

# Development of Metrics to Evaluate Effectiveness of Emergency Response Operations

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*The Future of C2*

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# Executive Summary

- ◆ 3 metrics are developed to describe the disaster event itself
- ◆ 8 metrics are developed to measure the effectiveness of response
- ◆ Primarily to be used in computer simulation with total information
- ◆ Could be used in a real world scenario

# Primary Motivation

- ◆ There will always be another disaster
- ◆ We can always do better in our response
- ◆ Need a method of comparison (Better than What!)



Photo Courtesy of FEMA [2]

# Problem Statement

- ◆ Idea of total preparedness
- ◆ Decentralized system of response
- ◆ Impossible to treat every locality individually
- ◆ How can we assess our ability to respond to catastrophic events

# Why?

- ◆ Lack a standardized system of measurement necessary for comparison [1]
- ◆ Need an objective way to identify deficiencies in response in order to improve
- ◆ Global applicability
- ◆ Funding

# Define Disaster

- ◆ Spatial-temporal event which abnormally negatively affects some population beyond its ability to mitigate the effects of the event
- ◆ Natural
- ◆ Artificial

# Define Responder

- ◆ Any person who actively engages in an organized effort to assist victims and mitigate the effects of a disaster
- ◆ Protection of lives and property

# The Use of Simulation

- ◆ Using real data is reactive and not proactive [1]
- ◆ Simulation provides a safe, cost-effective way to train responders and test technology
- ◆ Provides perfect information for more precise measurements

# Measuring a Disaster

- ◆ Geographic Scope
- ◆ Scope of Injuries
- ◆ Scope of Property Loss

# Disaster Metrics

- ◆ Total 2-D area of the region primarily and most directly affected by the disaster
- ◆ Matrix of injury types and severities as a percentage of the total population affected
- ◆ Matrix of property damage types and severities as a percentage of the total property affected

# Example of Injury Matrix

	Mild	Moderate	Severe	Death	
Respiratory	2.8%	1.9%	0.3%	0.2%	5.2%
Cardiac	2.5%	1.8%	0.3%	0.2%	4.8%
Broken Bones	11.0%	7.6%	1.3%	0.9%	20.8%
Crushing	5.9%	4.1%	0.7%	0.5%	11.2%
Lacerations	24.5%	16.8%	2.9%	1.9%	46.1%
Burns	2.0%	1.4%	0.2%	0.2%	3.8%
Unknown	4.3%	3.0%	0.5%	0.3%	8.1%
	53.1%	36.5%	6.3%	4.1%	

# Example of Damage Matrix

	Mild	Moderate	Severe	Total	
Concrete Building	6.3%	1.2%	0.2%	0.1%	7.9%
Wood Building	11.9%	2.3%	0.4%	0.3%	14.8%
Metal Building	16.7%	3.2%	0.6%	0.4%	20.8%
Roadway	9.0%	1.7%	0.3%	0.2%	11.2%
Bridge	8.1%	1.6%	0.3%	0.2%	10.1%
Transportation Vessel	9.8%	1.9%	0.3%	0.2%	12.2%
Power Infrastructure	11.3%	2.2%	0.4%	0.2%	14.1%
Communications	7.1%	1.4%	0.2%	0.2%	8.9%
	80.1%	15.4%	2.8%	1.7%	

# How to Measure Effectiveness

- ◆ Measuring Effectiveness vs. Performance [3][4]
- ◆ The Goal-Attainment approach
- ◆ Different ways to accomplish the same goal
- ◆ Measure Effectiveness regardless of disaster type

# Goals

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- ◆ Turn Chaos into Order
- ◆ Protect Lives and Property
- ◆ Stabilization
- ◆ Rescue
- ◆ Mitigation
- ◆ Safety

# Constraints

- ◆ FEMA's 4 stages of a disaster
- ◆ Only dealing with immediate assistance phase
- ◆ Only measuring the effect of *organized* response

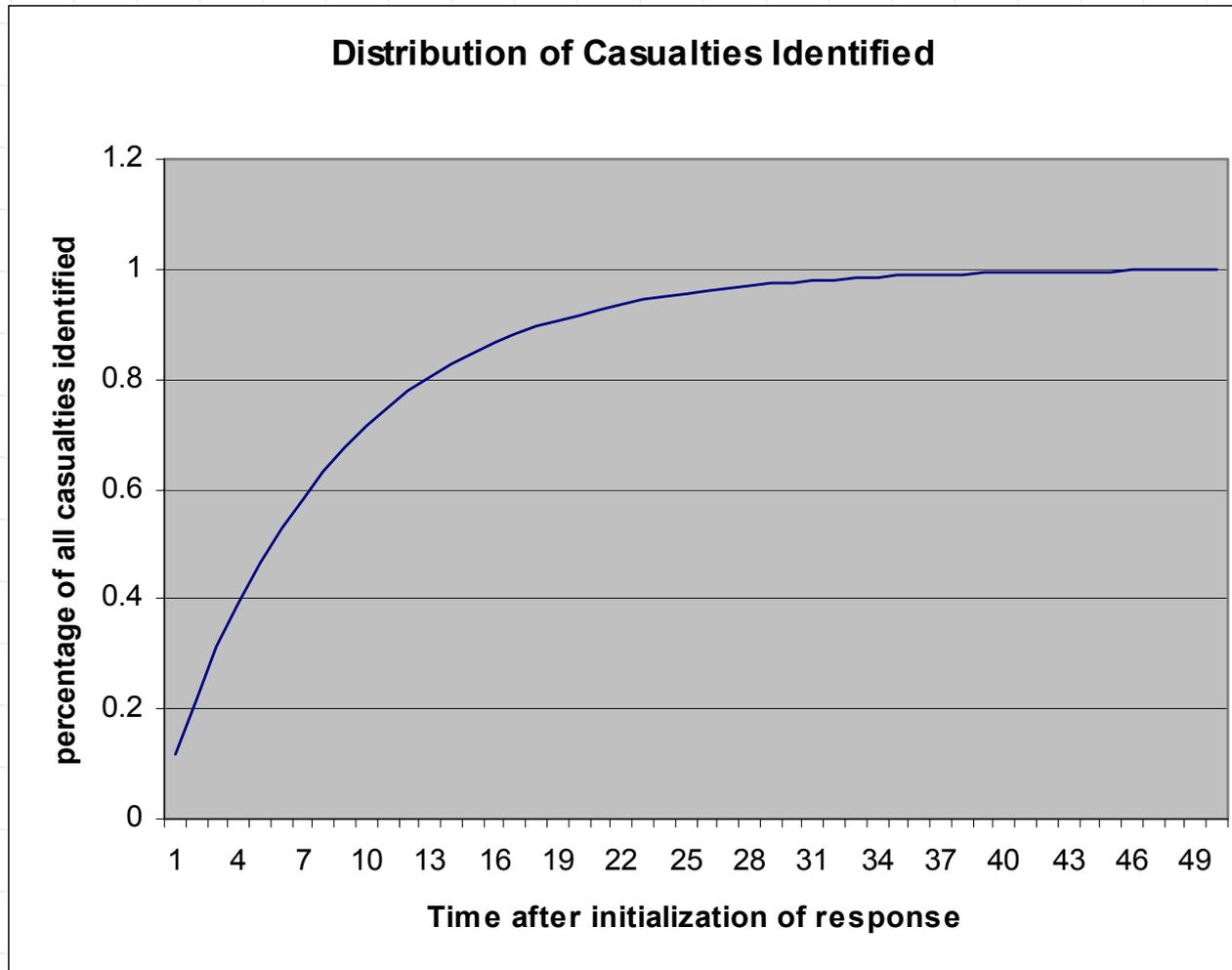
# Response metrics (Scope and Safety of the Response)

- ◆ Total number of branches and sectors of the initiated command structure as defined in the National Incident Management System
- ◆ Time from initialization of response until the disaster region is declared under control by the incident commander
- ◆ Matrix of responder casualty severities with respect to injury types

# Response Metrics(Rescue)

- ◆ Distribution of percentage of casualties identified versus the time after the initialization of response efforts
- ◆ Distribution of percentage of all property damage identified versus the time after the initialization of response efforts

# Example of Distribution of Identified Casualties



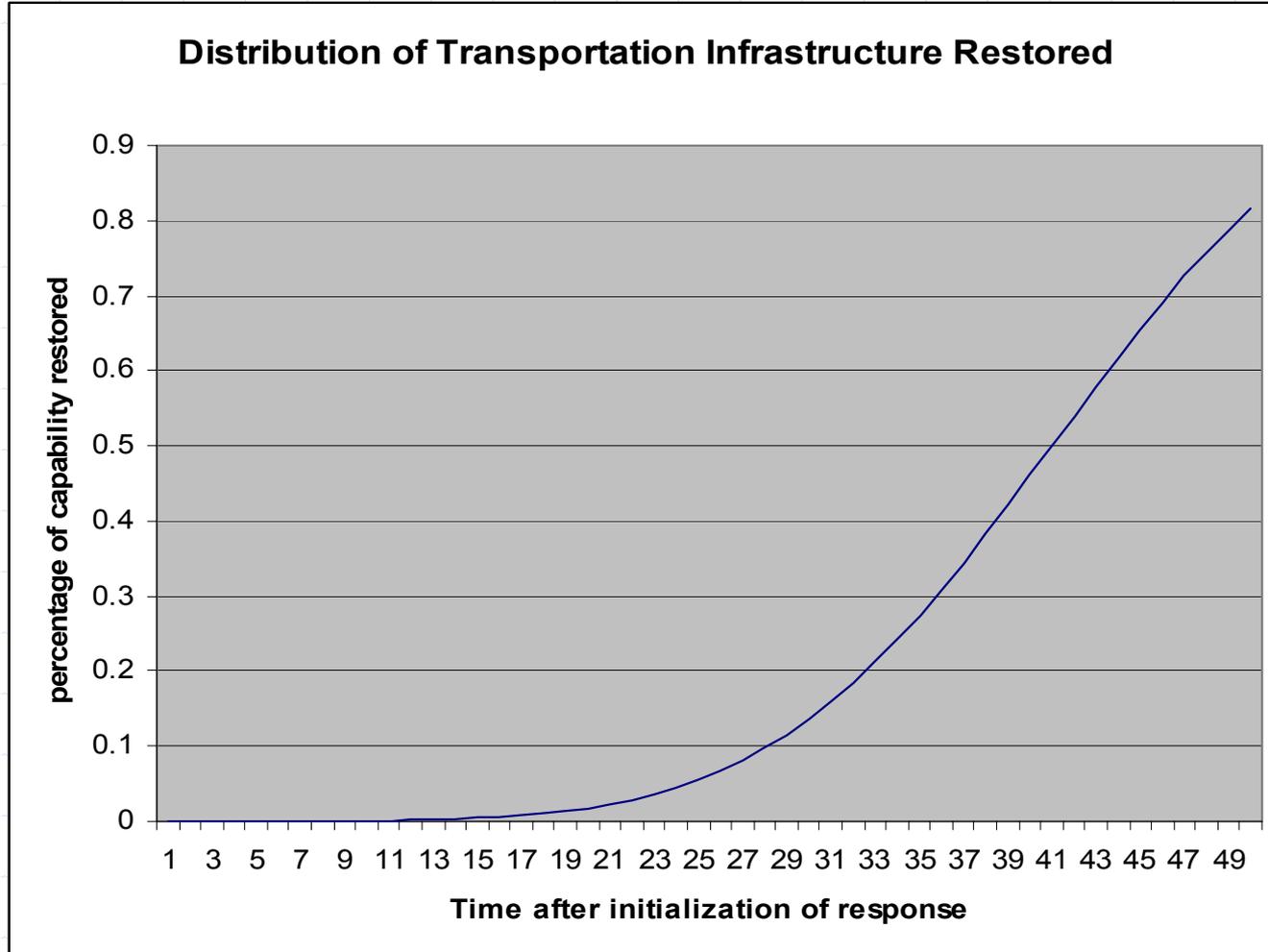
# Response Metrics (Stabilization, Rescue, Mitigation)

- ◆ Percentage of casualties of each injury type whose condition worsens after being identified by responders
- ◆ Percentage of property of each property type that sustains further damage after being identified by responders
- ◆ Also the same percentages except for those casualties and damage that are not identified by responders

# Response Metrics (Stabilization, Mitigation)

- ◆ Distribution of percentage of a community's human capabilities and infrastructure functionality versus time after the onset of response efforts

# Example of Distribution of Restoration of Infrastructure



# Final Comments

- ◆ Take disaster type into consideration only after metrics have been assessed
- ◆ Interpret metrics in context
- ◆ Future work: refining categories like injury types and severities
- ◆ Future work: proving statistical sufficiency of metrics

# References

- ◆ [1] Guha-Sadir, Debarati and Regina Below. 2000. *The Quality and Accuracy of Disaster Data: A Comparative Analysis of Three Global Data Sets*. A study by the Provention Consortium.
- ◆ [2 ] Federal Emergency Management Agency, Photo Library.  
<http://www.photolibrary.fema.gov/>.
- ◆ [3] Green, John M. and B.W. Johnson. 2002. "Towards a Theory of Measures of Effectiveness." Presented at CCRTS, June, 2002.
- ◆ [4] Goode Harry H. and Robert E. Machol. 1957. *System Engineering; An Introduction to the Design of Large-Scale Systems*. NewYork: McGraw-Hill.