Systems Thinking:
Lessons from Safety-Critical Technological Systems and Industries

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&
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Member, Governance Board, Patient Safety Movement Foundation

World Health Organization & Imperial College of London
Global Patient Safety Collaborative (GPSC) Webinar Series
Webinar 11: Systems Thinking
November 23, 2023
Via Microsoft Teams

My story…

Defining characteristics of my last 38-years of academic work - conducting research, teaching and consulting:

- **Safety-critical systems and industries**
- **Interdisciplinary orientation**
- **Cross-cutting nature of Human-Systems Integration (HIS)**
- **Safety Culture advocacy/evangelism**

My story…

Last 38 years of working directly with and experience with:

- **Nuclear power**
- **Petrochemical**
- **Refining**
- **Oil & Gas Pipeline**
- **Offshore Drilling**
- **Aviation**
- **Railroad**
- **Maritime**
- **Coal Mining**
- (last 25+ years) **Healthcare** industry

My life story…..

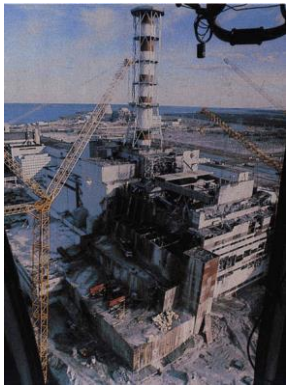
Three Mile Island

March 28, 1979

Bhopal

December 3, 1984

Chernobyl



April 26, 1986

BP Refinery

March 23, 2005

BP Deepwater Horizon

April 20, 2010

Fukushima

March 11, 2011

My life story + Aviation accidents

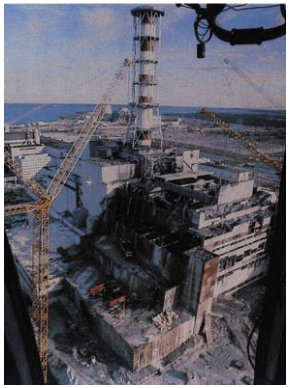
Three Mile Island

March 28, 1979

Bhopal

December 3, 1984

Chernobyl



April 26, 1986

BP Refinery

March 23, 2005

BP Deepwater Horizon

April 20, 2010

Boeing 737 Two Crashes 2018 & 2019

Fukushima

March 11, 2011

Tenerife, 1977

Avianca, 1990

Korean Air 801, 1997

Überlingen, 2002

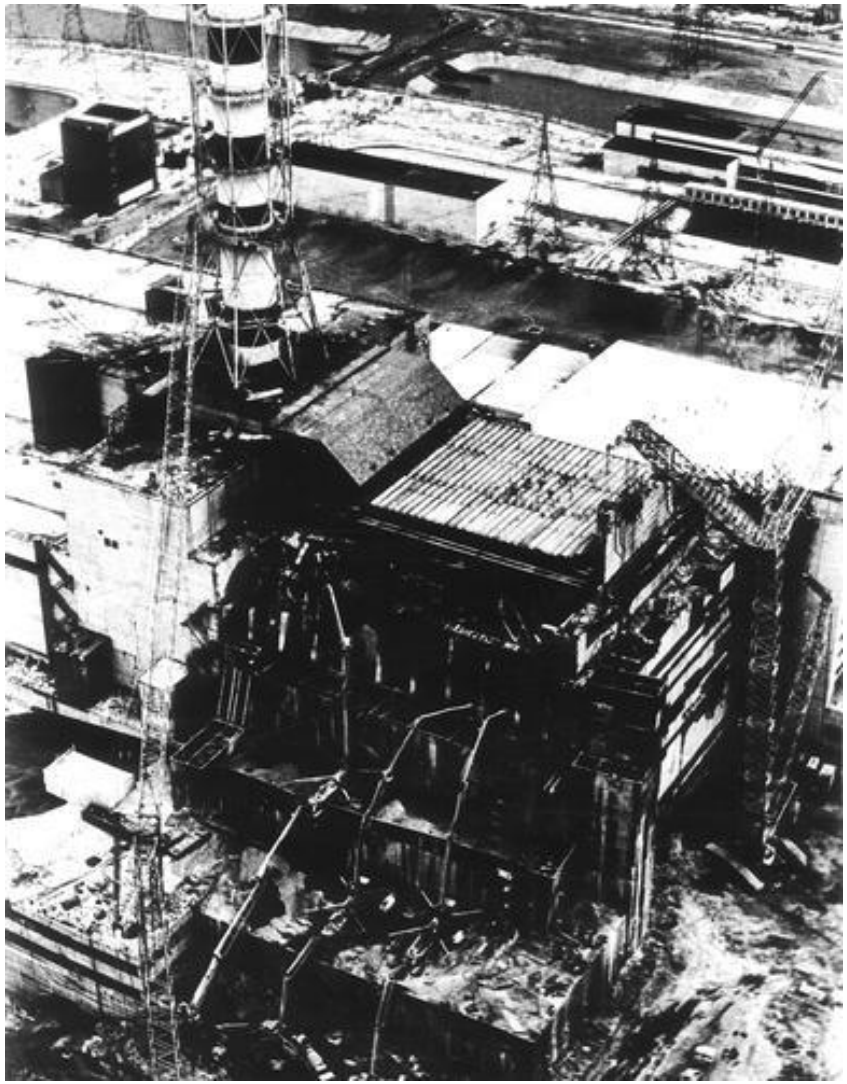
Asiana 214, 2013

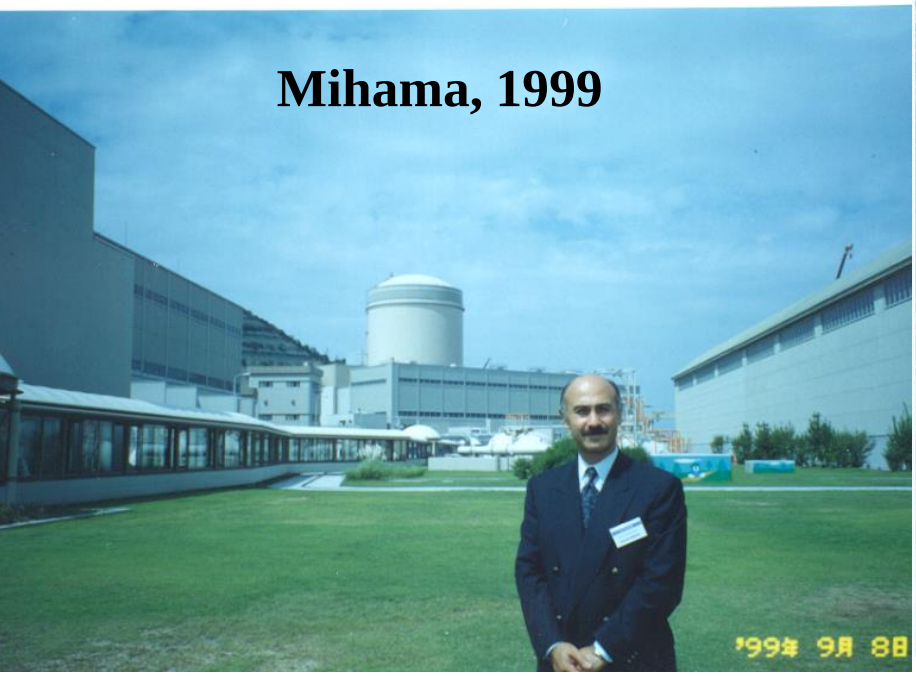
Visited and Conducted Research on Nuclear Power Plants

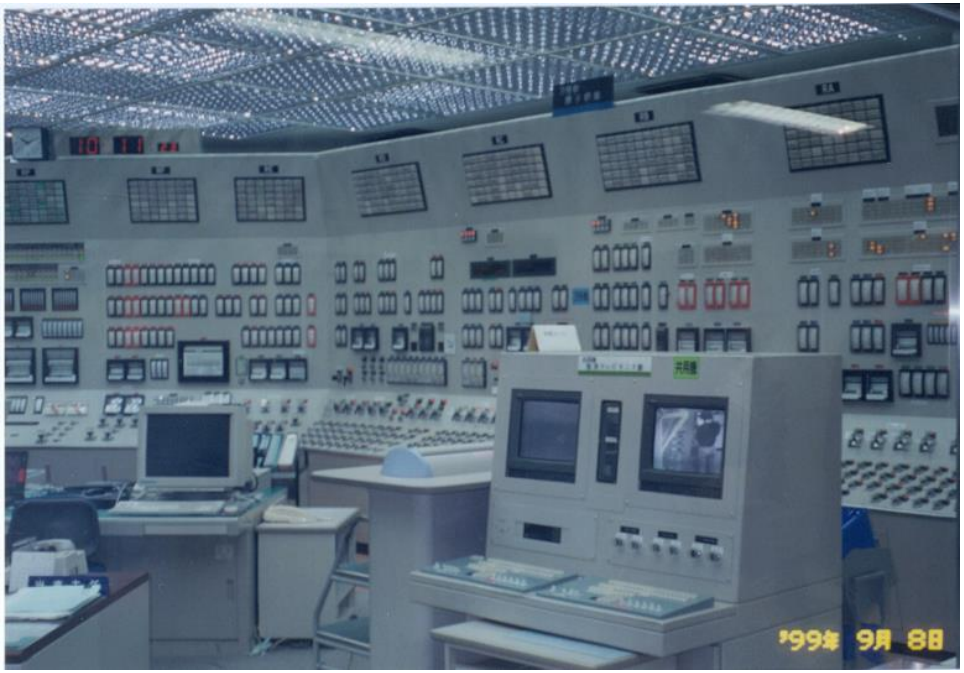
- San Onofre (USA)
- TMI (USA)
- EBR II (USA)
- Darlington (Canada)
- Chernobyl (Ukraine)
- Fukushima Daiichi & Daini (Japan)
- Mihama (Japan)
- Laguna Verdi (Mexico)
- Bushehr (Iran)
- Metsamor (Armenia)

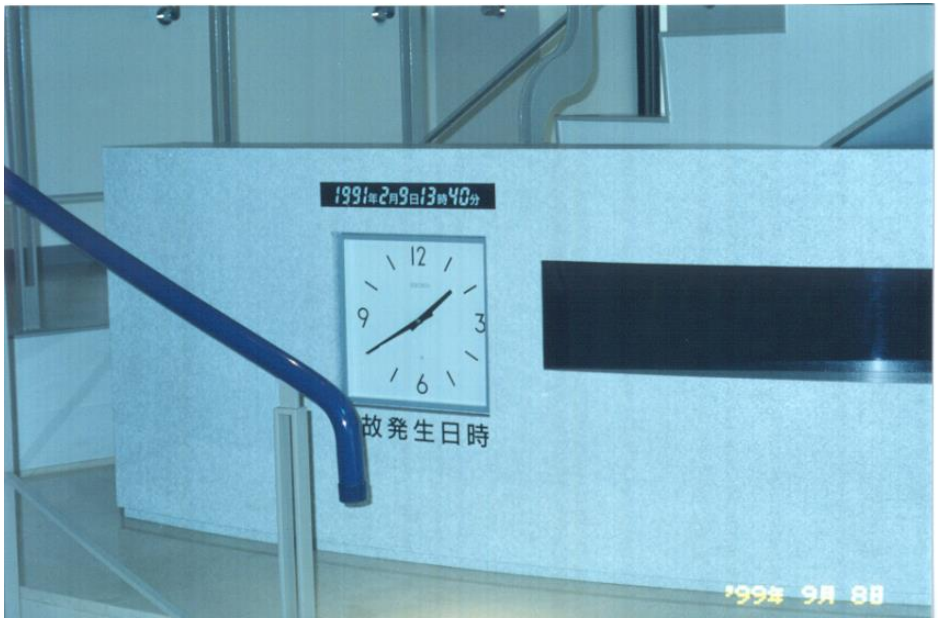
(Studied: Wolf Creek, Davis-Besse, Indian Point, Yankee Rowe, Rancho Seco, Diablo Canyon, etc.)

Chernobyl, 1997




Mihama, 1999
'99年 9月 8日


'99年 9月 8日


1991年2月9日13時40分
故発生日時
'99年 9月 8日


'99年 9月 8日

Fukushima Daiichi, 2012

U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

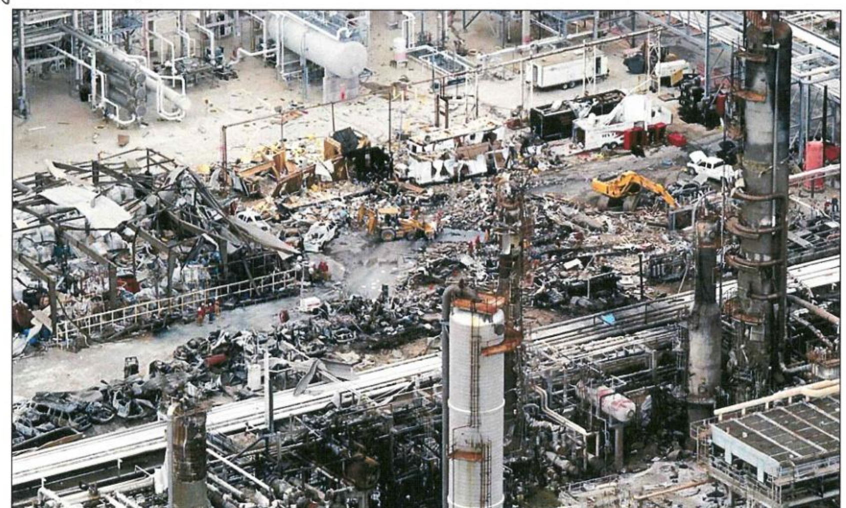
To Najm: your continued support and interest in our work is a treasure to me, Thanks for your work in worker safety. Regards Carolyn 03-20-07

INVESTIGATION REPORT

Final Draft for Board Vote

REFINERY EXPLOSION AND FIRE

(15 Killed, 180 Injured)



KEY ISSUES:

SAFETY CULTURE
REGULATORY OVERSIGHT
PROCESS SAFETY METRICS
HUMAN FACTORS

To Najm
Thanks for your report human factors and safety culture insights. You were an inspiration for our investigation team. Don Holmstrom

BP

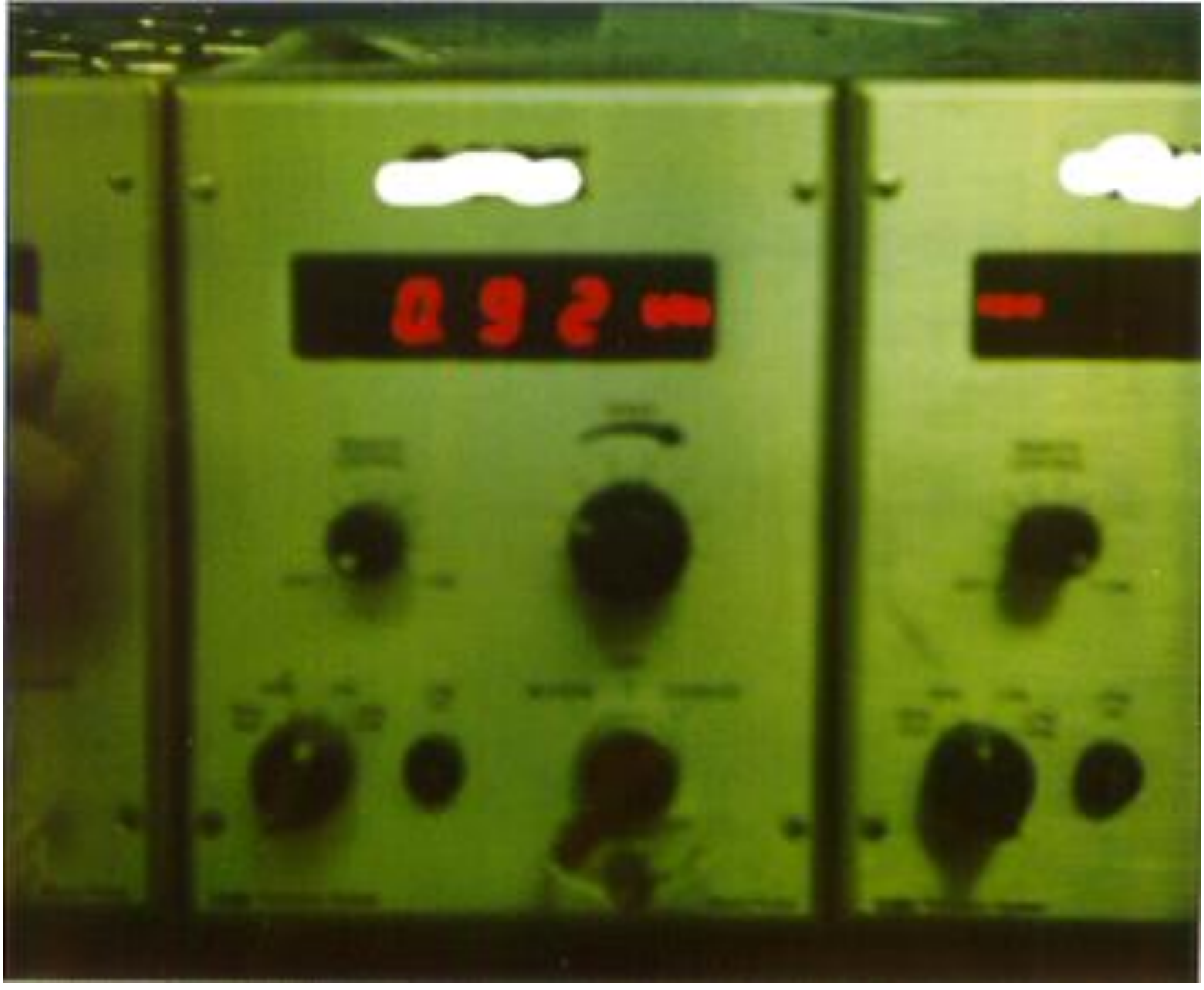
TEXAS CITY, TEXAS
MARCH 23, 2005

REPORT NO. 2005-04-I-TX
MARCH 2007

BP Deepwater Horizon


USC

Perfusion Pump Example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USC Keck Hospital, Perioperative Project, 2014

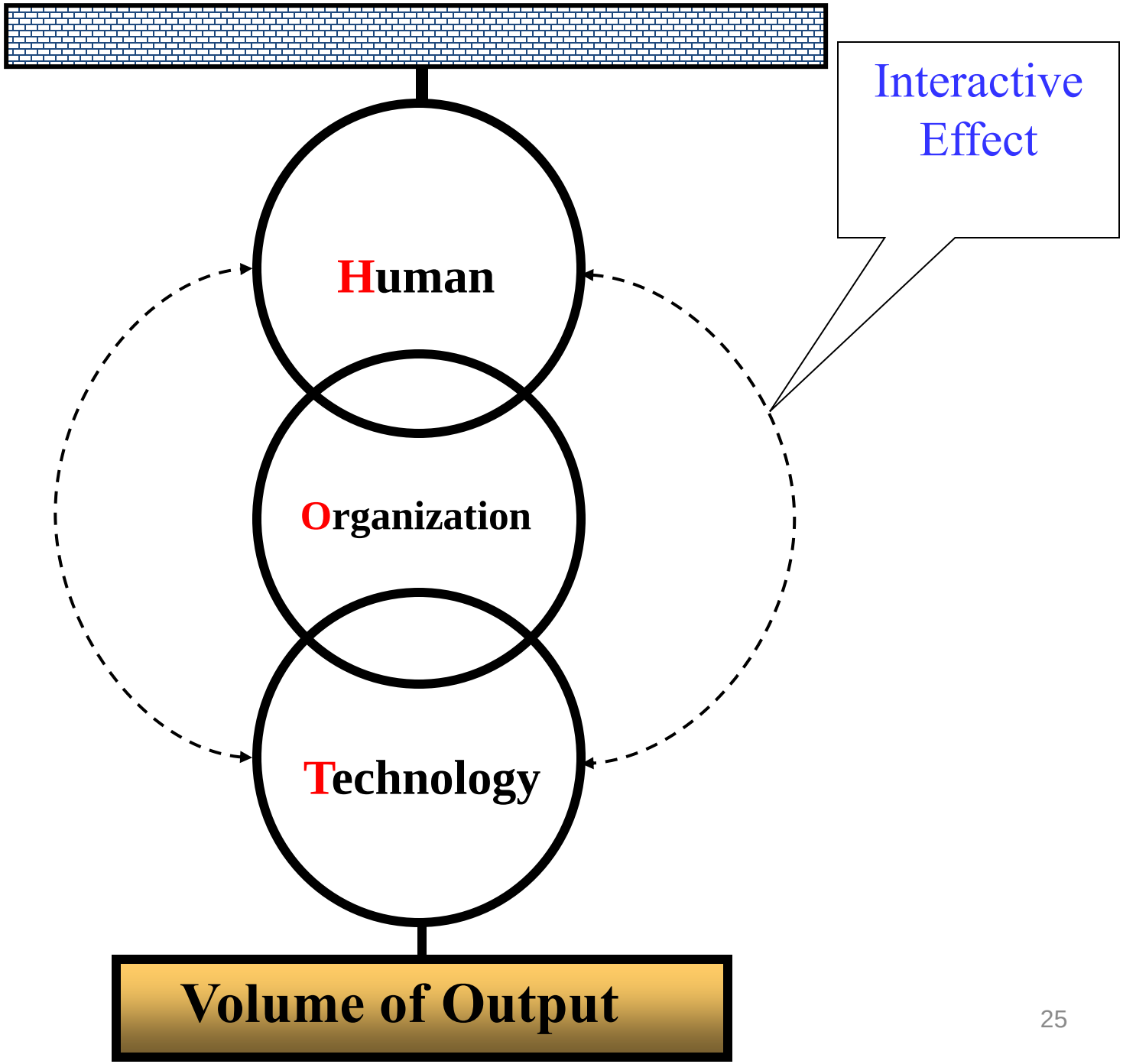
From Left to Right:

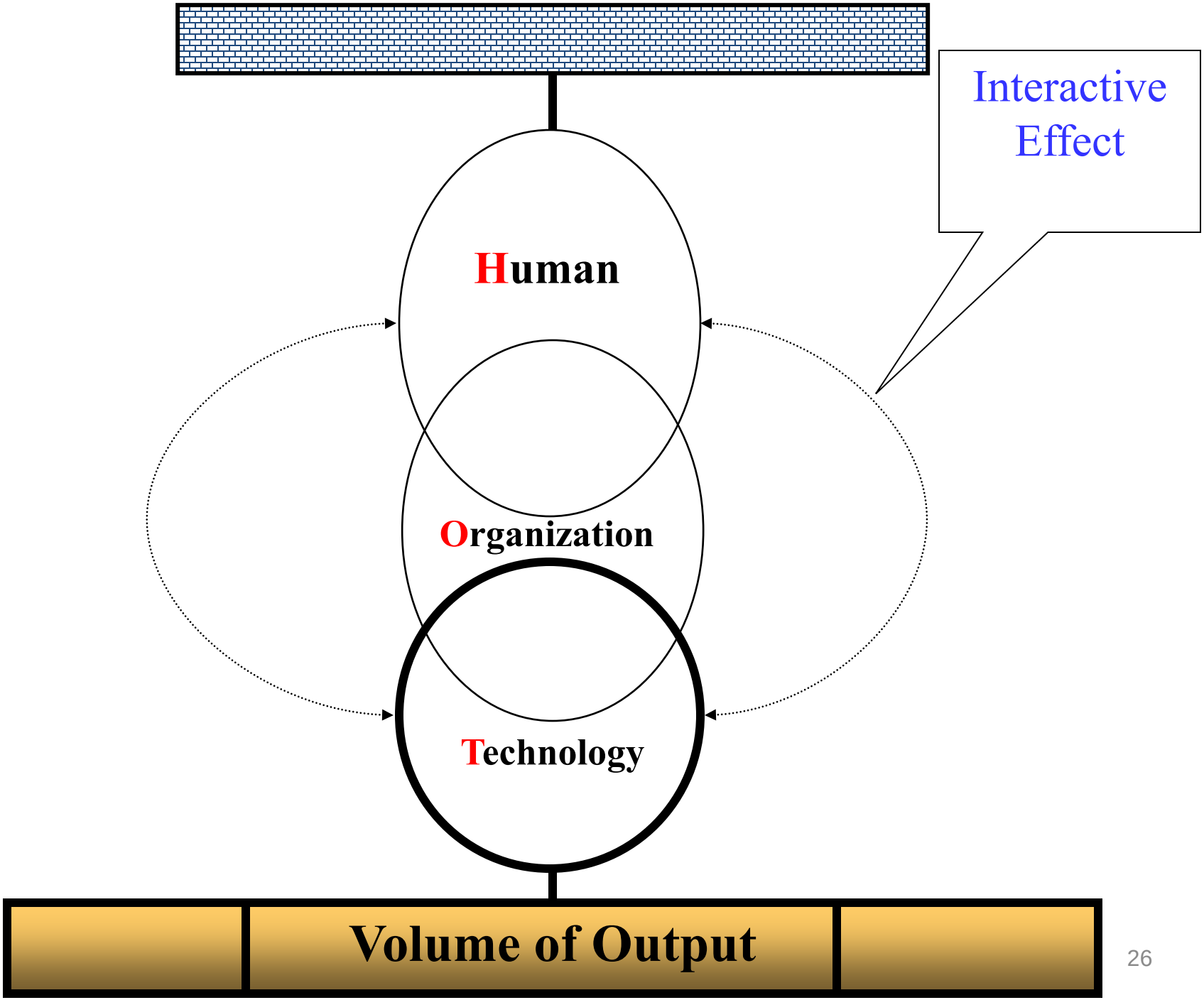
Dr. John Franklin
Dr. Sanaz Massoumi
Najm Meshkati
Dr. Greg Placencia
Dr. Yalda Khashe
Dr. Maryam Tabibzadeh
Dr. Joshua Gray

Some recent works…

The ‘HOT’ Model
Major Subsystems of a Complex Safety-Critical Technological System

(e.g., a hospital)


Interactive Effect
Human
Organization
Technology
Volume of Output


Interactive Effect
Human
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Technology
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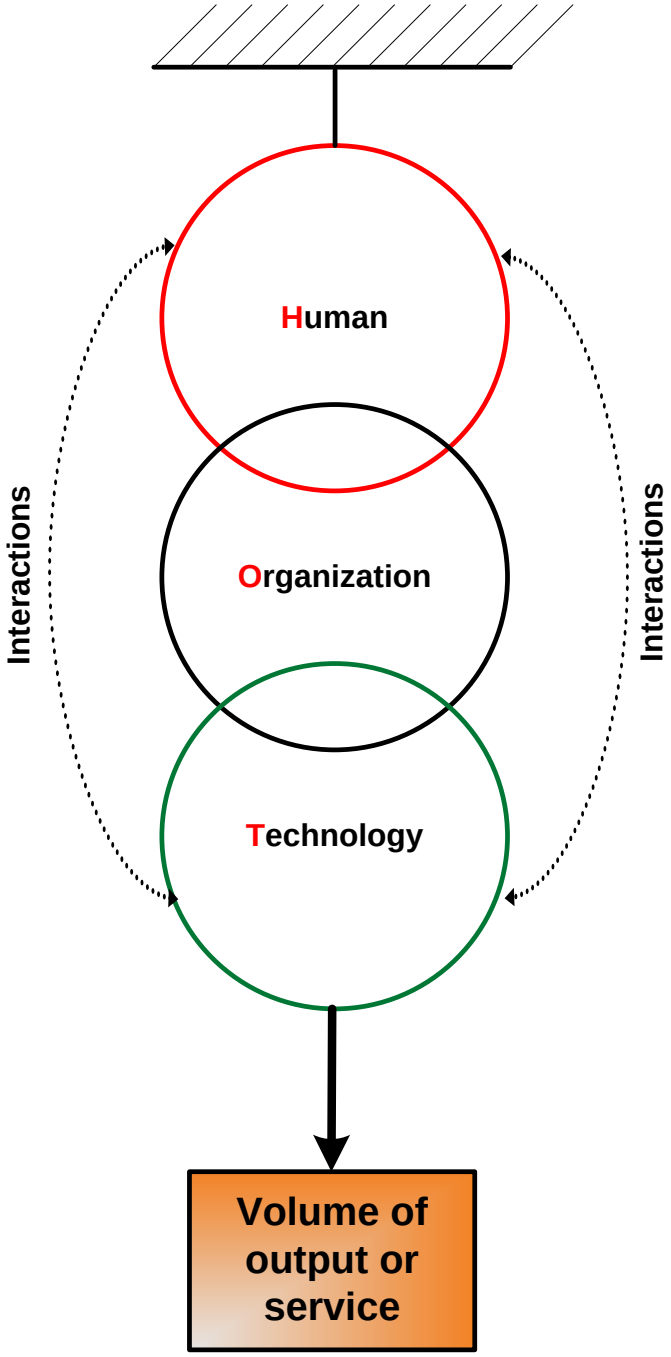
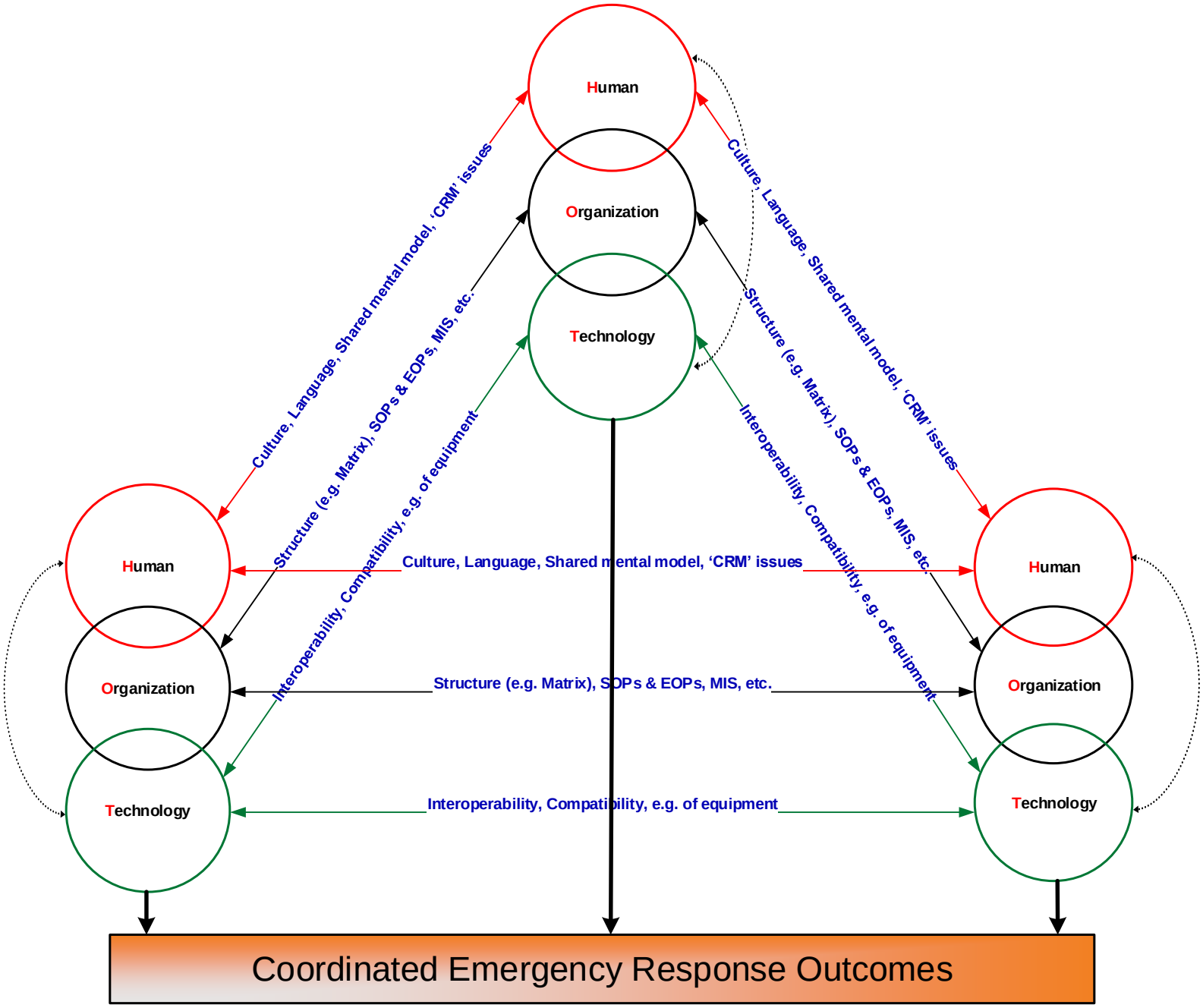

Human
Organization
Technology
Interactions
Interactions
Volume of output or service

An Example:
Systems Thinking
Application to Interoperability and Emergency Response

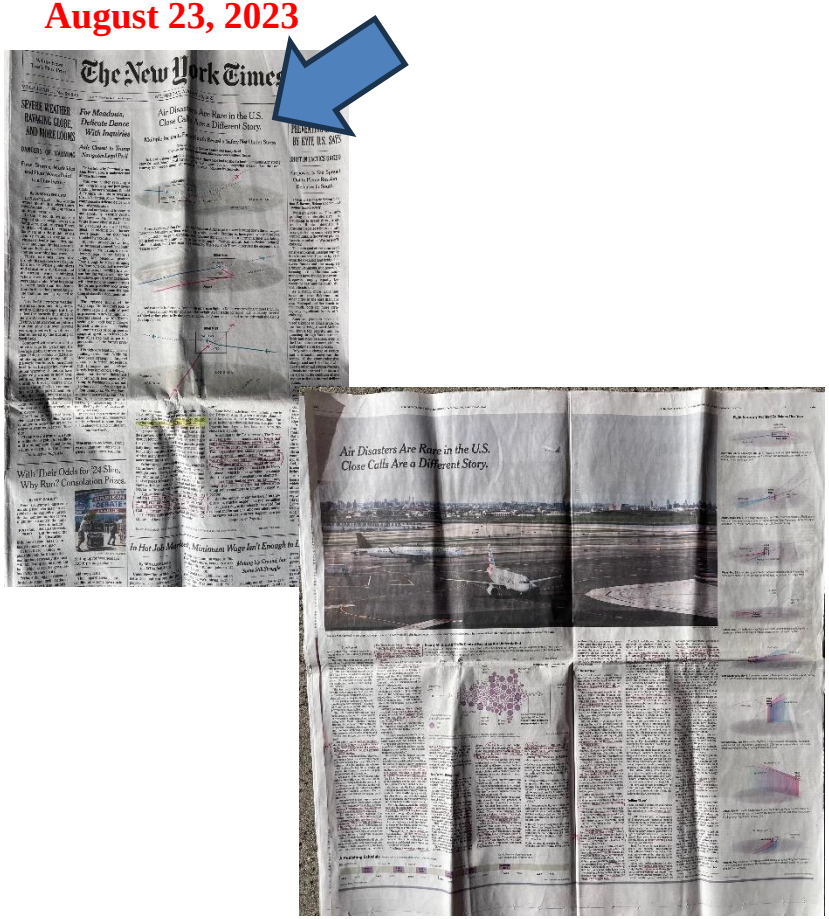


Interoperations of the three layers, human, organization and technology, of three interacting first responders during an emergency response and factors affecting their effectiveness (Adopted from Meshkati, 2010)

An Example:
Systems Thinking
Application to Runway Safety

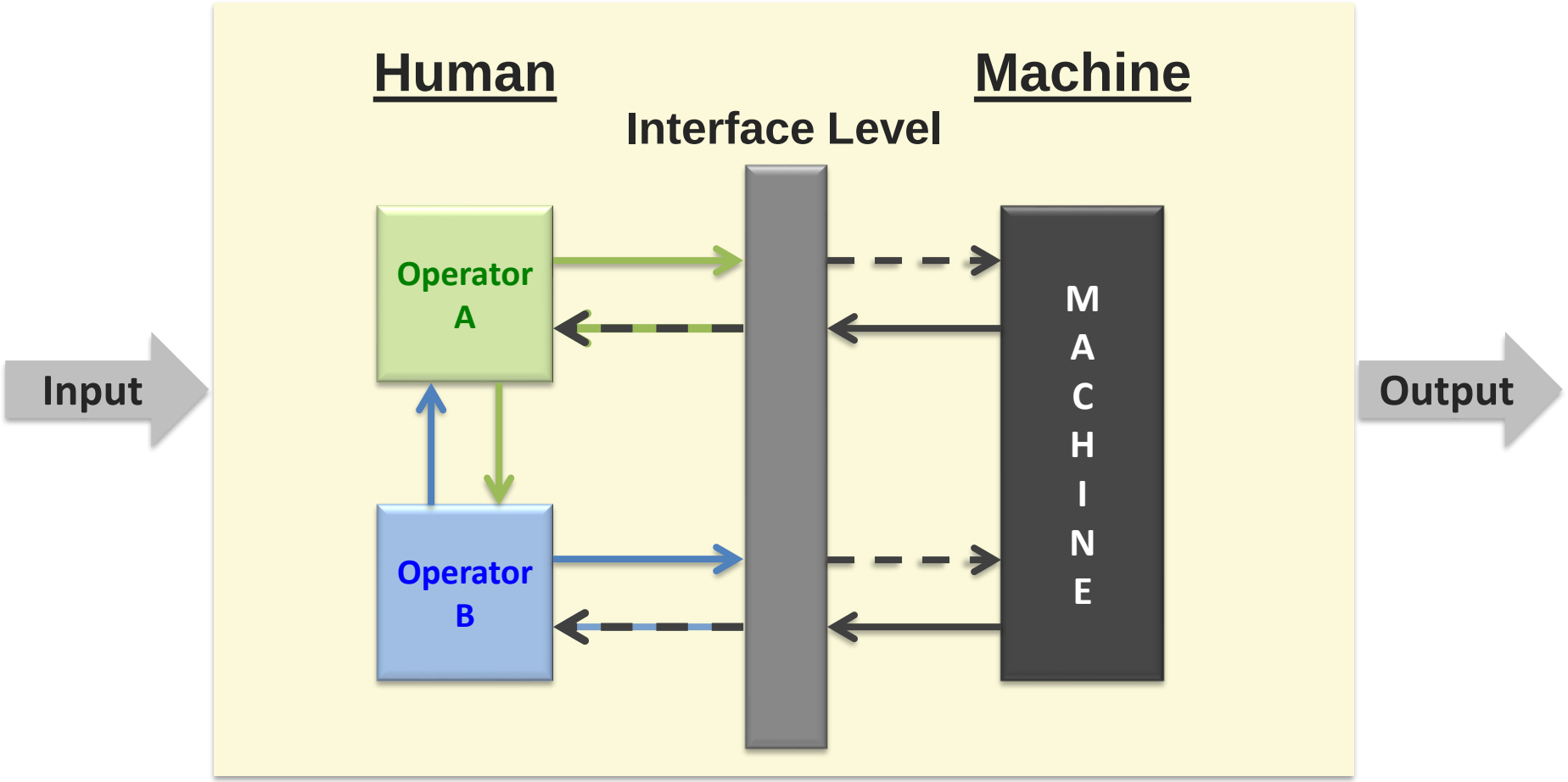
Dire State of Runway Incursions in the US

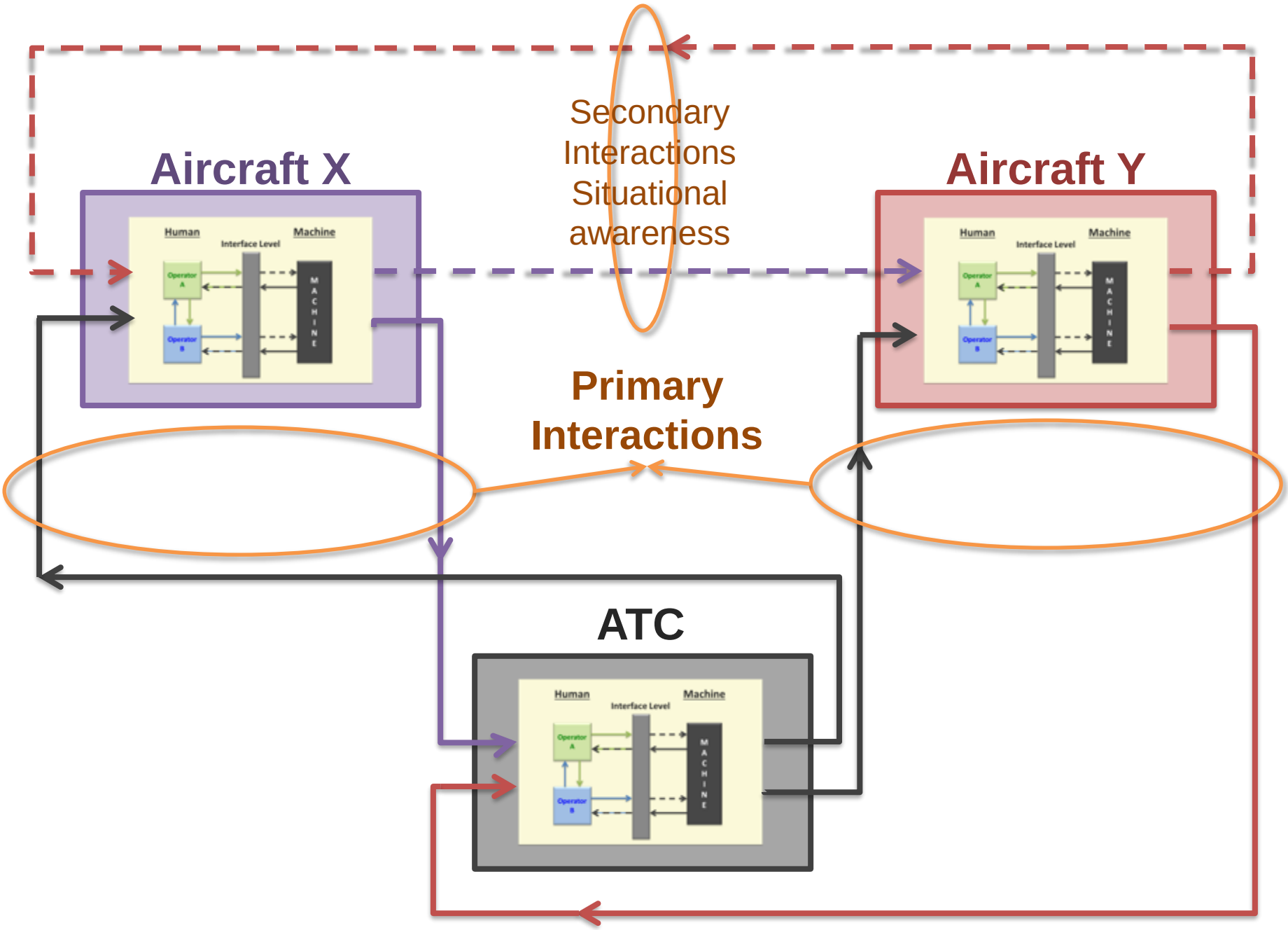
August 23, 2023

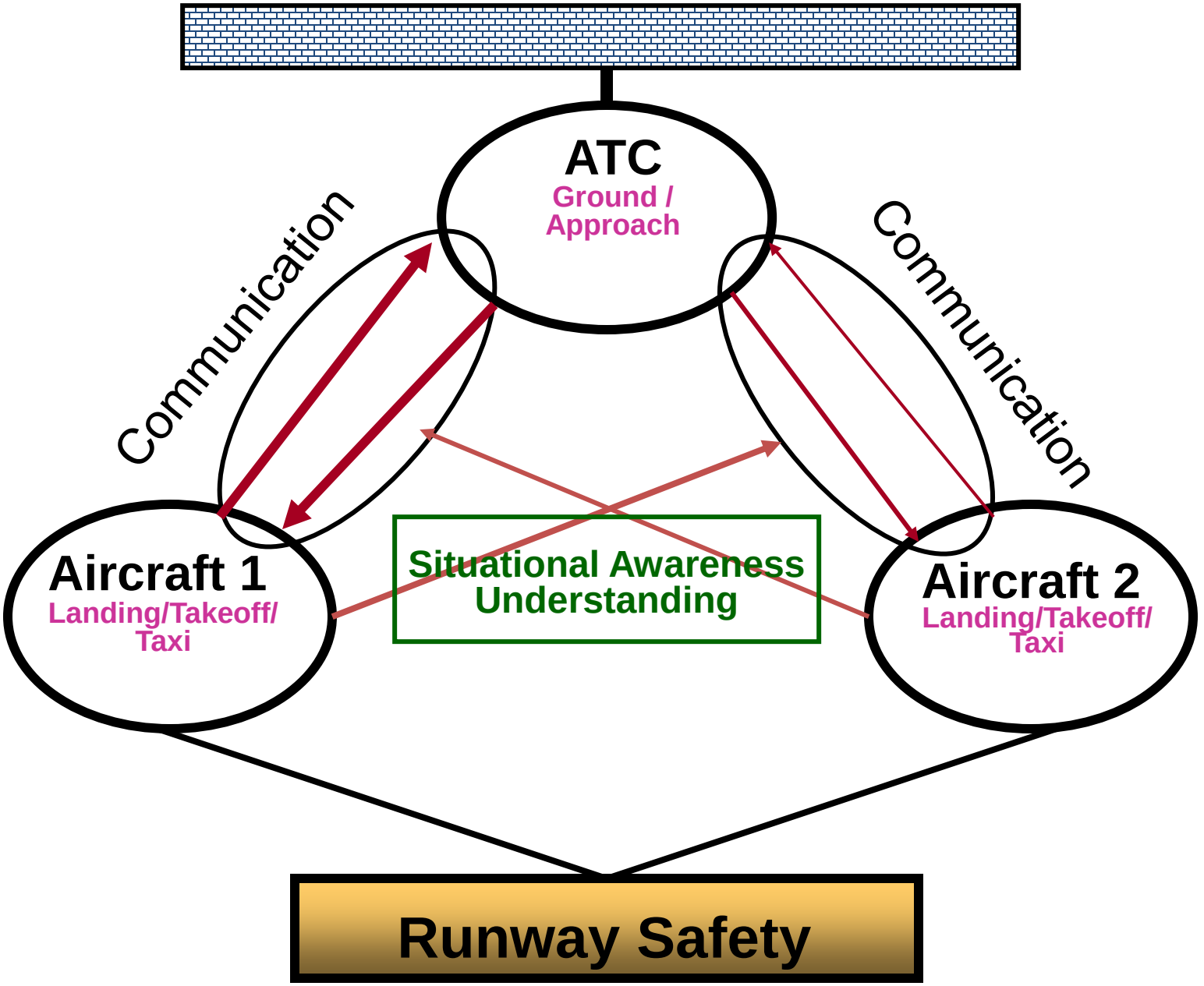


October 15, 2023

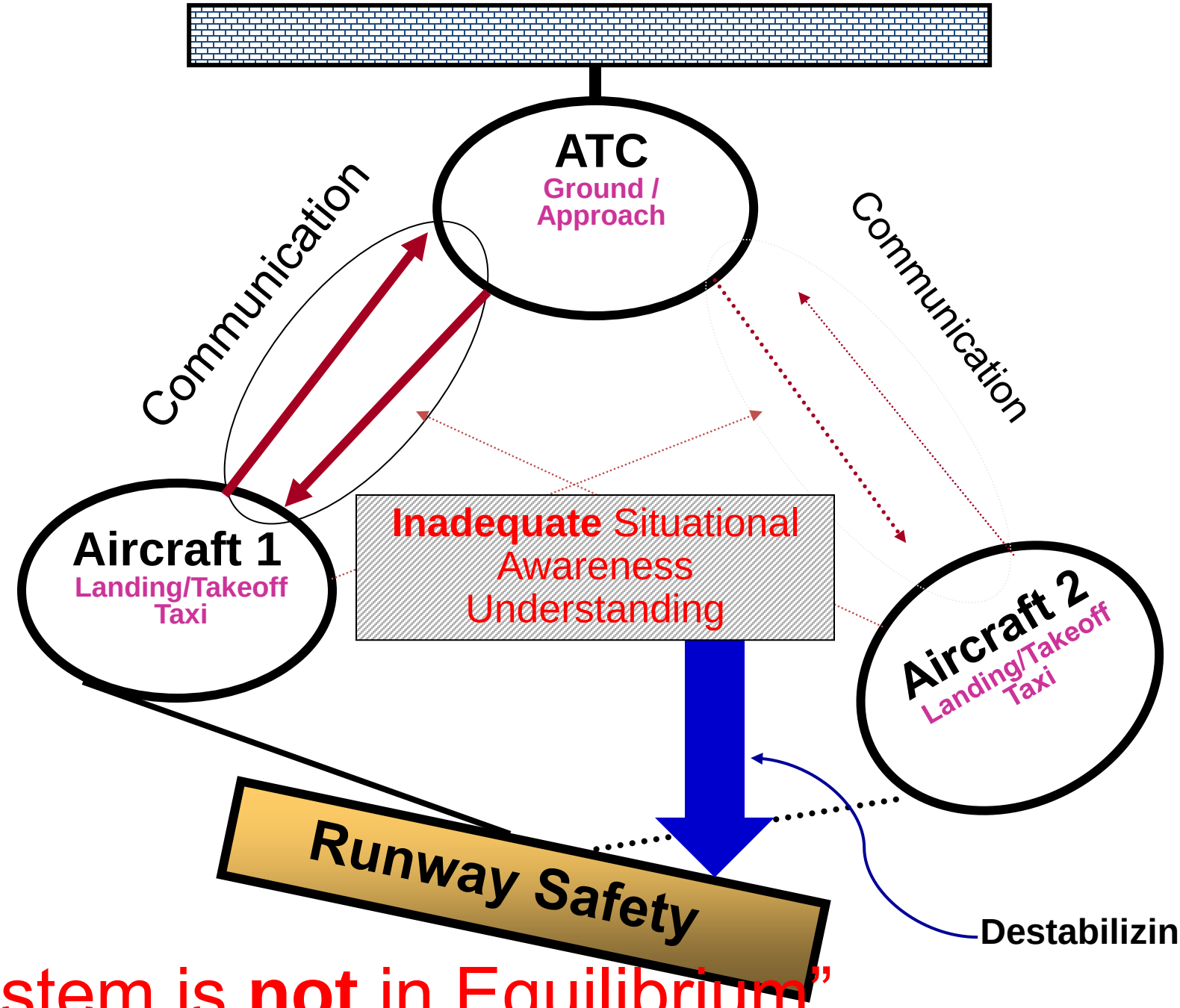
Human-Machine System




Secondary
Interactions
Situational
awareness
Aircraft X
Aircraft Y
Primary
Interactions
ATC
Human
Machine
Interface Level
Operator A
Operator B
MACHINE



"System is in Equilibrium"



"System is **not** in Equilibrium"

Conclusion

Common & Universally Applicable Lessons from past Safety-Critical Systems

My Premise/Experience

In safety and reliability of complex technological systems

Human Factors

Human-Systems Integration

&

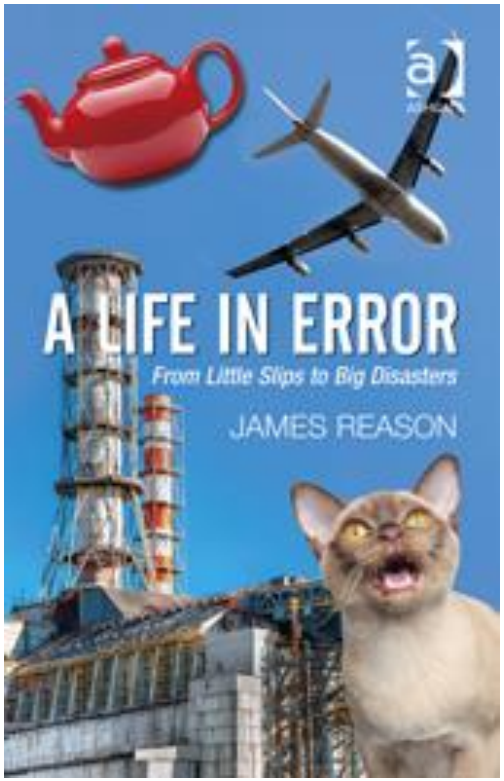
Safety Culture

considerations are common

cross-cutting issues

Safety Culture as a Root-Cause of a System's Common Mode Failure

- Because of their diversity and redundancies, the defense-in-depth will be widely distributed throughout the system.
- As such, they are only collectively vulnerable to something that is equally widespread. The most likely candidate is safety culture.
- It can affect all elements in a system for good or ill.



Professor James Reason, *A Life in Error*, 2013, Page 81

My “Understanding” of Safety Culture

- I believe that safety culture is analogous to the human body’s immune system that protects against pathogens and diseases.
- Due the pervasive nature of safety culture and its widespread impact, according to Prof James Reason, “it can affect all elements in a system for good or ill”.
- As such, it is incumbent upon the leadership to strive for immunizing, protecting, maintaining, and nurturing (**boosting**!) the healthy safety culture of any company.

With Professor James Reason in his House in Disley, UK

Dec. 8, 2011