
<tr>
<th>Output</th>
<th>Key Decision Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditional Risk</td>
<td>1.0</td>
</tr>
<tr>
<td>Owners’ Risk</td>
<td></td>
</tr>
<tr>
<td>Public’s Regional Risk</td>
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<tr>
<td>Resilience Metric</td>
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<tr>
<td>Option Value (Net Benefit)</td>
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</tr>
</tbody>
</table>

**Scales / Methods, Processes & Tools (Sponsors)**

**Conditional Risk | T = 1.0**

**Output**

- Owners’ Risk
- Public’s Regional Risk
- Resilience Metric
- Option Value (Net Benefit)
Review of Federal Lifeline CISR Tools
## Ratio Scales: counting

- Equal intervals
- True zero
- All arithmetic functions allowed
- Dollar-based benefit/cost analysis supported

## Ordinal Scales: ordering, ranking

- Unequal or unknown intervals
- No necessary zero
- Limited arithmetic functions allowed
- No true dollar benefit/cost analysis
## Review of Federal Lifeline CISR Tools

### Design Requirements

<table>
<thead>
<tr>
<th>Scales / Methods, Processes &amp; Tools (Sponsors)</th>
<th>Focus</th>
<th>Scenarios</th>
<th>Terms</th>
<th>Output</th>
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<tbody>
<tr>
<td>Ratios Scale Methods</td>
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</tr>
<tr>
<td>CISR Risk Management Process Design: Design Objective</td>
<td>Lifelines, Em. Mgt., All</td>
<td>A</td>
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### Ordinal Scale Methods
# Review of Federal Lifeline CISR Tools

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<tbody>
<tr>
<td>Lifelines, Emer. Mgmt., All</td>
<td>Non-Standardized</td>
<td>Threat Likelihood</td>
<td>Consequences</td>
<td>Outages</td>
<td>Dependencies</td>
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<tr>
<td>Dams (USACE)</td>
<td>Standardized</td>
<td>1</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
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<tr>
<td>Bridges (FHWA)</td>
<td>Standardized</td>
<td>2</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Tunnels (TSA)</td>
<td>Standardized</td>
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<td>Green</td>
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<tr>
<td>J100-10 (EPA, IP with AWWA); and Nashville regional field test (S&amp;T)</td>
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<td>2</td>
<td>Green</td>
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## Ratio Scale Methods

- **CISR Risk Management Process Design:** Life, Emer. Mgmt., All
- **Common Risk Model – Dams (USACE):** Dams
- **Component Level Risk Mgt for Bridges (FHWA):** Bridges
- **Component Level Risk Mgt for Tunnels (TSA):** Tunnels
- **Costing Asset Protections for Transportation Agencies (CAPTA, DOT):**
- **J100-10 (EPA, IP with AWWA); and Nashville regional field test (S&T):** Water, Waste, water, Elect., etc.
- **J100-15 (AWWA), in progress:** Water, Waste, water, Elect., etc
- **Threat & Hazard Identification & Risk Assessment (THIRA, FEMA):** Community Capabilities

## Ordinal Scale Methods

### Notes:
1. Scenarios: A = all; M = malevolent only; N = natural only
2. CRM uses $T = 1.0$ for single-dam assessments, but uses an “adversary value model” $T = F(V,C)(\text{dam attack})$ to establish a relative risk for a set of dams.
3. Risk is conditional risk, assuming threat likelihood $= 1.0$.
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# Review of Federal Lifeline CISR Tools

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<td>Costing Asset Protections for Transportation Agencies (CAPTA, DoT)</td>
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<td>A</td>
<td>3</td>
<td>4</td>
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<td>Maritime Security Risk Method (USCG)</td>
<td>Port</td>
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<td>State Energy Assessments (DOE)</td>
<td>Electricity</td>
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<td>Voluntary Chemical Assessment Tool (VCAT, IP)</td>
<td>Chemical</td>
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<tr>
<td>Vulnerability Assessment Framework (FHWA)</td>
<td>Highways</td>
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**Degree Satisfied**

- Required
- Fully
- Partially

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#### Ordinal Scale Methods

| Maritime Security Risk Method (USCG)                                                | Port        |           |       |        |                      | 3                       |
| State Energy Assessments (DOE)                                                      | Electricity |           |       |        |                      | 3                       |
| Voluntary Chemical Assessment Tool (VCAT, IP)                                       | Chemical    |           |       |        |                      | 3                       |
| Vulnerability Assessment Framework (FHWA)                                           | Highways    |           |       |        |                      | 3                       |
| Vulnerability Assessment Scoring Tool (VAST, FHWA)                                  | Highways    |           |       |        |                      | 3                       |

#### Degree Satisfied

- **Required**
- **Fully**
- **Partially**

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5. Dependencies are modeled as loss of supply of critical resources, including utilities, personnel, supplies, and proximity, but are not analyzed across infrastructures.
5. Measure Effectiveness

E.2 Enterprise Infrastructure
- Define & screen assets based on mission
- Confirm threat-asset scenarios

E.3 Enterprise Risk Analysis
- Calculate baseline risk & fragility for enterprise (1)
- Aggregate enterprise baseline risk & fragility

E.4 Enterprise Implementation
- Define options to reduce risk & fragility
- Calculate option's net benefits
- Select options for enterprise funding, assess uncertainties
- Aggregate enterprise risk & fragility objectives
- Implement chosen options

E.5 Enterprise Effectiveness Measurement
 Outputs: Were chosen options implemented as planned?
 Outcomes:
  - Document actual events & exercises
  - Estimate actual enterprise & regional post-option risk & fragility for CISR progress
  - Aggregate actual enterprise risk & fragility

Each Participating Enterprise

(1) Risk = Threat Likelihood x Vulnerability x Consequences = R = T x V x C
Fragility = Threat Likelihood x Vulnerability x Outage = F = T x V x O
Where: Outage = Average Daily Unmet Demand x No. of Days
5. Measure Effectiveness

E.1 Enterprise Goals
- Negotiate info sharing
- Define & weight enterprise objectives
- Select threats & hazards

E.2 Enterprise Infrastructure ID
- Define & screen assets based on mission
- Confirm threat-asset scenarios

E.3 Enterprise Risk Analysis
- Calculate baseline risk & fragility for enterprise (1)
- Update enterprise & regional risk & fragilities for dependencies
- Aggregate enterprise baseline risk & fragility

E.4 Enterprise Implementation
- Define options to reduce risk & fragility
- Calculate options' net benefits
- Select options for enterprise funding, assess uncertainties
- Implement chosen options

E.5 Enterprise Effectiveness Measurement
- Outputs: Were chosen options implemented as planned?
- Outcomes:
  - Document actual events & exercises
  - Estimate actual enterprise & regional post-option risk & fragility for CISR progress
  - Aggregate actual enterprise risk & fragility

R.1 Regional Goals
- Organize regional coalition
- Develop information sharing protocol
- Define & weight regional objectives
- Select threats & hazards

R.2 Regional Infrastructure ID
- Define & screen essential regional systems
- Select threat-system scenarios

R.3 Regional Risk Analysis
- Analyze dependencies; confirm cascades
- Estimate regional CI baseline risk & fragility with dependencies
- Aggregate regional baseline risk & fragility

R.4 Regional Implementation
- Analyze dependencies; confirm cascades
- Estimate regional CI baseline risk & fragility
- Aggregate regional risk & fragility objectives
- Implement chosen options

R.5 Regional Effectiveness Measurement (Outcomes)
- Outputs: Were chosen options implemented as planned?
- Outcomes:
  - Document actual events & exercises
  - Estimate actual regional post-option risk & fragility for CISR progress
  - Aggregate actual regional risk & fragility

Each Participating Enterprise OR Incentive Grantor

Voluntary Regional Coalition

Information Sharing & Protection

R2 = TVC

Where: Outage = Average Daily Unmet Demand x No. of Days

Figure 2. NIPP 2013 CI Risk Management Framework & Summary of Regional CISR Risk Management Process

(1) Risk = Threat Likelihood x Vulnerability x Consequences = R = T x V x C
Fragility = Threat Likelihood x Vulnerability x Outage = F = T x V x O

Each Column is a Core Phase (e.g. 1. Set Goals & Objectives) and Each Arrow Represents an Activity (e.g. Incentives, Outputs, Outcomes, Dependencies)

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<table>
<thead>
<tr>
<th></th>
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<tr>
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<td><strong>E.3 Enterprise Risk Analysis</strong></td>
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<td>• Negotiate info sharing</td>
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<td>• Calculate baseline risk &amp; fragility for enterprise (1)</td>
<td>• Define options to reduce risk &amp; fragility</td>
<td><strong>Outputs:</strong> Were chosen options implemented as planned?</td>
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<td>• Define &amp; weight enterprise objectives</td>
<td>• Confirm threat-asset scenarios</td>
<td>• Update enterprise &amp; regional risk &amp; fragilities for dependencies</td>
<td>• Calculate option’s net benefits</td>
<td><strong>Outcomes:</strong></td>
</tr>
<tr>
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<td></td>
<td>• Aggregate enterprise baseline risk &amp; fragility</td>
<td>• Select options for enterprise funding; assess uncertainties</td>
<td>• Document actual events &amp; exercises</td>
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<thead>
<tr>
<th><strong>G.1 National/State Goals</strong></th>
<th><strong>G.2 National/State Infrastructure ID</strong></th>
<th><strong>G.3 National/State Risk Analysis</strong></th>
<th><strong>G.4 National/State Implementation</strong></th>
<th><strong>G.5 National/State Effectiveness Measurement (Outcomes)</strong></th>
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<tr>
<td>• Set CISR goals, policy &amp; strategy, e.g., PPD, NIPP</td>
<td>• National criticality studies</td>
<td>• Analyze inter-regional baseline dependencies</td>
<td>• Analyze inter-regional dependencies w/ both funded &amp; unfunded options</td>
<td><strong>(1) Risk = Threat Likelihood \times Vulnerability \times Consequences = \text{R} = T \times V \times C</strong></td>
</tr>
<tr>
<td>• Facilitate regional coalitions</td>
<td>• Advise on national hi-priority threat-asset pairs</td>
<td>• TT&amp;AQA to enterprises &amp; regions</td>
<td>• Provide grants &amp; incentives for locally unfunded risk/fragility mitigation options</td>
<td><strong>Fragility = Threat Likelihood \times Vulnerability \times Outage = \text{F} = T \times V \times O</strong></td>
</tr>
<tr>
<td>• Develop &amp; test CISR tools; train TT&amp;AQA(2)</td>
<td></td>
<td>• Provide guidance on man-made threats &amp; likelihood</td>
<td>• TT&amp;AQA to enterprises &amp; region</td>
<td>Where: <strong>Outage = Average Daily Unmet Demand \times No. of Days</strong></td>
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<td>• Provide intelligence to standard threat set</td>
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<td>• Develop models</td>
<td>• Provide guidance on man-made threats &amp; likelihood</td>
<td>\footnote{(1) Risk = Threat Likelihood \times Vulnerability \times Consequences = \text{R} = T \times V \times C}</td>
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\footnote{(2) TT&AQA = Training, Technical Assistance & Quality Assurance}
Bottom-up/Inside-out Implementation Approach

- Conventional “top-down/outside-in” implementations of Federal risk/resilience tools & methods have failed
- Proposed is a “bottom-up/inside-out” approach
  - Highly tailored to individual enterprises’ on-going processes
  - But with common logic, terms & basic process to yield results consistent & comparable enough for interdependencies & aggregation
  - Adapting on-going processes to incorporate risk/resilience analysis process as routine SOP
  - Integrated with regional organizing and regional analysis building
  - Incentives can be tailored to specific, local needs – minimizes “free riders” – maximizes incentive impact per dollar
- The process shouldn’t be a “tool,” but an open model process or standard, implemented through a variety of compliant tools and locally developed variations, with consistency and comparability
Anticipated Long-Term Outcomes

- Reduced risk & fragility – i.e., increased security & resilience of infrastructures, agencies, enterprises, regions
- Increased investment in security & resilience from diverse conventional & unconventional sources, incl. incentives – Rationally allocated to maximize benefits given budgets
- Enterprise & CI risk/fragility management become ingrained in management & governance – in asset management & budgeting
- Federal outlays for disaster relief decrease significantly
- Communities become resilient to climate change and all hazards
- Massive reductions in fatalities, losses & outages
Acknowledgement
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Gap Analysis & Next Steps

- Current gaps in available tools – needed for application
  - Information sharing/protection protocol & model contract
  - Standard Threat/Hazard Set
  - Terrorism likelihood estimation by a Federal agency or committee
  - Analysis of cyber attacks on process controls & recovery times
  - Analysis of aging & overload risks (asset management systems)
  - Integrated modeling of CI interdependencies & economic activity
  - Sensitivity analysis of uncertainties that could change decisions
  - Outcomes evaluation by measuring risk/fragility reduction – governance & management – proof of concept

- Developmental Field Pilots: 3 or 4, after quick case studies

- Strategically deferred (for now) improvements
  - Full uncertainty capture of all key terms
  - Risk & fragility modeled by Monte Carlo simulation
  - Interdependencies modeled with full uncertainties & M.C. Post-event, real-time resource allocation & restoration sequencing