Analysis of the Fukushima Disaster: Reinforcement for using STAMP as a Vector of Safety Governance

Lucas STEPHANE
MS Experimental Psychology
MS Business Intelligence

Research Assistant
Florida Institute of Technology

March 28, 2013
MIT, MA

© Lucas STEPHANE, 03/28/2013

Research Context

- PhD Candidate, Human Centered Design Institute, Florida Institute of Technology

- PhD title: ***Visual Intelligence in Crisis Management***
- Expected graduation: November 2013

- ***Sponsor***: AREVA R&D, France

- ***Mission***: early exploration of relevant emerging technologies
- ***Vision***: sociotechnical Human-Centered ***Convergence***

- ***Research Focus***: D&E of a sociotechnical tool for Decision-Making support in Crisis Situations

- ***Target location***: distributed Crisis Units

© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights

- Accident investigated by several Japanese commissions (M. Aoki, G. Rothwell, 2013) generating reports (not all translated in English yet)
    - Hatamura, *Shimokobe*, *Kitazawa*, *TEPCO*, **Kurokawa**
- Lots of other reports generated since 2011
    - TEPCO
    - NISA
    - NRC State of the Art Reactor Consequence Analysis (SOARCA)

© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Kurokawa, 2012)

- Kurokawa Report (*Executive Summary*)
  - Nuclear Accident Independent Investigation Commission (NAIIC)
  - **Formed by the Diet of Japan** on October 17, 2011
  - Chaired by Prof. Kiyoshi Kurokawa
  - Report published on June 5, 2012

© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Kurokawa, 2012)

- **Root cause(s) manmade = *the hazard was inside the system***
  - Earthquake & tsunami of March 11, 2011 = high magnitude natural disasters
  - However, the Fukushima Daiichi was a **manmade disaster**
  - Could have been mitigated … by a **more effective human response**

- **Cultural impact on Safety Culture**
  - Specificities of the Japanese culture…
    - Ingrained conventions
    - Obedience
    - Reluctance to question authority
    - 'Sticking' with the program
    - **Except for Plant manager Yoshida who exercised strong leadership** (Aoki & Rothwell, 2013)
    - **Except for the Fukushima 50 (++)**

- **Learning rather than Blame Culture**
  - The goal is not – and should not be – to lay blame
  - The **goal must be to learn from this disaster**, and reflect deeply on its fundamental causes

- **Similar to STAMP guidelines**
- **However, *after* the accident (cf. STAMP findings…)**

© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Kurokawa, 2012)

Large scale Investigation

- 900 hours of hearings & interviews with 1,167 people
- 9 visits to NPP (including Fukushima Daiichi & Daini)
- Maximum degree of information disclosure through 19 commission meetings open to the public & broadcast on Internet
- Use of Social media for gathering comments (170,000 received)
- International meetings with experts

Focus on witnesses who held responsible positions at the time of the accident:

- Government
- TEPCO
- Nuclear regulators

Gathering direct feedback from evacuees

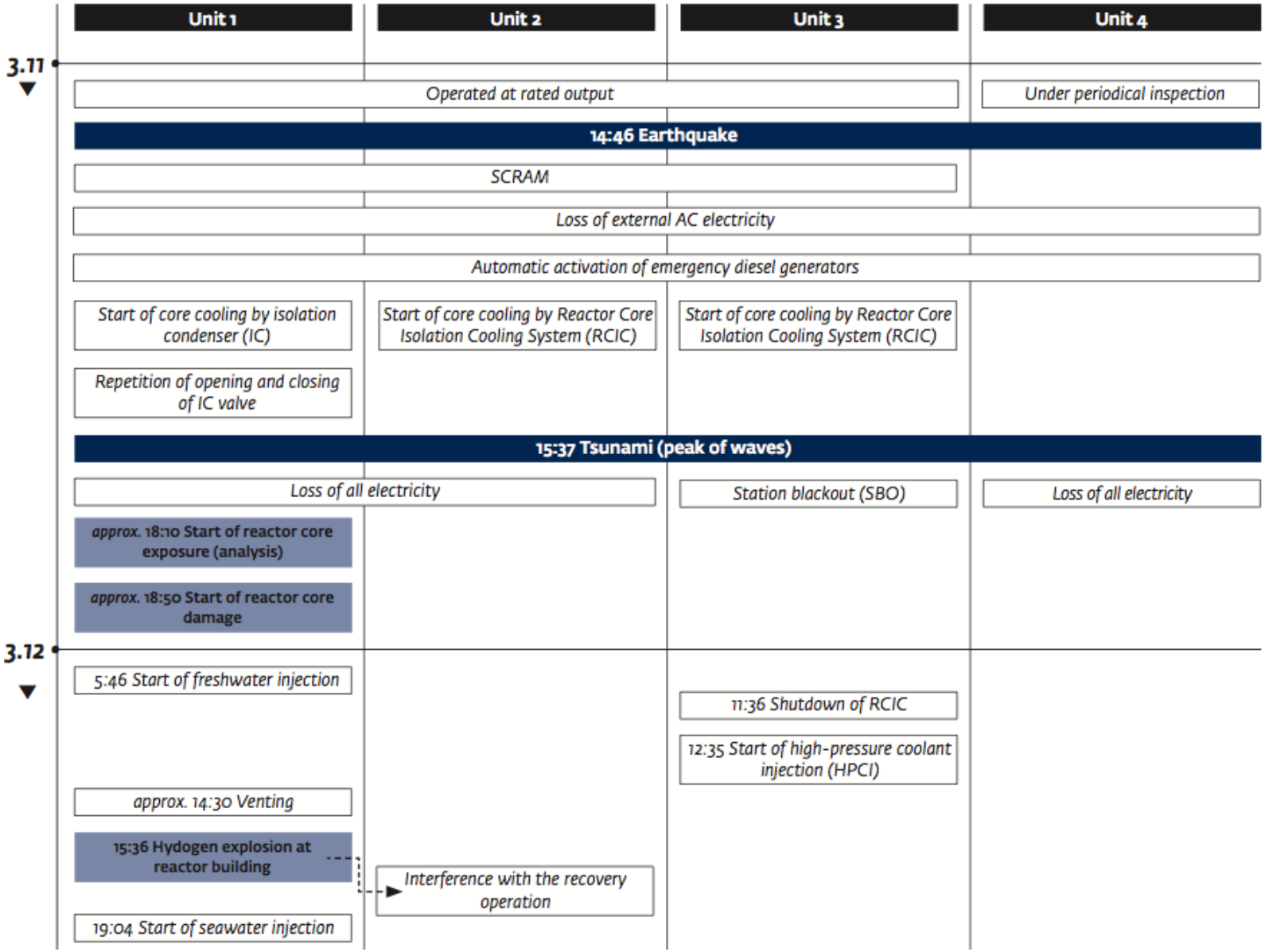
- 3 town hall meetings with 400 people

Survey and interviews with evacuees & NPP workers in 12 municipalities

- 10,633 responses from residents
- Many responses from workers from about 500 contractors

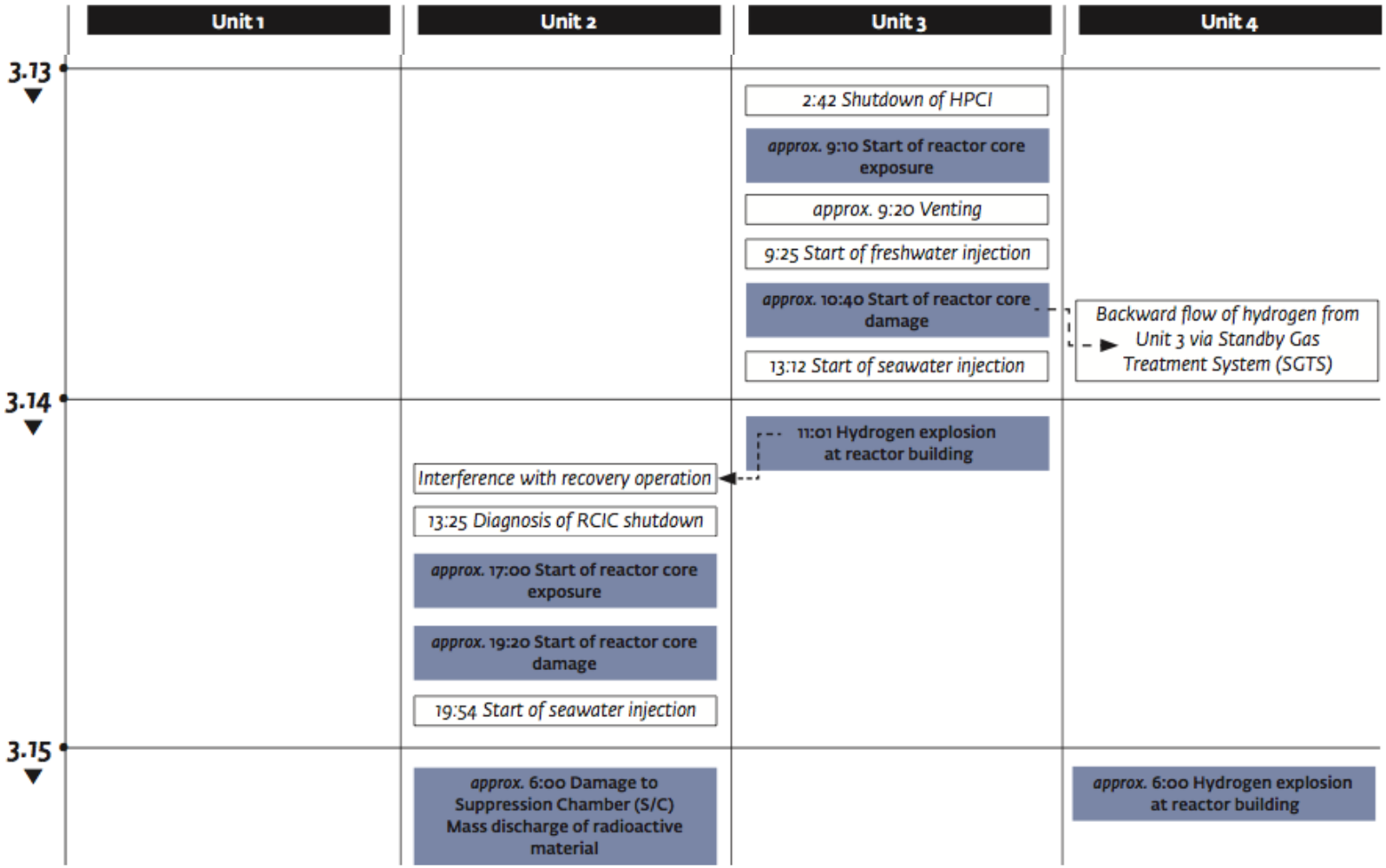
© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Kurokawa, 2012)



© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Kurokawa, 2012)



© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Kurokawa, 2012)

(some) **Conclusions of the Investigation**

"In order to prevent future disasters

- **fundamental reforms must take place**.
- These reforms must cover both the structure of the electric power industry
- and the structure of the related government and regulatory agencies
- as well as the operation processes.
- They must cover **both normal and emergency situations**."

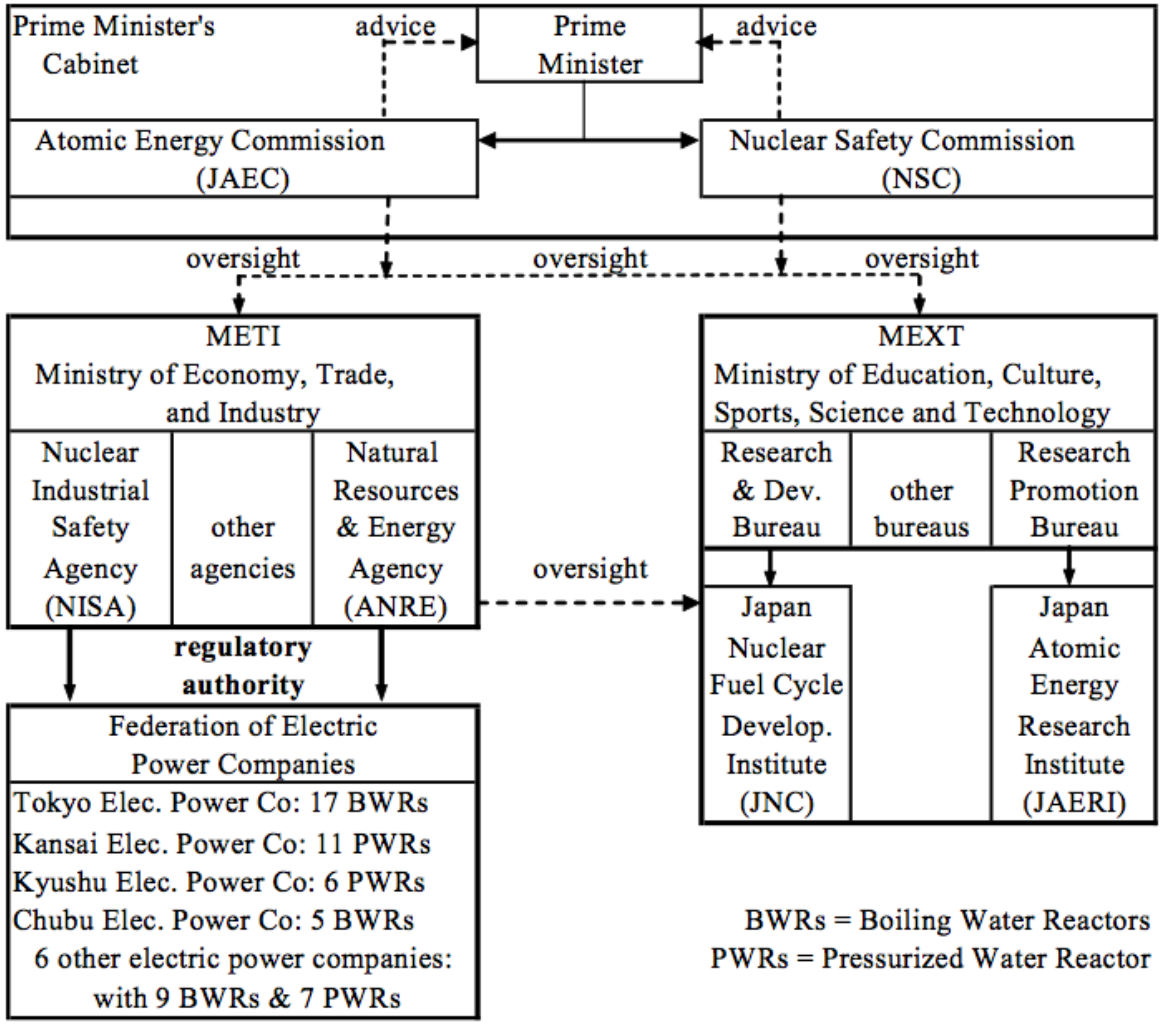
"A "manmade" disaster

- The TEPCO Fukushima Nuclear Power Plant accident was the **result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties**. […]
- Therefore, we conclude that **the accident was clearly "manmade."**
- We believe **that the root causes were the organizational and regulatory systems that supported faulty rationales for decisions and actions**, rather than issues relating to the competency of any specific individual."

© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Aoki & Rothwell, 2011)

Japan's Nuclear Industrial Complex Organization Chart

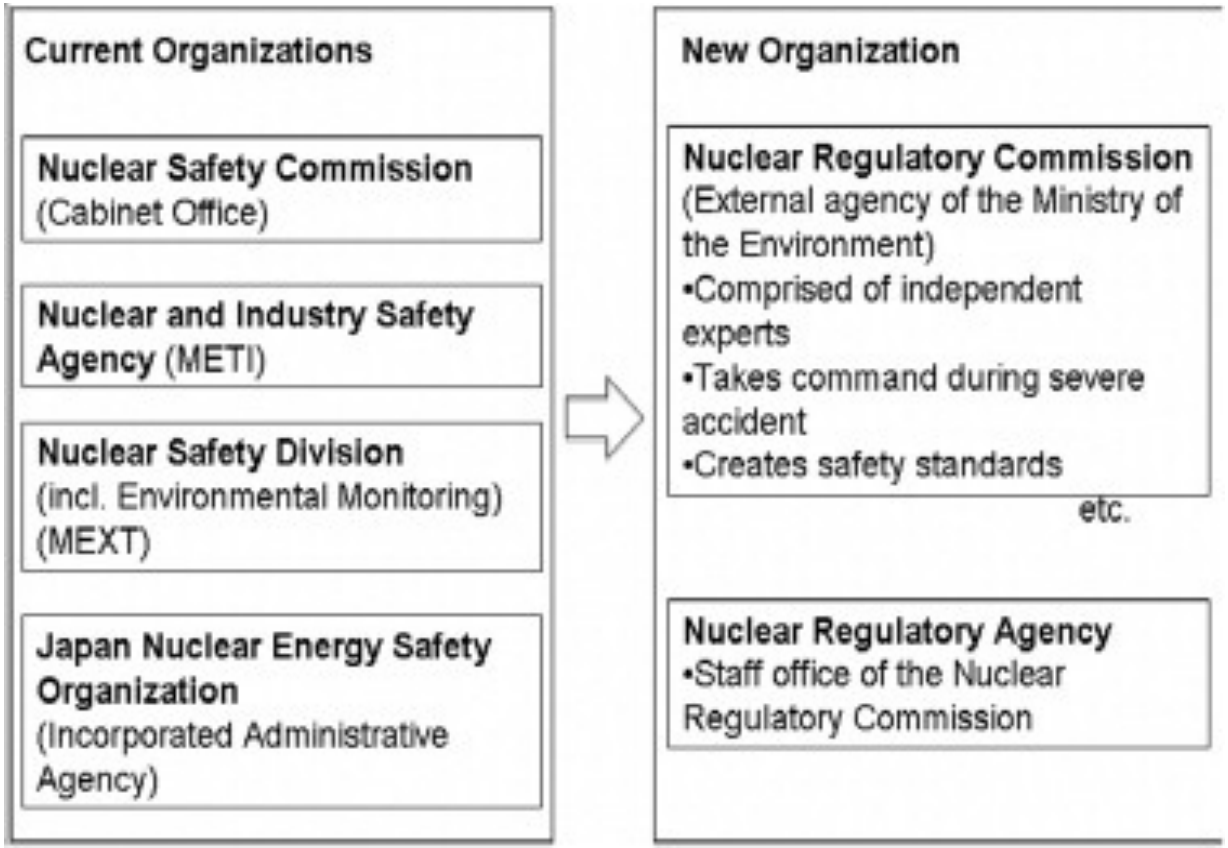


Source: http://www-pub.iaea.org/MTCD/Publications/PDF/CNPP2011_CD/countryprofiles/Japan/Japan2011.htm

© Lucas STEPHANE, 03/28/2013

Fukushima Daiichi highlights (Aoki & Rothwell, 2013)

Restructuring the Complex Organizational Chart…



- **the clear separation of nuclear plant management and their regulator is imperative**
  - **Modularity proposed by Aoki & Rothwell (2013)**

© Lucas STEPHANE, 03/28/2013

STAMP as a Vector of Safety Governance (I)

Governance

- Defines the organizational core & long-term values
  ⇒ **Systems Safety should be such a value**

- Spans
  - Mission
  - Vision
  - Strategy

- Determines who has authority and responsibility for making decisions (SOA RA, 2008; section 5.1.1)

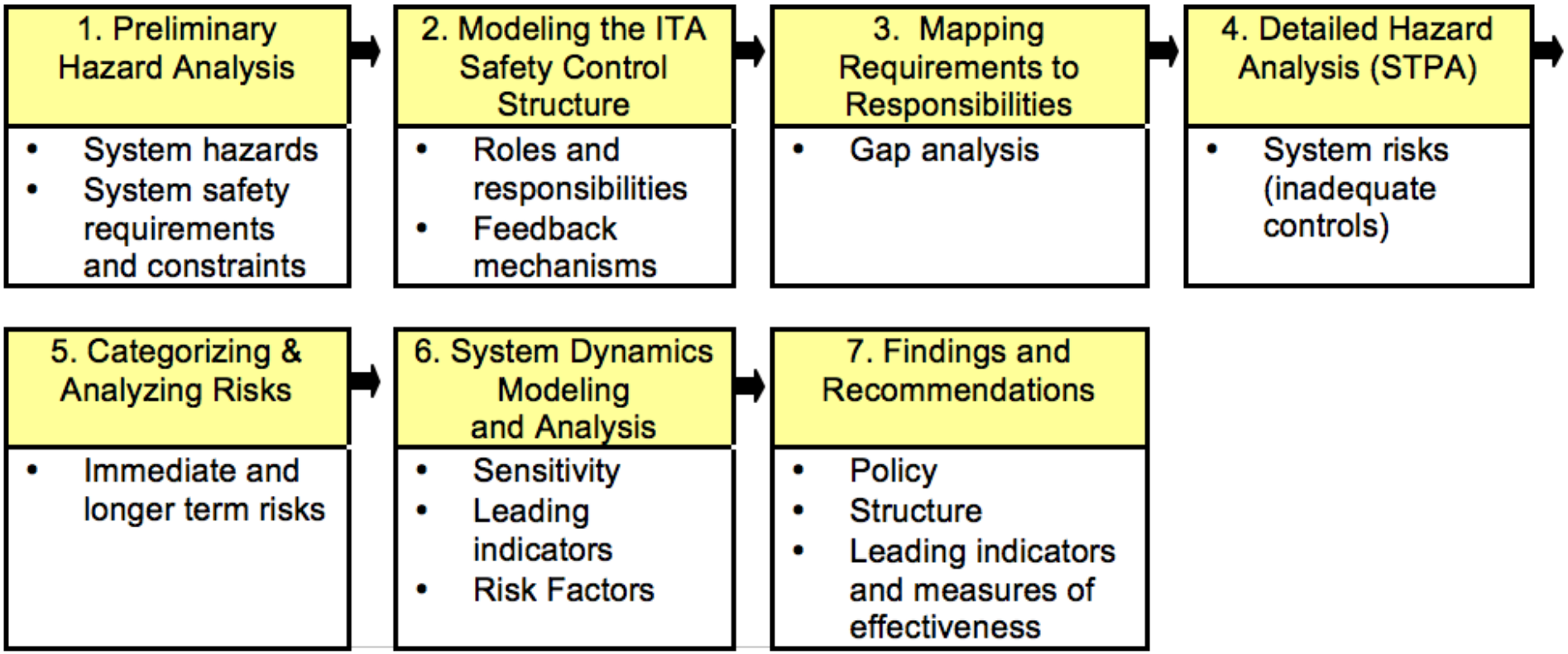
Management

- is the actual process of making, implementing, and measuring the impact of those decisions (SOA RA, 2008; section 5.1.1)

STAMP as a Vector of Safety Governance (I)

For Organizational Restructuring

- STAMP-based past work performed for Risk Analysis of the NASA Independent Technical Authority (Leveson et al., 2005)
- Rigorous approach for Organizational Risk Analysis



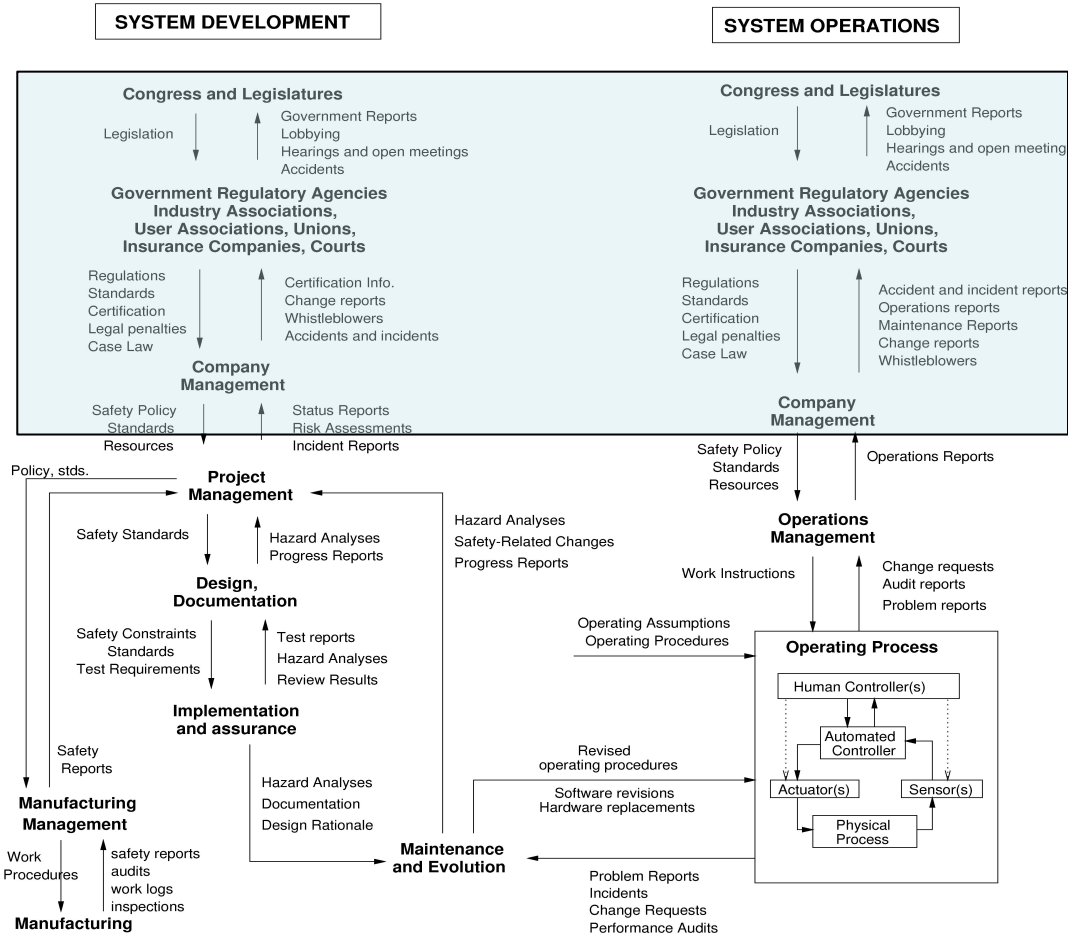
© Lucas STEPHANE, 03/28/2013

STAMP as a Vector of Safety Governance (I)

For Organizational Restructuring

- Identify Safety Control Structure also in the higher levels
- Identify Senior Management 'mental models'

- Identify types of control at the top of the hierarchy
  (i.e. who is the controller above)



Leveson, 2004, 2011

© Lucas STEPHANE, 03/28/2013

STAMP as a Vector of Safety Governance (II)

For Emergency/Crisis Management

Expanding STAMP with
- Uncertainty
- Uncertainty Culture (Yoe, 2011)
- Unknowns: KUUUB (Fenton & Neil, 2012)
- Dynamic Contexts

- Starting with CAST for identifying the causality structures
- Readapting processes & resources with STPA
- Assessing 'what-if' consequences

- Focus on Control Actions (i.e. proactive), their feasibility & their risk analysis

- Extend the existing STAMP inter et intra-communication (Design & Operations) with Safety-Related Communication toward the public (i.e. evacuation, etc.)

© Lucas STEPHANE, 03/28/2013

STAMP as a Vector of Safety Governance (II)

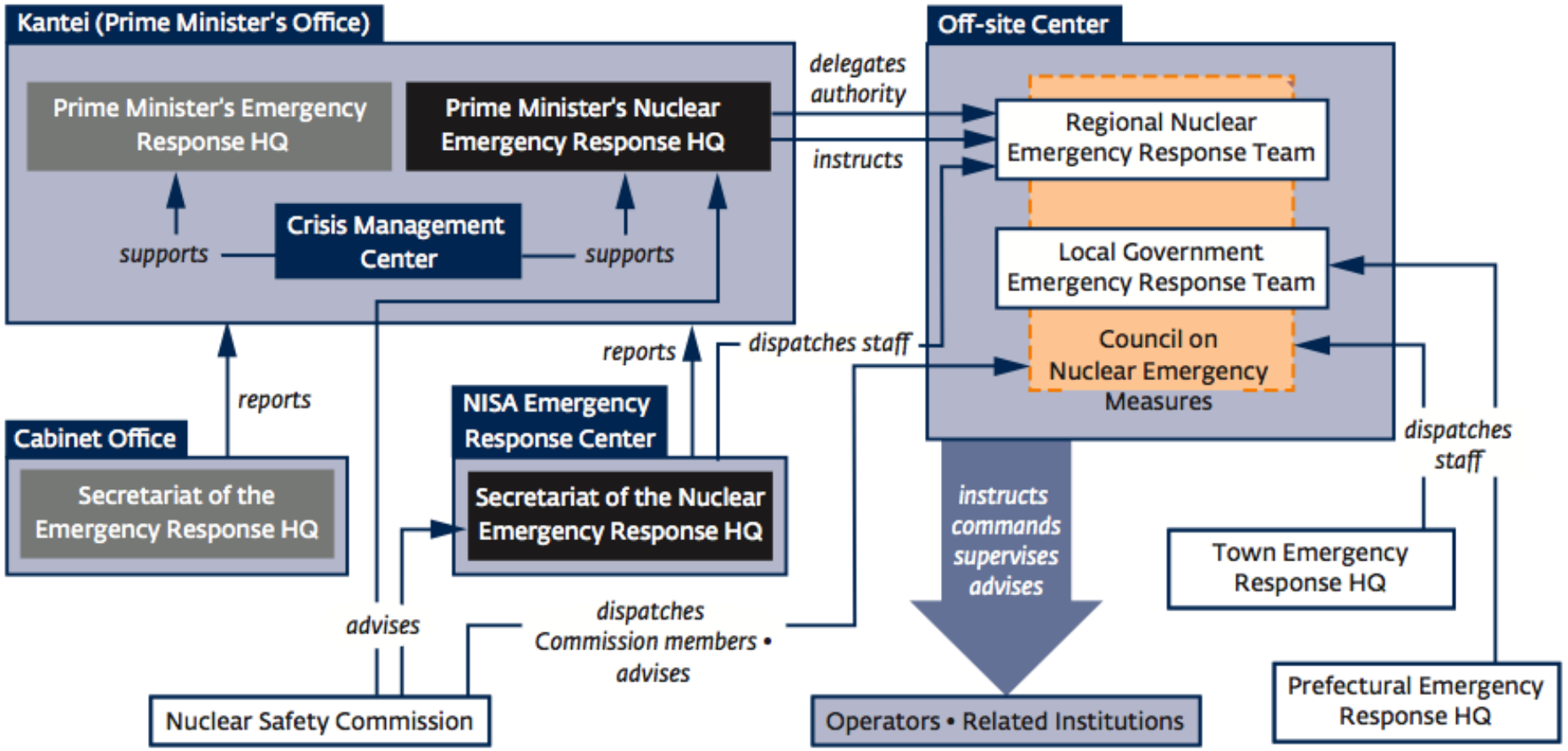
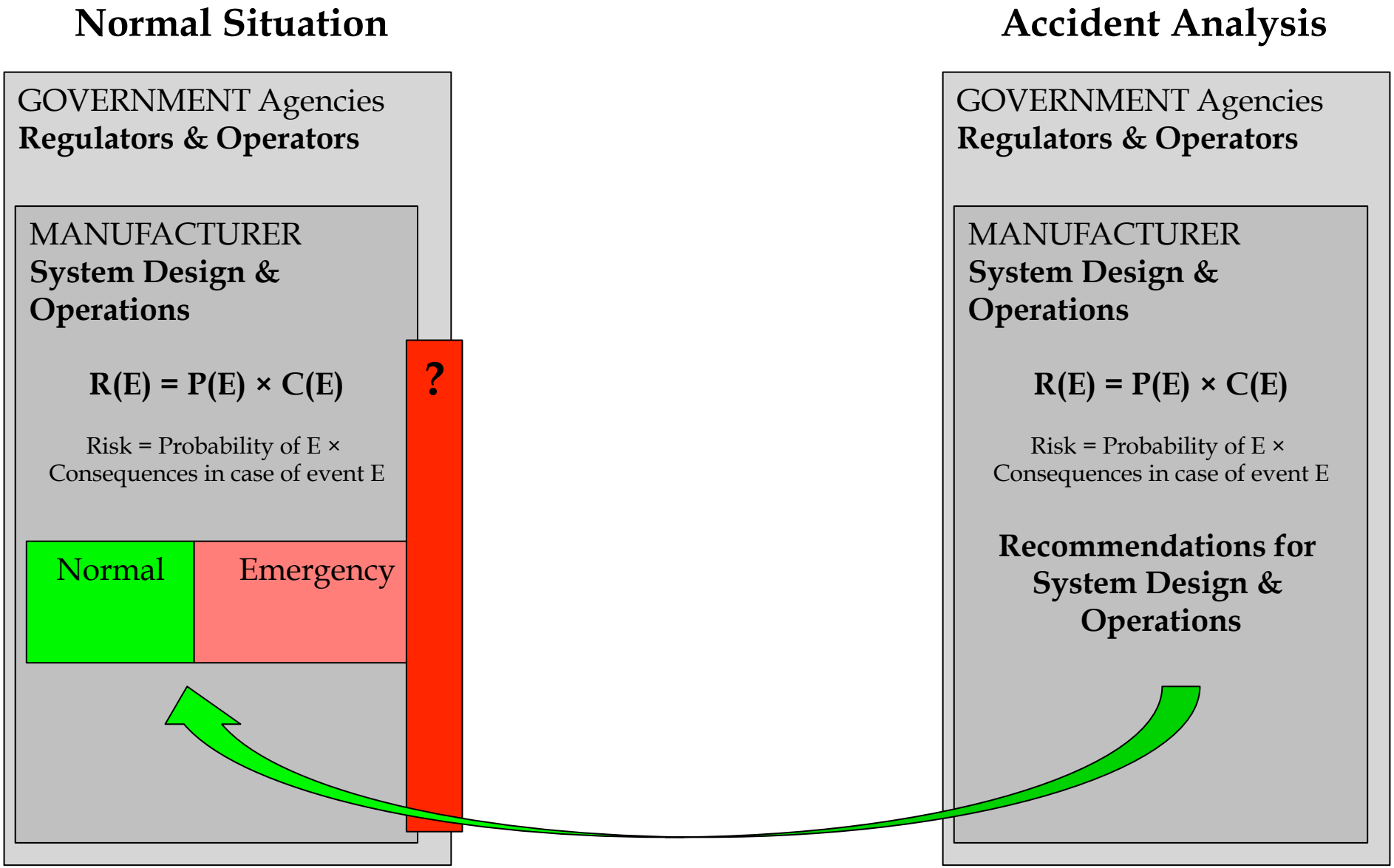


Diagram of the Emergency Communication Protocol, Kurokawa, 2012

Language Game (PM Kan in Aoki & Rothwell, 2013)

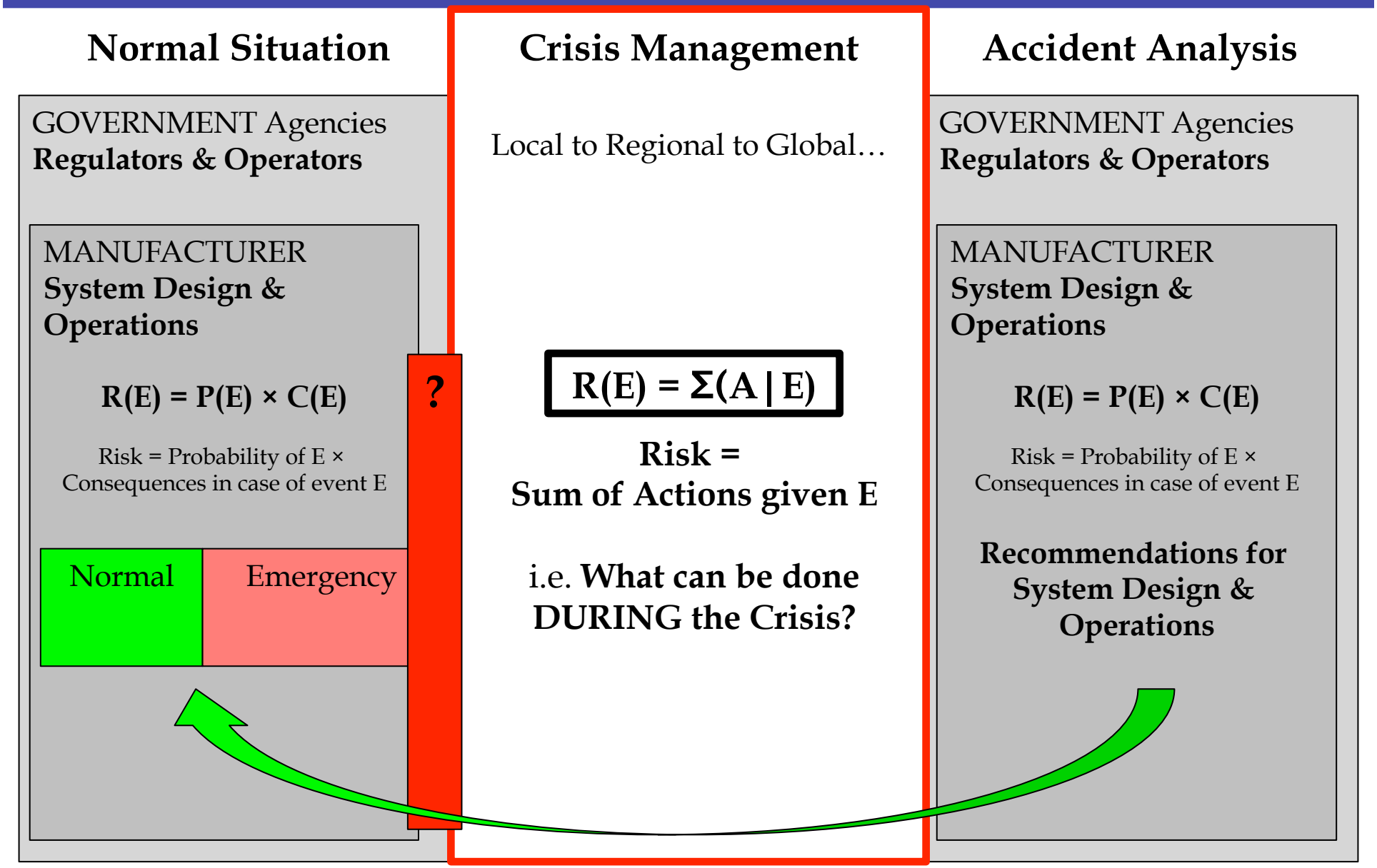
© Lucas STEPHANE, 03/28/2013

Systems Design & Accident Analysis



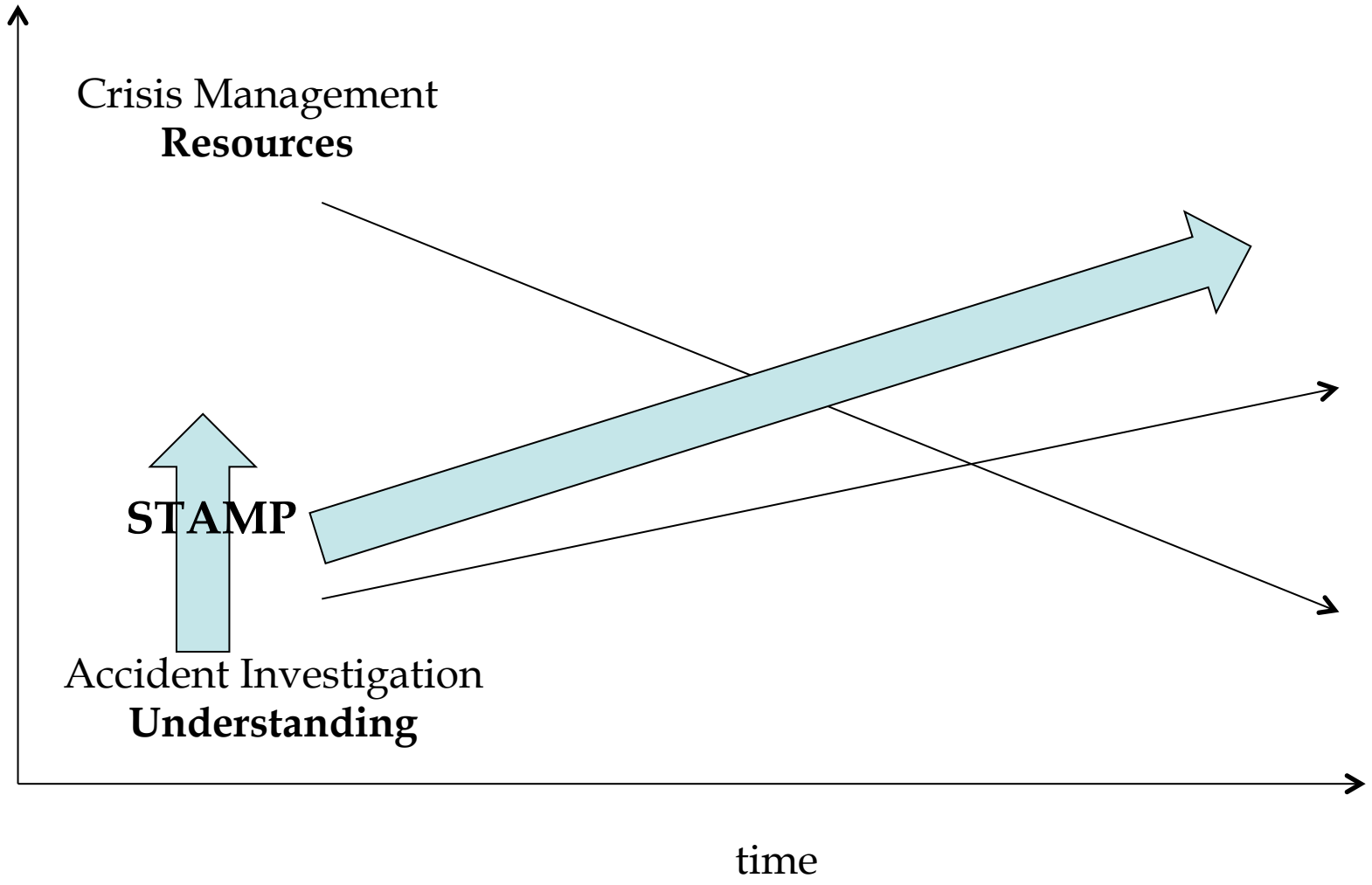
© Lucas STEPHANE, 03/28/2013

Crisis Management Layer…



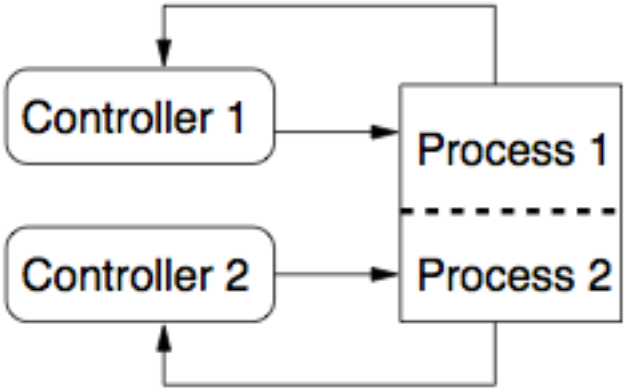
© Lucas STEPHANE, 03/28/2013

Crisis Management Layer…

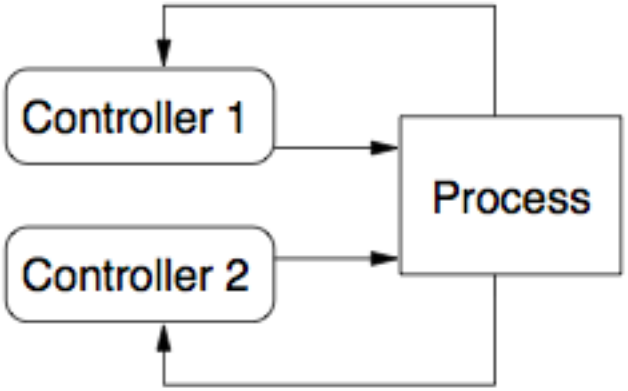


© Lucas STEPHANE, 03/28/2013

Coordination & Collaboration



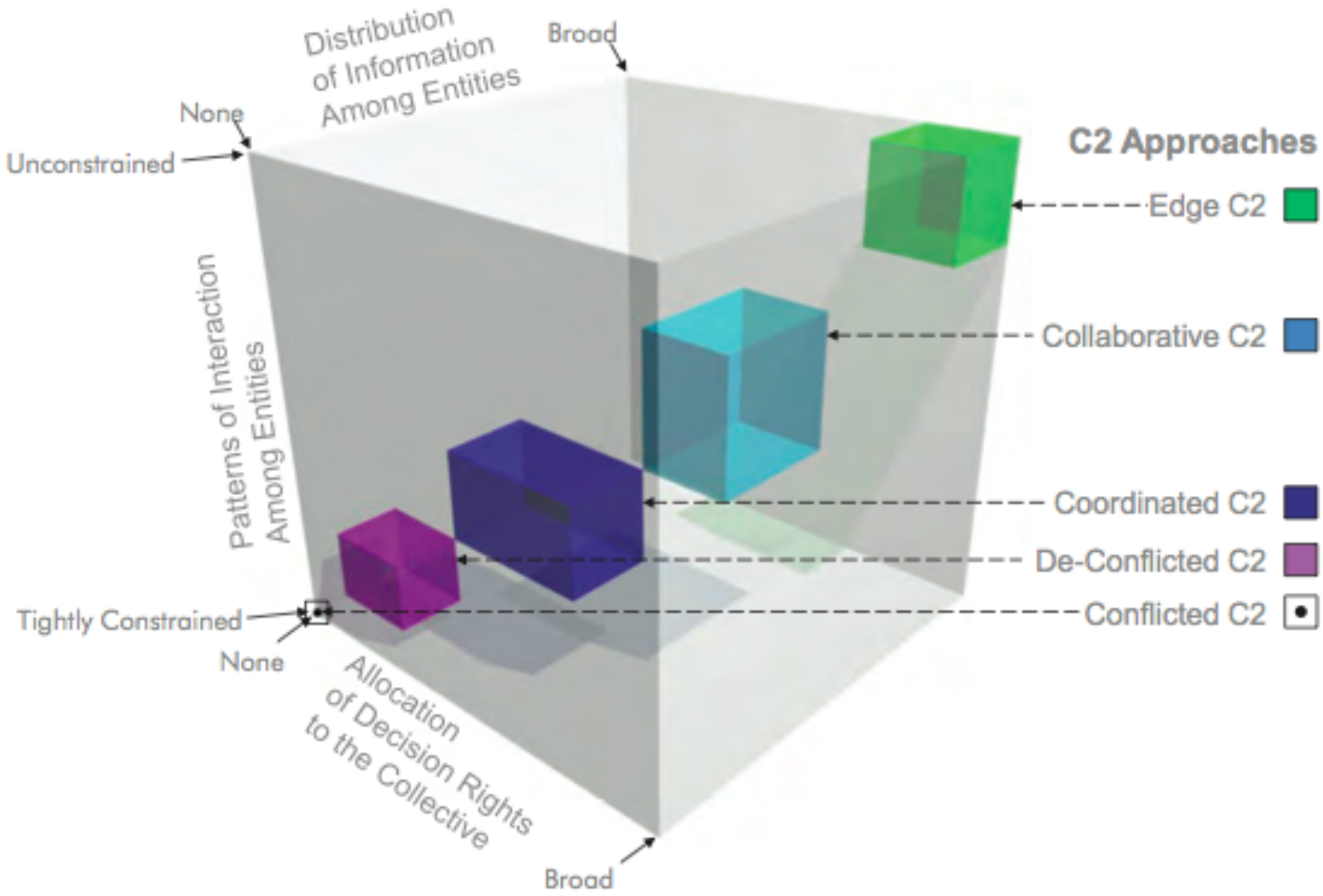
Boundary Areas



Overlapping Control

Leveson, 2004

Crisis Theory – Edge



Moffat, 2011

© Lucas STEPHANE, 03/28/2013

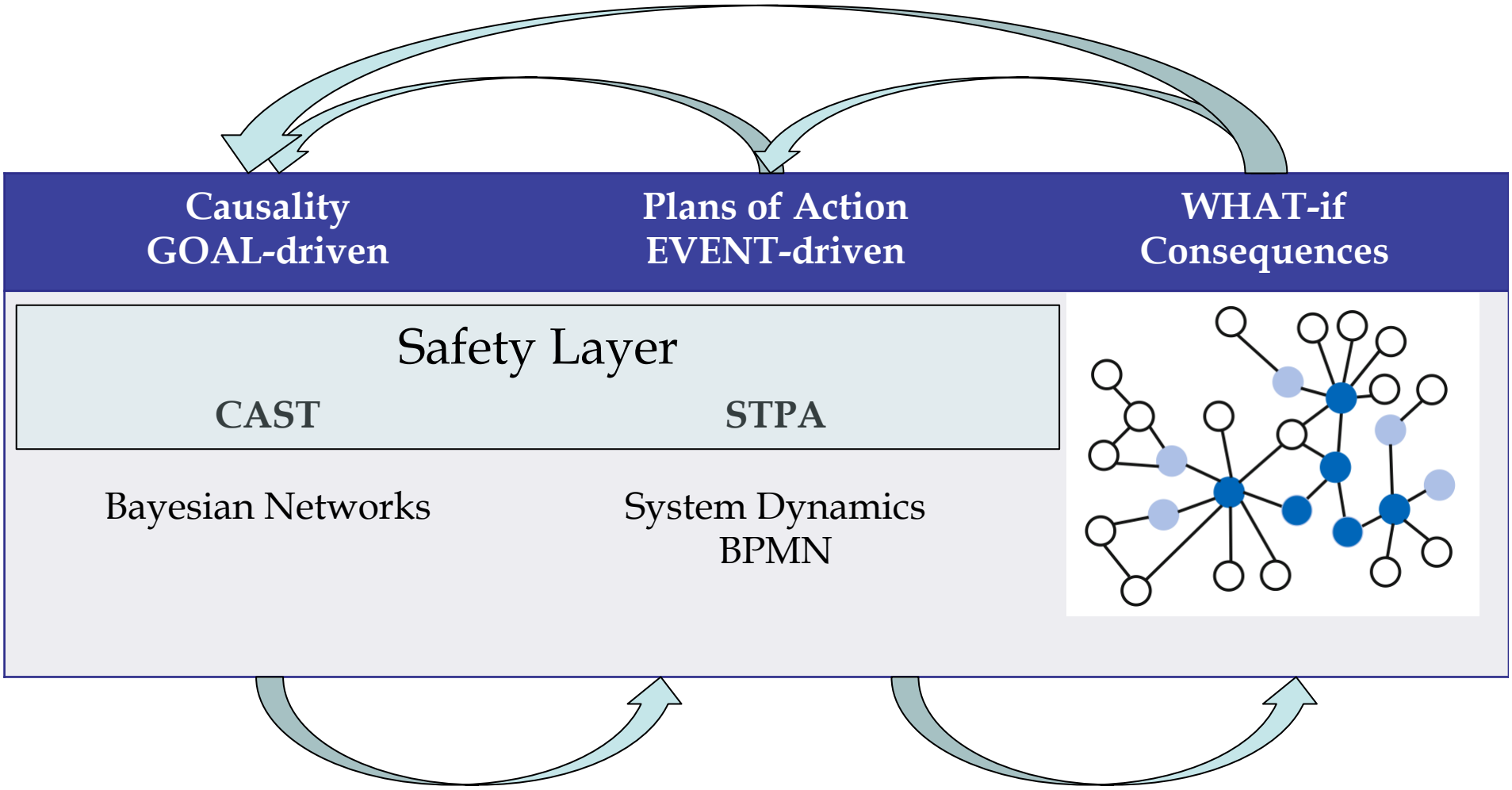
Crisis Theory

- **Fractal** approach (Topper & Lagadec, 2013)
    - No top-down hierarchy **during** the crisis
- 4 **Fractal** Dimensions
    - **Spatial**: Working in parallel from local to regional, national, continental & global scales
    - **Temporal**: Leveraging instantaneous dynamics (i.e. social networks, crisis mappers,…)
    - **Actors**: From social groups to individual responsibility & involvement
    - **Making sense**: multiple subjective sense-making processes

© Lucas STEPHANE, 03/28/2013

Crisis Theory

A fractal proposal…



© Lucas STEPHANE, 03/28/2013

Conclusions

- From **practice background** (i.e. NASA ITA, Leveson et al., 2005)
    - STAMP could be very useful in helping the current restructuring in Japan (or elsewhere if needed…)

- From **theoretical research**
    - STAMP could be very useful for Crisis Management
        - By explicitly tackling safety on top of other more general models

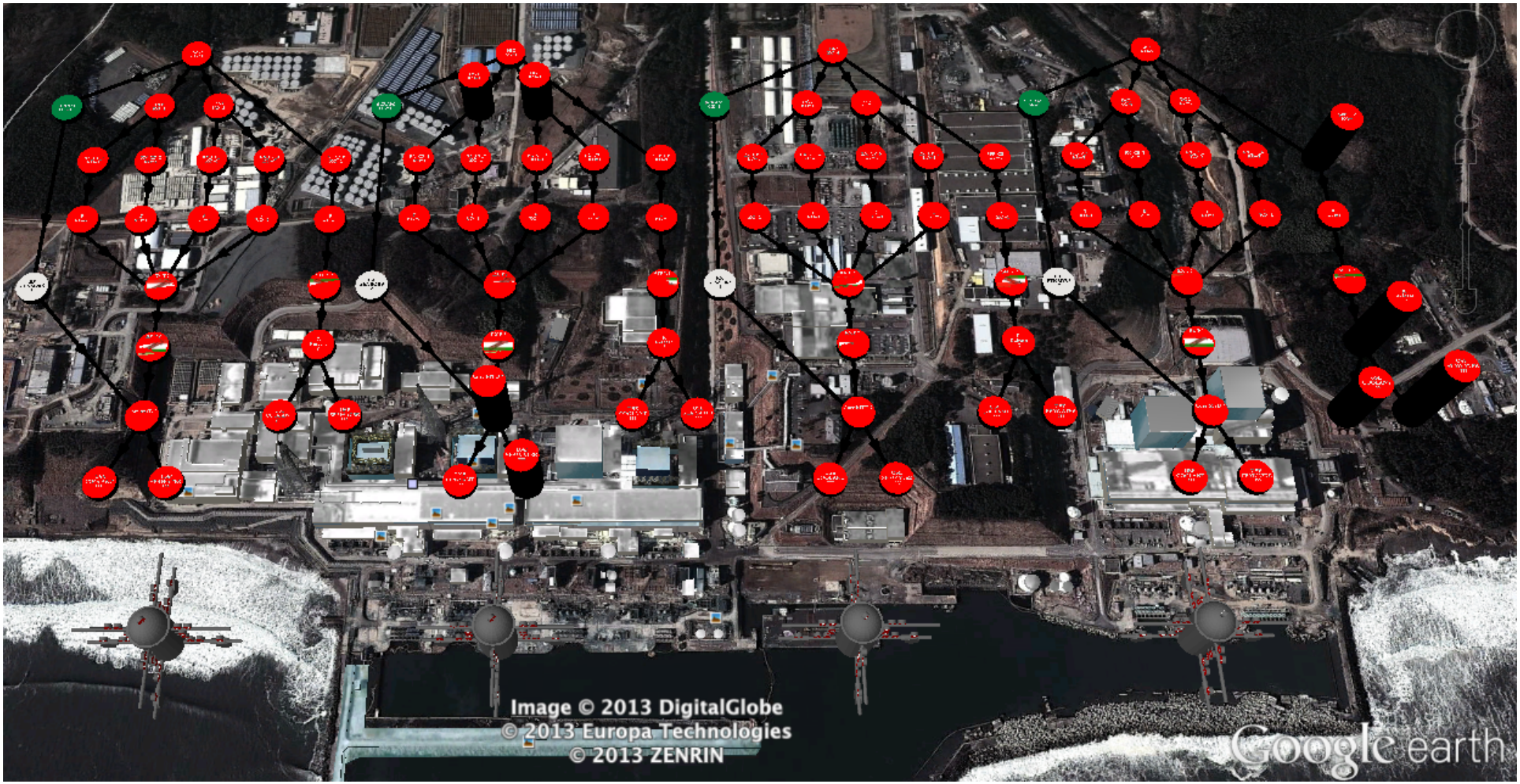
- STAMP should be employed for Safety Governance (conclusions of the Fukushima disaster analyses)

Discussion…

Thanks for your feedback & feedforward

- I am interested in Definitions of Risk **other than** R=P x C
- If you have any, please send them to:
  astephane2010@my.fit.edu
  http://www.linkedin.com/in/lucasstephane

Prototype…



Google Earth: Fields of <u>Structured</u> Information…

Acknowledgements…

- Dr. Nancy Leveson, MIT

- Dr. Guy Boy, FIT
- Dr. Semen Köksal, FIT
- Dr. Jeff Bradshaw, IHMC
- Dr. Andrew Duchowski, Clemson
- Dr. Marco Carvalho, FIT

- Areva HF Expert Ludovic Loine

- Ret. Astronaut Winston E. Scott, FIT
- Dr. Patrick Lagadec, Ecole Polytechnique, FR
- Dr. Charles Yoe, Notre Dame of Maryland University
- Dr. Christophe Kolski, Univ. Valenciennes, FR
- Dr. Sherry Borener, FAA

© Lucas STEPHANE, 03/28/2013

References

- Aoki, M., Rothwell, G. Organizations under Large Uncertainty: An Analysis of the Fukushima Catastrophe. NEPI Working Paper, Oct. 7, 2011
- Aoki, M. Rothwell, G. A comparative institutional analysis of the Fukushima nuclear disaster: Lessons and policy implications. *Energy Policy* 53 (2013) 240-247
- Fenton, N., Neil, M. Risk Assessment and Decision Analysis with Bayesian Networks. CRC Press, 2012
- Kurokawa, K. et al. The official report of The Fukushima Nuclear Accident Independent Investigation Commission: Executive summary. The National Diet of Japan, 2012
- Leveson, N. et al. Risk Analysis of NASA Independent Technical Authority. MIT, 2005
- Leveson, N. A New Accident Model for Engineering Safer Systems. *Safety Science*, Vol. 42, No. 4, April 2004, 237-270
- Leveson, N.G. Engineering a Safer World: Systems Thinking applied to Safety. MIT Press, 2011
- McCabe, F.G. et al. Reference Architecture for Service Oriented Architecture Version 1.0. OASIS, 2008
- Moffat, J. Adapting Modeling & Simulation for Network Enabled Operations. Crown Copyright, 2011
- Topper, B., Lagadec, P. Fractal Crises – A new Path for Crisis Theory and Management. *Journal of Contingencies and Crisis Management*, Vol. 21, No. 1, March 2013
- Yoe, C. Principles of Risk Analysis: Decision Making Under Uncertainty. CRC Press, 2011

© Lucas STEPHANE, 03/28/2013