

## Proposal of a methodology for Downtime assessment of Natech accidents in Chemical industrial parks

○Jiang peiyin, Cruz Ana Maria

### Introduction

Natural hazard triggered technological accidents involving the release of hazardous materials are known as Natechs(Cruz, Suarez, 2019).

The Natechs triggered during the Great East Japan earthquake and other disasters have shown that the risk management of Natech hazards requires an area-wide perspective to ensure regional industrial resilience.



*Fig.1 Tank explosion caused by the 2011 earthquake of the Pacificoast of Tōhoku*

Downtime includes the time necessary to plan, finance, and complete repairs on facilities damaged in earthquakes or other disasters (Comerio, 2005). How to evaluate downtime is an important topic of risk management for industrial facilities to deal with disasters.

Natech events have proved to be more severe in terms of damage and may have broader environmental impacts than natural disasters themselves. (Khoirunissa Ariyanta et al, 2019)

### Research Purpose and Objectives

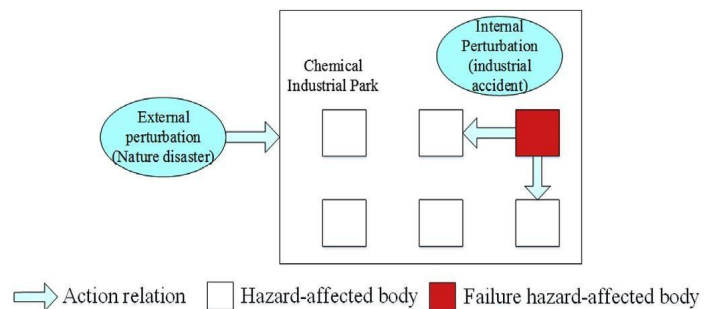
Even though various methodologies and research exist for the purposes of downtime assessment and calculation, now there is little downtime research on

the possibility of Natech events in some industrial facilities or chemical plants.

Some works focused only on rating performance based on individual risk (number of potential disasters per year). We urgently need a evaluation method or framework for Natech based on downtime.

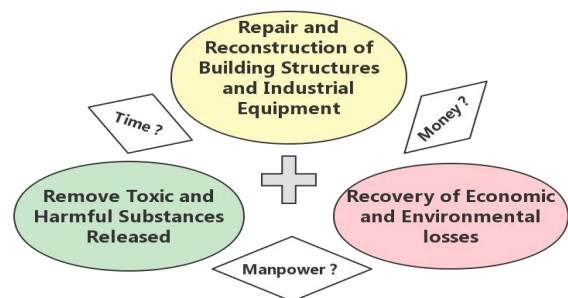
### Questions to explore

Finding out how the interaction happens in different bodies of the complex system(CIP).



*Fig.2 Interaction of different bodies in the CIP under disaster*

Prioritizing the time, economic and manpower resource of cost in these steps to improve recovery efficiency.



*Fig.3 Main recovery categories after Natech*

My aim is to developing an integrated model to assess downtime of oil refinery CIP under Natech scenarios.

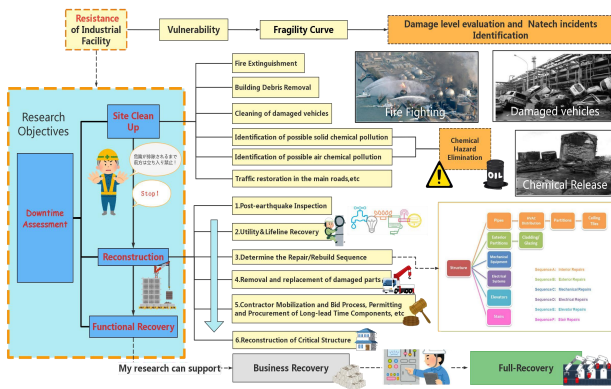


Fig.4 Important intermediate processes from shutdown to opening of a chemical plant after a disaster

### Literature Review

There are a few methodologies designed for downtime assessment in different fields. The REDi rating system is an engineering methodology of downtime evaluation.

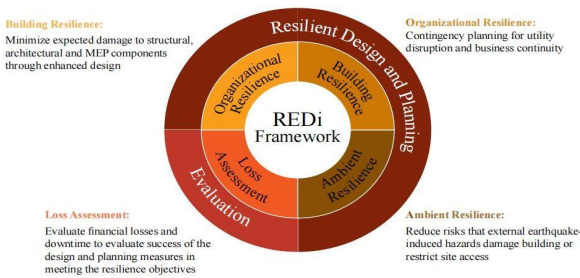


Fig.5 REDi Downtime Assessment (Almufti and Willford, 2013)

Almost all methods recognize the importance of building or structure repair time in the overall downtime. In addition to the important maintenance time, other factors that delay the start of repair are considered by different authors. At present, most of the modeling and analysis of downtime caused by natural disasters only focus on earthquake, just one type of natural disaster; At present, the downtime analysis is hardly related to the Natech events. The most important thing about the Natech event is how to deal with the hazardous materials released due to disasters, which depends on the local response.

Rating Framework: The whole system composed by the Natech risk management framework and the rating system is called Natech RateME. (SUAREZ PABA MARIA CAMILA, 2019)

It considers natural hazard threats in the design, construction, and operation of industrial facilities to ensure industrial safety. This framework can provide some categories and rating criteria about Natech.

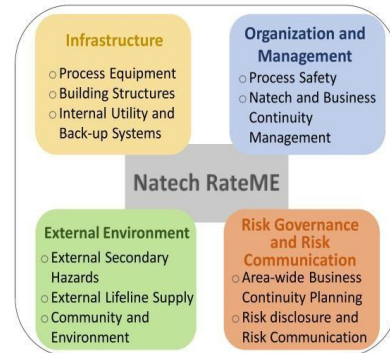


Fig.6 Four main categories and their components of Natech RateME framework

### Methodology

Resilience engineering method/Systems approach considering industrial factories as a complex system: Qi Tong et al. (2020) proposed a method based on dynamic Bayesian network (DBN) to assess the probability of system resilience by incorporating the time process of adaptation and recovery into the system function analysis. Chen et al. (2019) proposed a new quantitative methodology to carry out vulnerability assessment in Chemical Industrial Park based on CA (cellular automata) theory and GIS. And a partition method (Regional division) is proposed to assess the regional vulnerability. This method may be helpful to visualize the differences in downtime in different areas of the chemical plant. Using these two methods to model the process from shutdown to startup is the focus of this study.

### Thinking and future work

In the future work, how to evaluate the downtime from vulnerability to reconstruction or recovery is a problem that needs attention. The functional change of the CIP caused by the Natechs event may be a breakthrough, but the downtime thus derived should only include the maintenance and recovery phases. Before the post disaster reconstruction, some delay factors should also be consider.