



# MINDING THE CYBER-PHYSICAL GAP: MODELING REALITY VS ITS PERCEPTION WITH OPM

Yaniv Mordecai, PhD

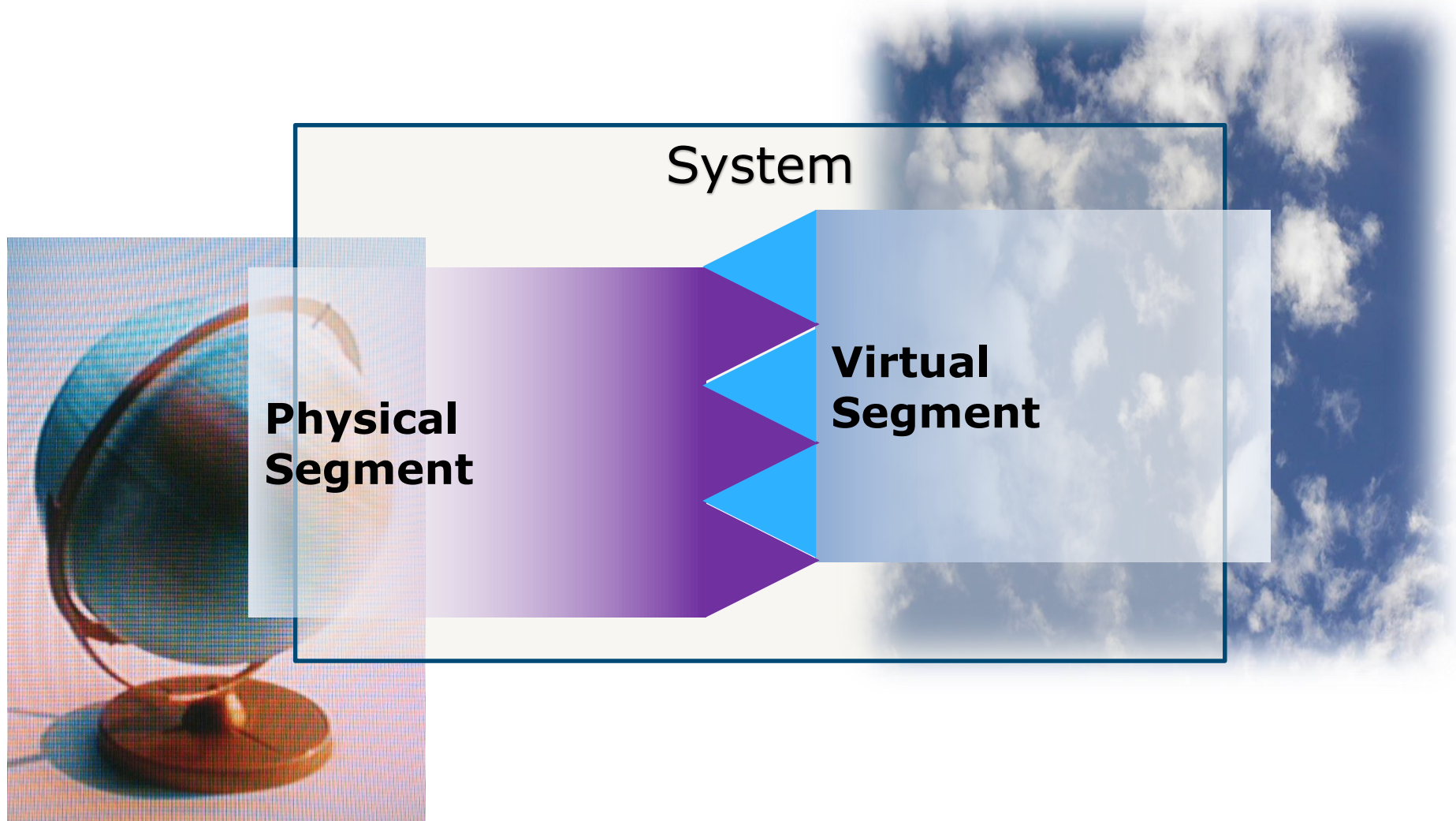
[yanivmor@technion.ac.il](mailto:yanivmor@technion.ac.il)

Joint work with Prof. Dov Dori, INCOSE Fellow

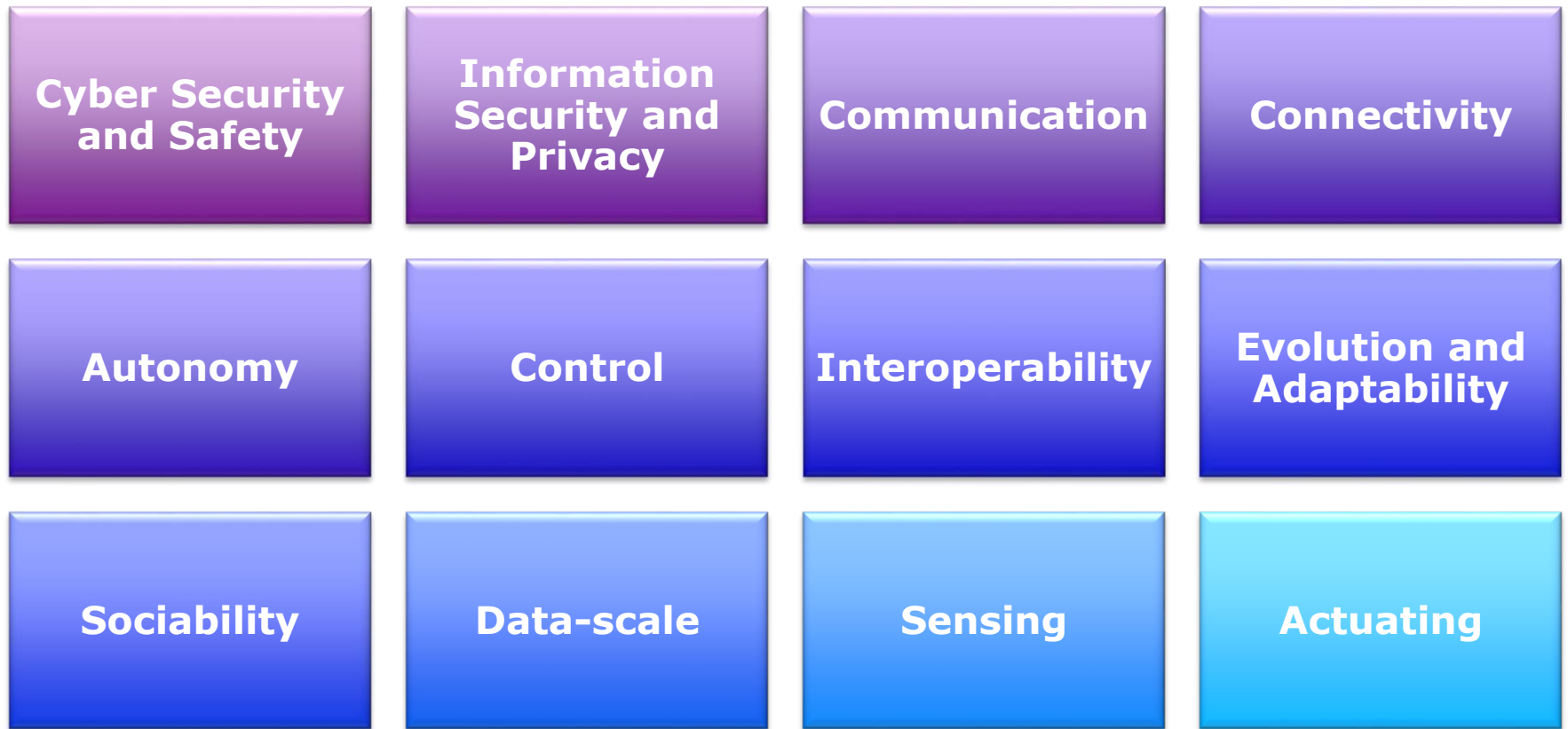
February 2016



# Cyber-Physical Systems



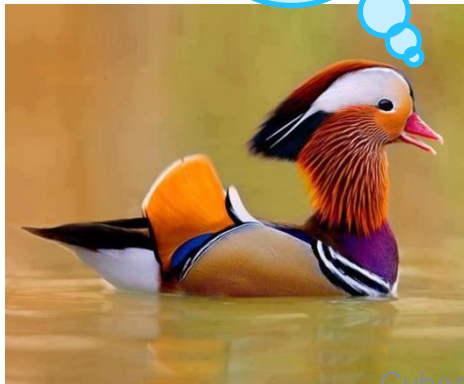
# Cyber-Physical Challenges



# Cyber-Physical Duality

- ▶ The existence of an **entity** as
  - the **original-physical embodiment** of the entity, and
  - the (set of) **representational-informatical manifestation(s)** of the entity, as held by agent(s) and sub-system(s) interacting with it.

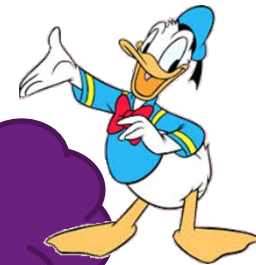
My name is  
Alexey, not  
Alexander!  
And I'm not  
a person!



Person X  
Name =  
Alex



Person X  
Name =  
Sasha



**Cyber-Physical Gap:**  
Mismatch between the  
state of the original  
entity and the state that  
is recorded for the  
representing entity by its  
owning agent.



# Literature

- Info—Data Duality (Bar-Hillel & Carnap 1953)
- Info—Matter (Hayles 1999)
- Epistemic Information (Mizzaro 2001)
- *Physical—Cyber* duality of the *Natural world* (Wang, Kinsner, and Zhang 2009)
- The role of informatical manifestations of "real-world" entities – a fundamental challenge of Cybernetics and Informatics (Kolin 2010).
- Study and analysis of catastrophic implications of systemic misconceptions (Leveson 2011)

# The Cyber-Physical Gap

## What is the potential damage?

Differences  
between system  
expectation and  
actual evidence

Failure to conduct  
successful  
interaction with  
the environment

Failure to obtain  
system objectives

Potential adverse  
impact of system  
on itself or its  
peer systems

Potential adverse  
collateral impact  
on the  
environment



# Lost Baggage



## BAGGAGE PROCESS TRACING

**WorldTracer**  
20 Years of service – 100's of millions of bags traced ..... Next Generation GUI and CrewPad

Passenger **Mr James Oconnor**

Flyer Number

Booking Ref **W7H08** Arrival Airport **Miami Intl (MIA)**

**Identify Bags**  
Tap on each bag below to edit information.

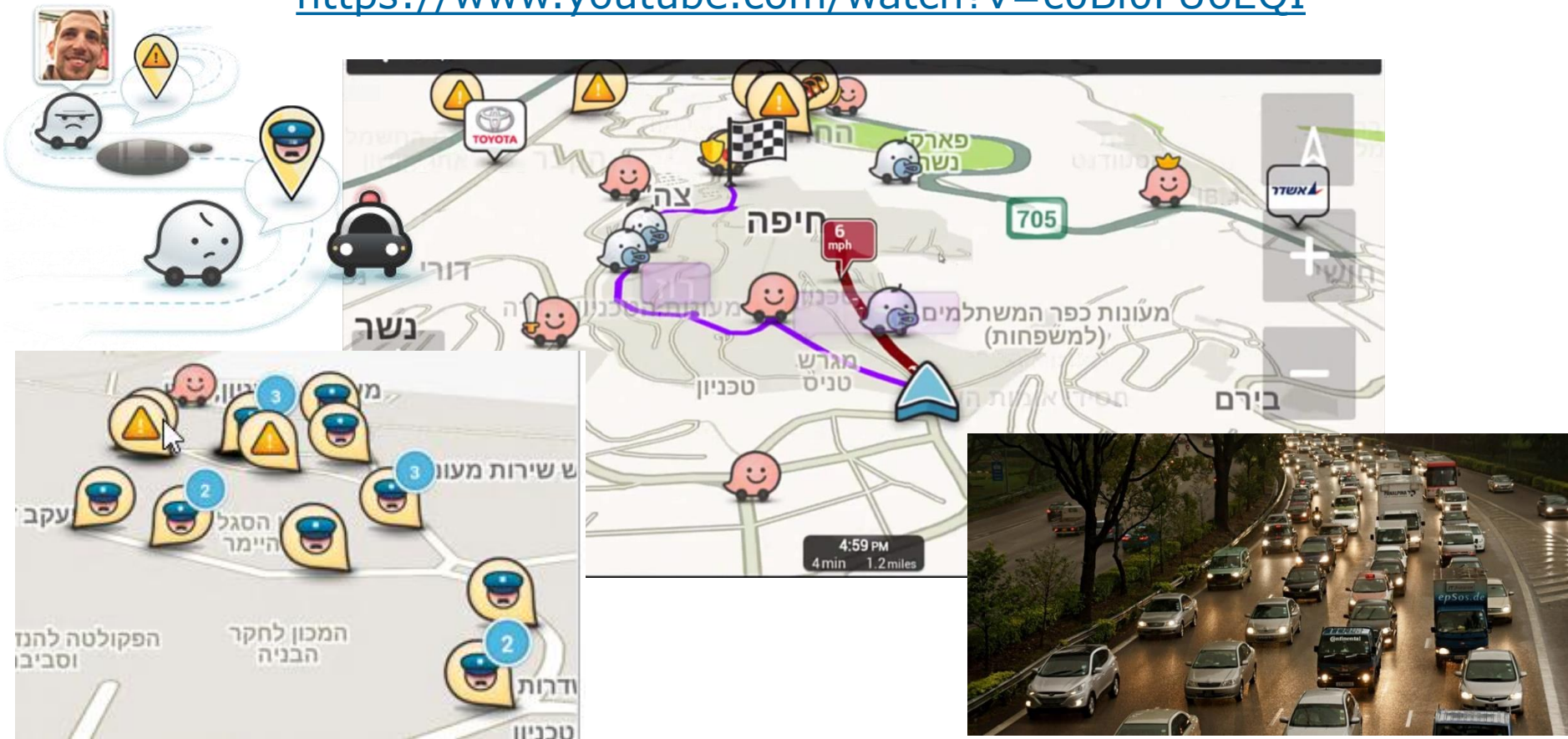
	<b>Black</b>	<b>White</b>		
	<b>Blue</b>	<b>Grey</b>		
	<b>Red</b>	<b>Purple</b>		
	<b>Pattern</b>	<b>Yellow</b>		
	<b>Green</b>			

**SITA**  
Create success. Together

# Technion's Cyber Attack on Waze (March 2014)

<http://www.geektime.co.il/technion-students-outsmart-waze-app/>

<https://www.youtube.com/watch?v=c0BI0PU6EQI>





# Gear-Up Landing

- ▶ 1998-2003: ~100 gear-up landing incidents each year in the US.
- ▶ Reasons:
  - Pilot distraction, preoccupation, forgetfulness
  - Landing gear lock mechanism reliability (Dash-8)
  - hydraulic systems failure
- ▶ 2016 Memo cancels special FAA advisory circular on gear-up landing prevention (1980).



## Federal Aviation Administration

### Memorandum

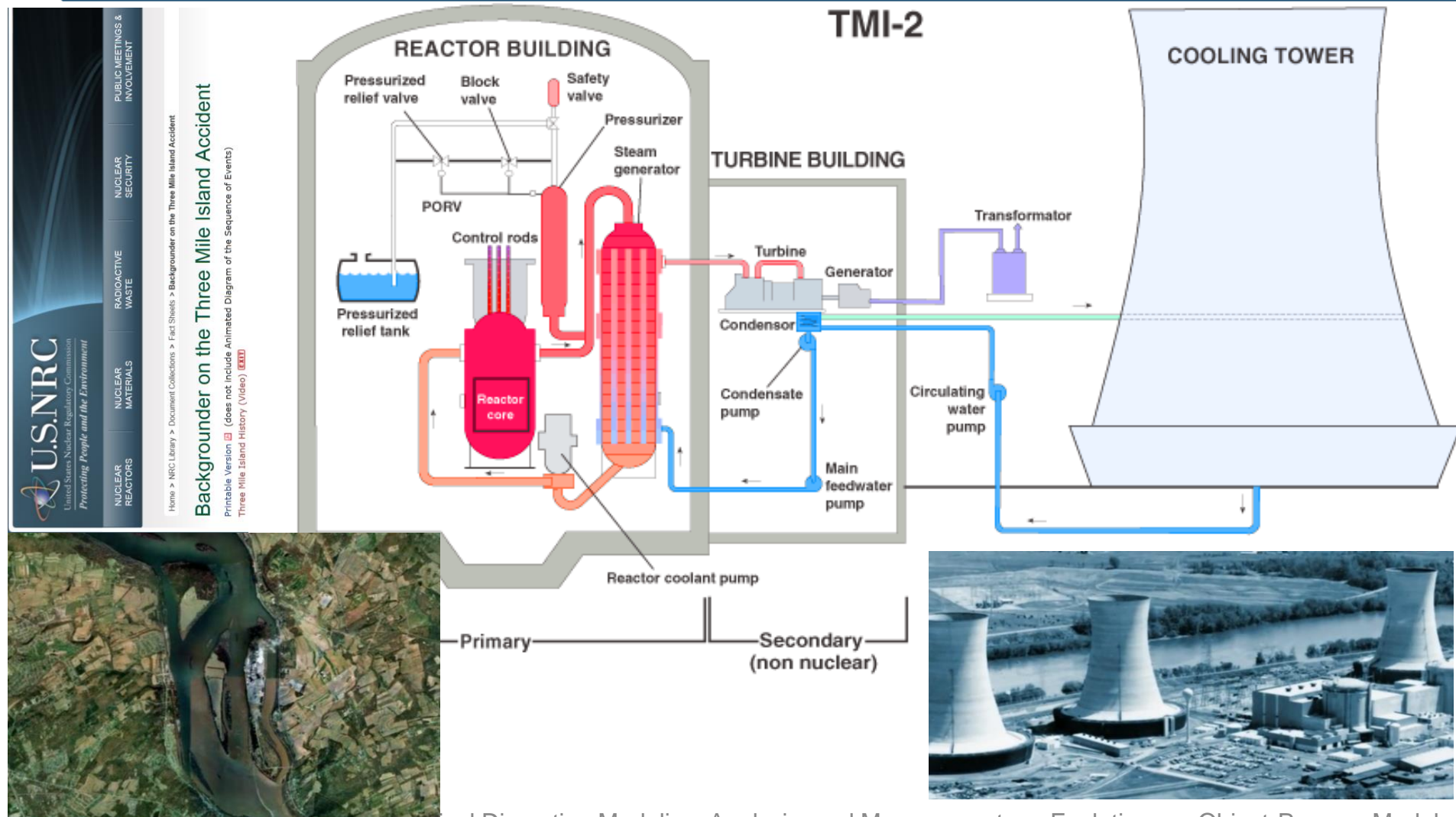
Date: 02/01/16  
To: Al Spence, Directives Program Manager, ASP-110  
From: John S. Duncan, Director, Flight Standards Service, AFS-1 *JS*  
Prepared by: Richard Mathews, Directive Management Officer, AFS-140 *RM*  
Subject: Cancellation of Advisory Circular AC 20-34D, Prevention of Retractable Landing Gear Failures

Flight Standards Service is requesting the cancellation of the following AC 20-34D, Prevention of Retractable Landing Gear Failures. A review of two years' worth of data in the FAA Incident & Accident database showed 17 incidents for gear collapse on the landing or take off in the US fleet. Additionally, several of the incidents admitted they were hard landing related. The problem is not statistically significant and the AC should be cancelled. This AC will not be rewritten.

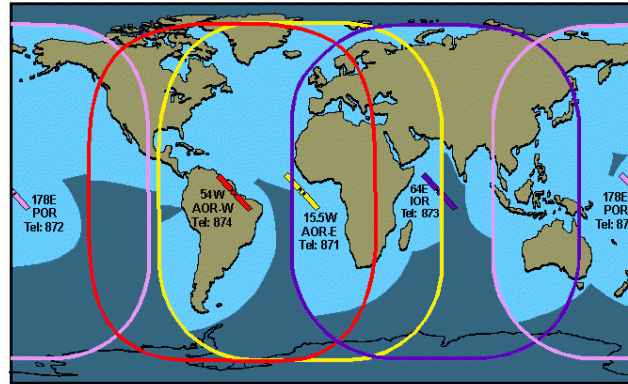
# Three Mile Island 2 Accident

March 28, 1979

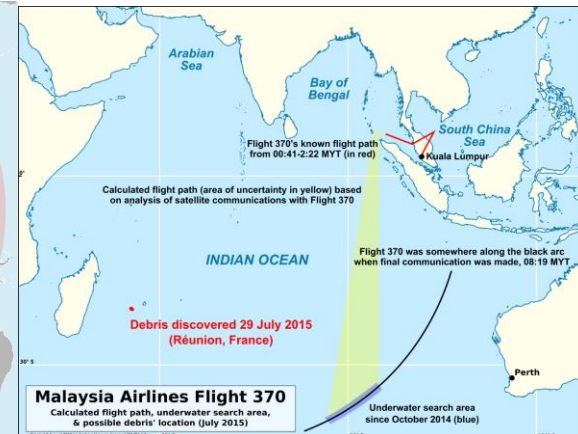
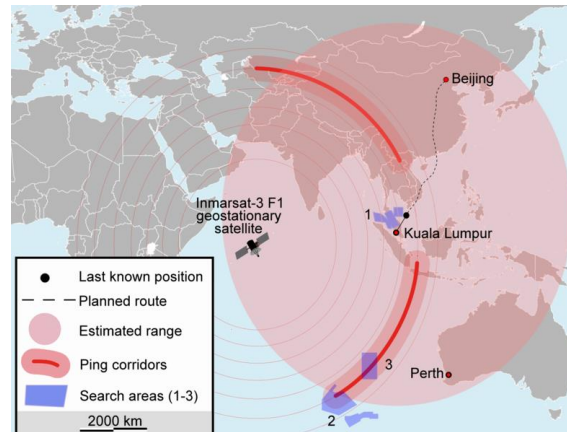
<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>



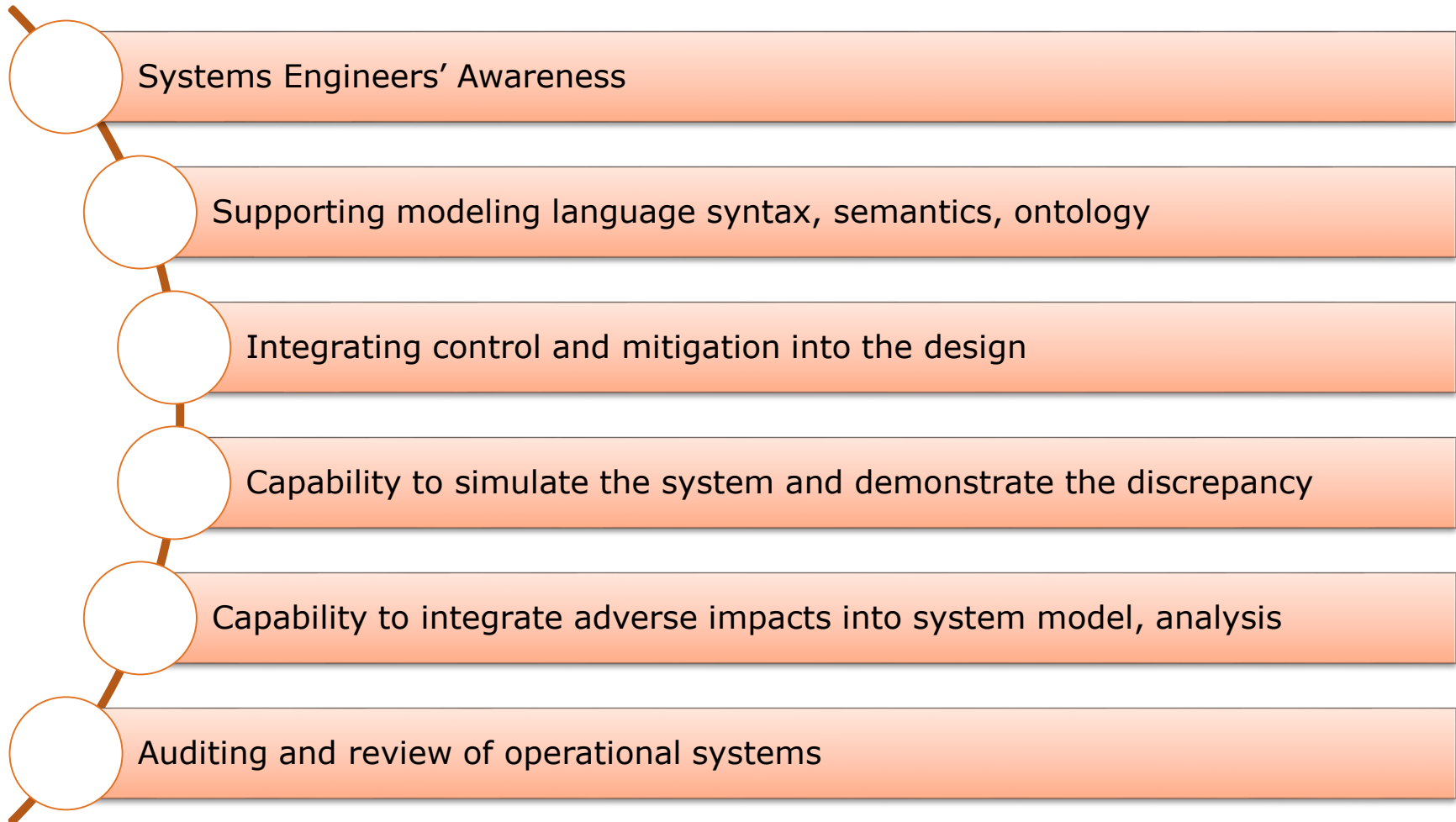
# Malaysia Airlines Flight 370



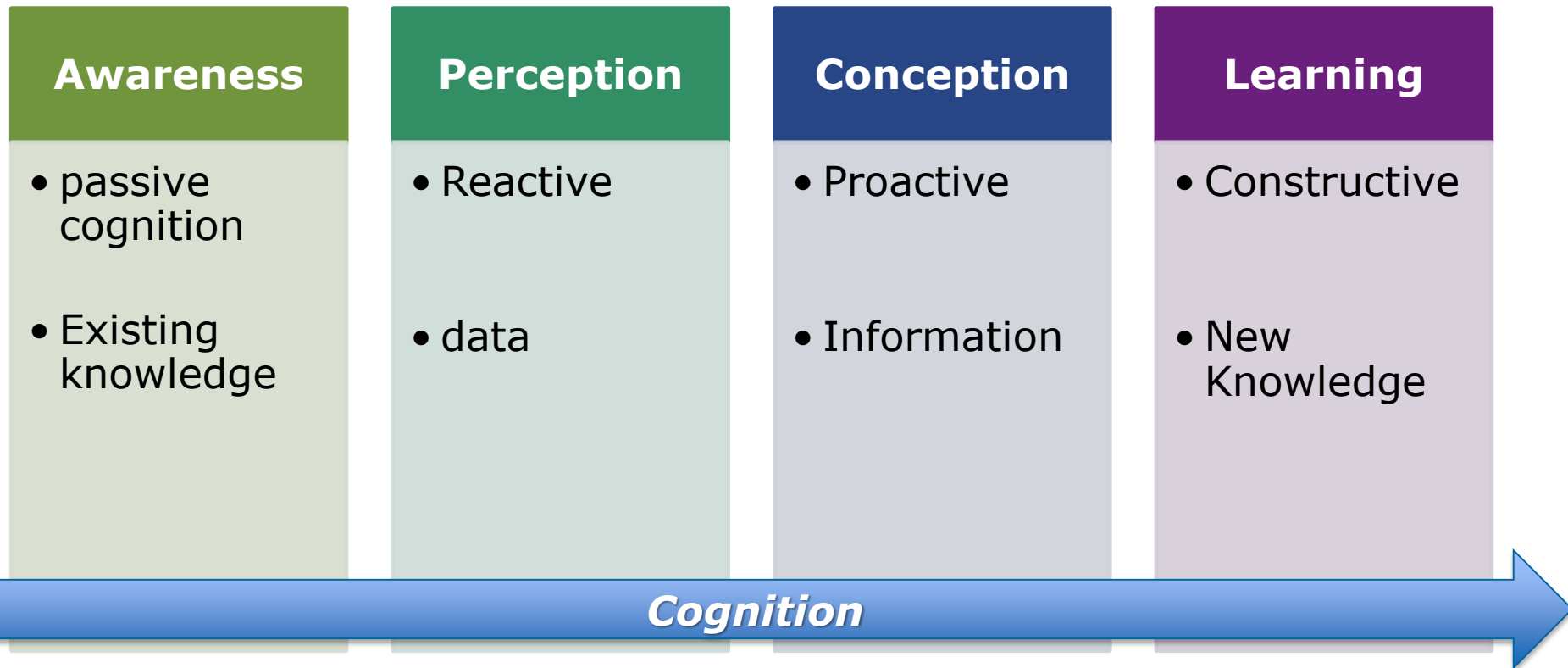
Mini-M Service Coverage



# Mitigating the impact of the Cyber-Physical Gap

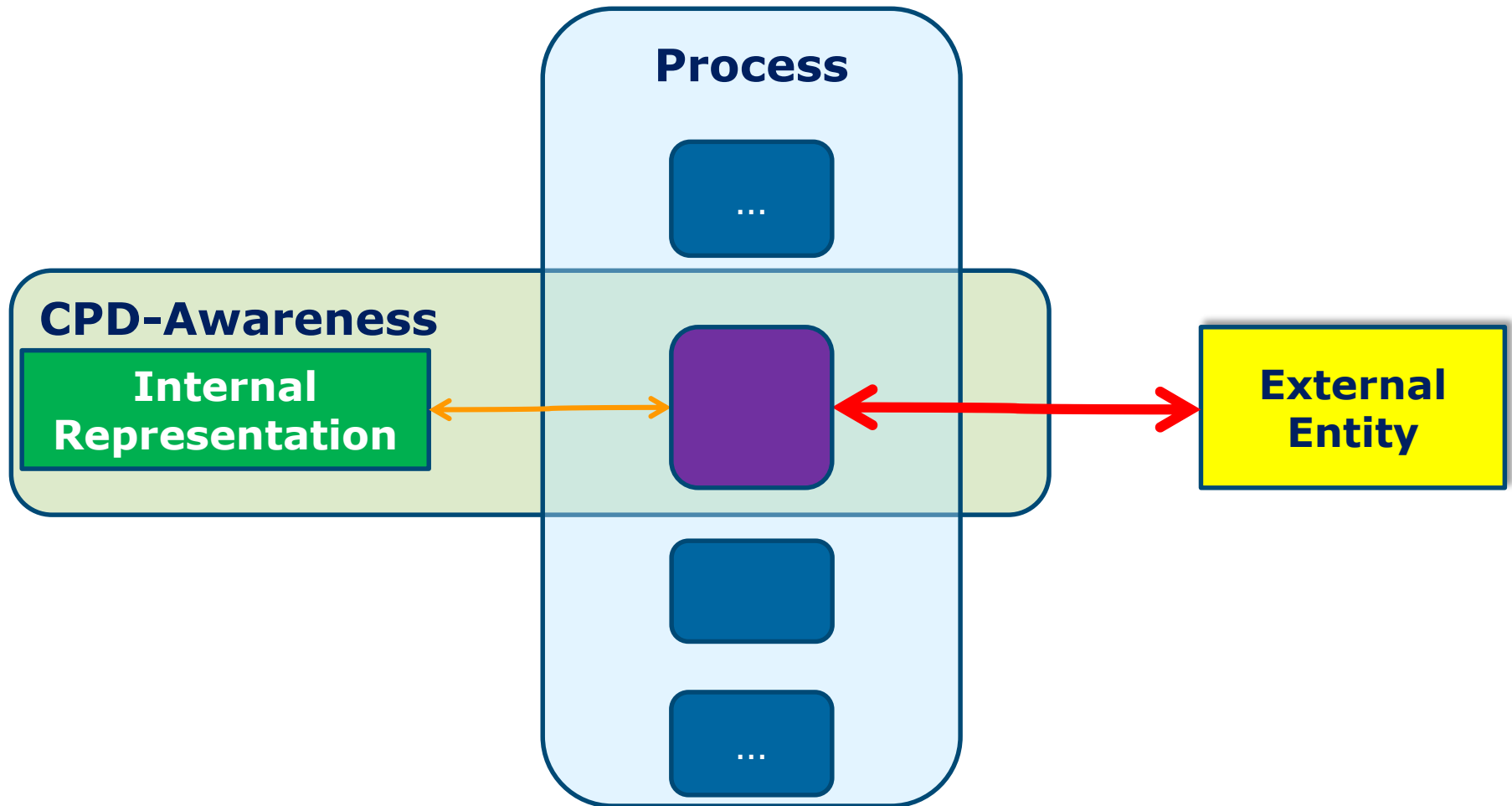


# Cognitive levels

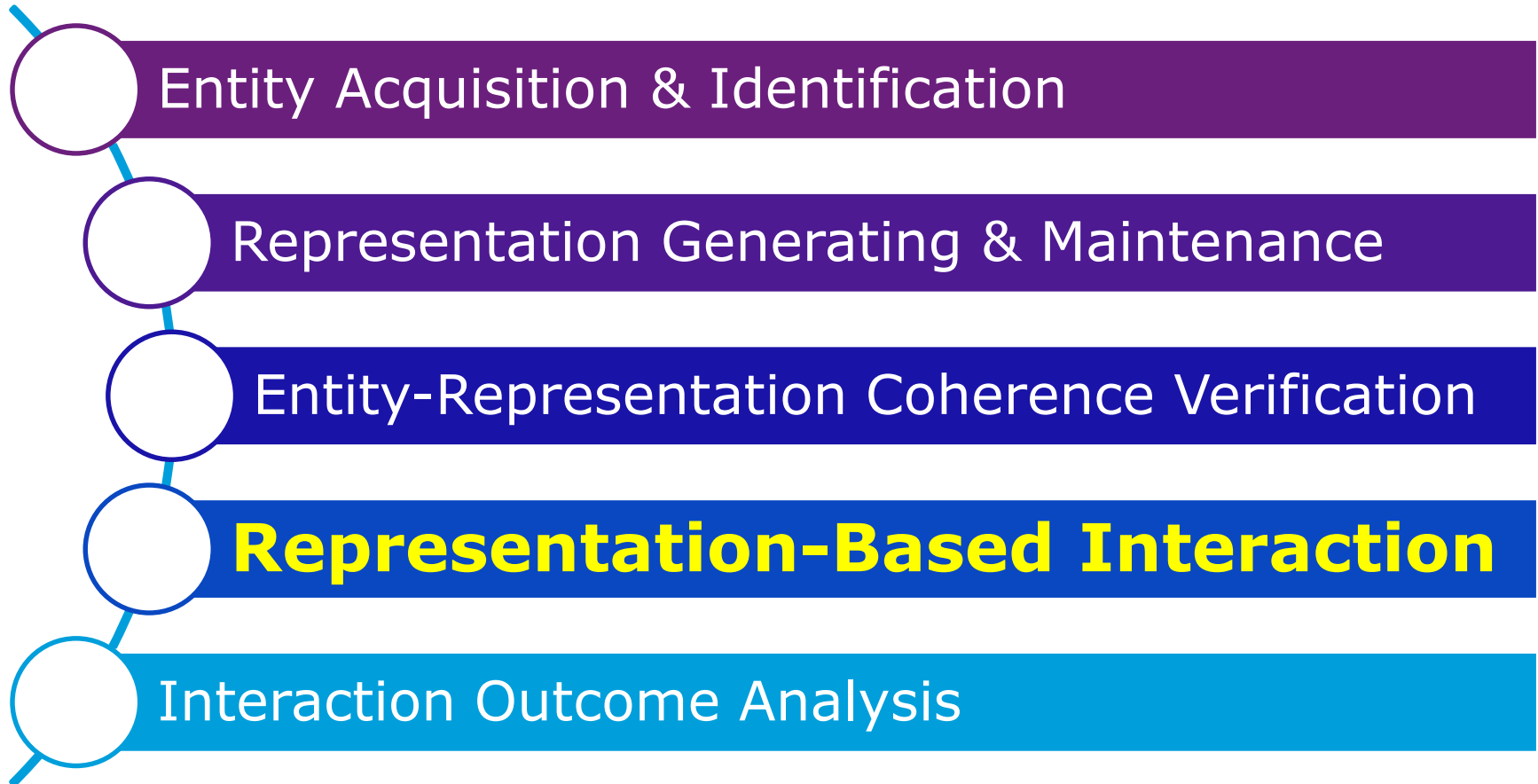




# CPD-Aware System Modeling



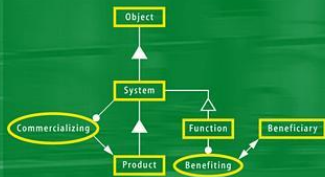
# CPD-Aware Modeling Principles



# Object-Process Methodology: A Disruption-Accommodating Modeling Language

## Object-Process Methodology

A Holistic Systems Paradigm

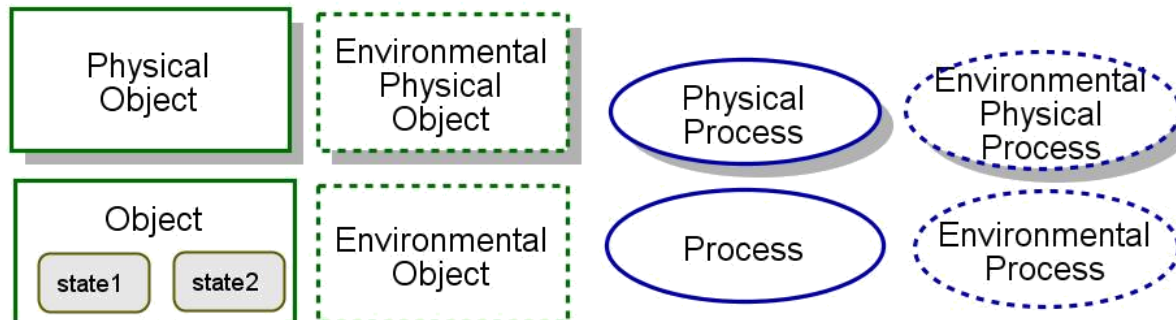


Dov Dori



► **Dov Dori**, [Object-Process Methodology - A Holistic Systems Paradigm](#), Springer Verlag, Berlin, Heidelberg, New York, 2002

► **Dov Dori**, [Model-Based Systems Engineering with OPM and SysML](#), Springer Verlag, **2016 – to appear**



# Object Process Methodology (OPM)

Conceptual  
modelling language  
and paradigm

Based on the  
minimal universal  
ontology principle

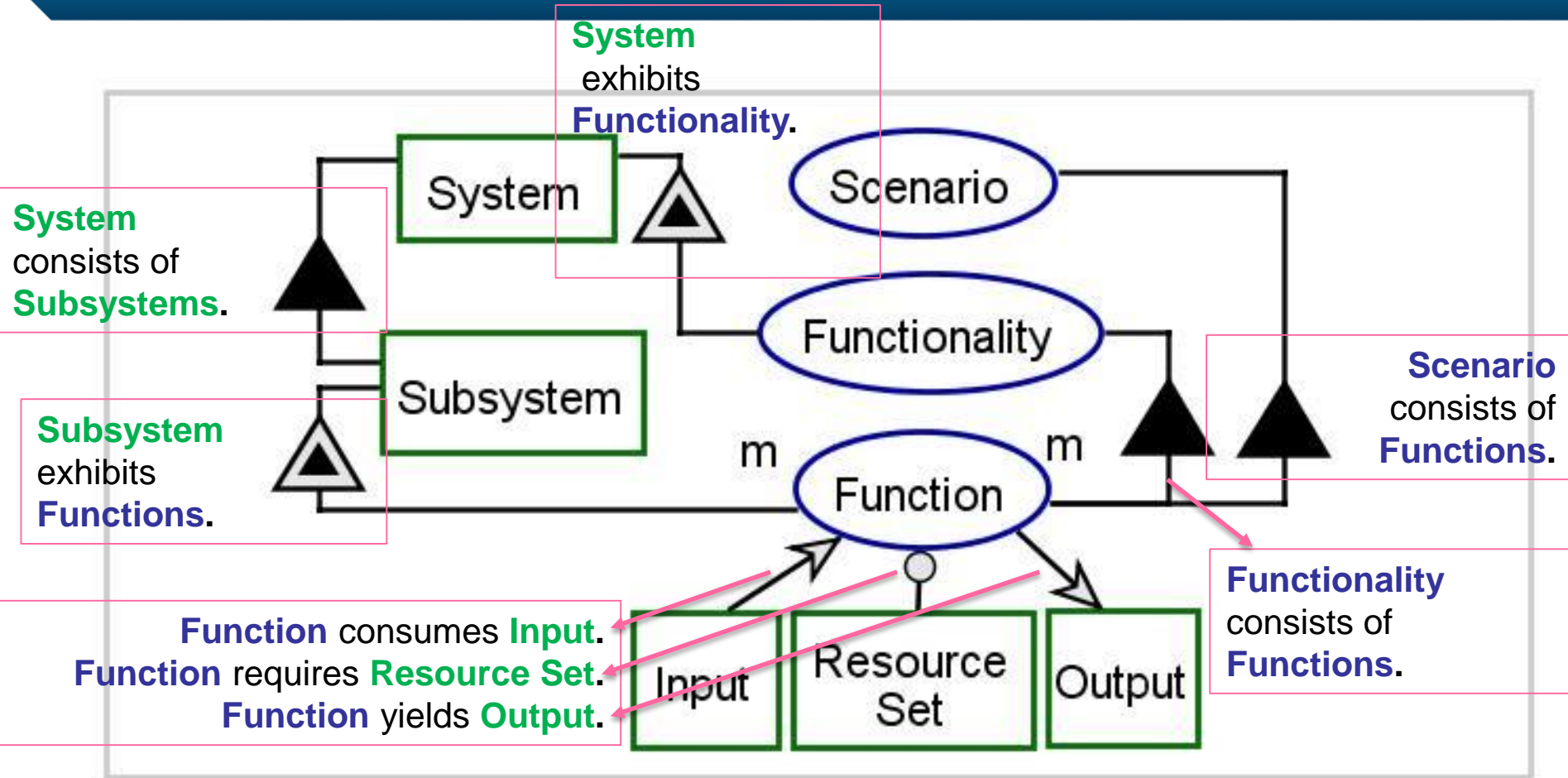
Has one diagram  
kind that expresses  
structural,  
functional, and  
procedural aspects

Diagrams are  
organized  
hierarchically

Bimodal: the model  
is both graphical  
and textual.

Standard: OPM is  
ISO 19450

# Binding the Building Blocks: Structural and Procedural Links





# OPL: The Textual Modality

- › **System** consists of **subsystems**.
- › **System** exhibits **functionalities**.
- › **Functionality** consists of **functions**.
- › **Subsystem** exhibits **functions**.
- › **Function**
  - Receives **input**
  - Requires **resource set**
  - Returns **output**
- › **Scenario** consists of ordered **functions**.

# How does OPM cater to CPG Modeling?

Informatical/  
Physical Essence  
Distinction

Systemic/  
Environmental  
Affiliation  
Distinction

Model execution  
and simulation  
support

Evolutionary  
modeling and  
detail  
decomposition

Bimodality of  
graphics and text  
enables formal  
specification

Supporting  
disruption  
modeling  
framework

# **OPM Demo with OPCAT a free MBSE tool**

**OPCAT download:**

**[http://esml.iem.technion.ac.il/?page\\_id=1849](http://esml.iem.technion.ac.il/?page_id=1849)**

# Summary

- The Cyber-Physical Gap: an important notion that must be accounted for in cyber-physical interactions.
- A series of steps to raise systems' awareness by-design of the cyber-physical gap and its potential adverse impact.
- Object-Process Methodology as a CPG accommodating modeling language.
- Demonstration of the integration of CPG handling into a nominal system model.



***Reality cannot be simplified by  
disregarding its complexity...***

**Thanks!**

**Yaniv Mordecai**

**[yanivmor@Technion.ac.il](mailto:yanivmor@Technion.ac.il)**