

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

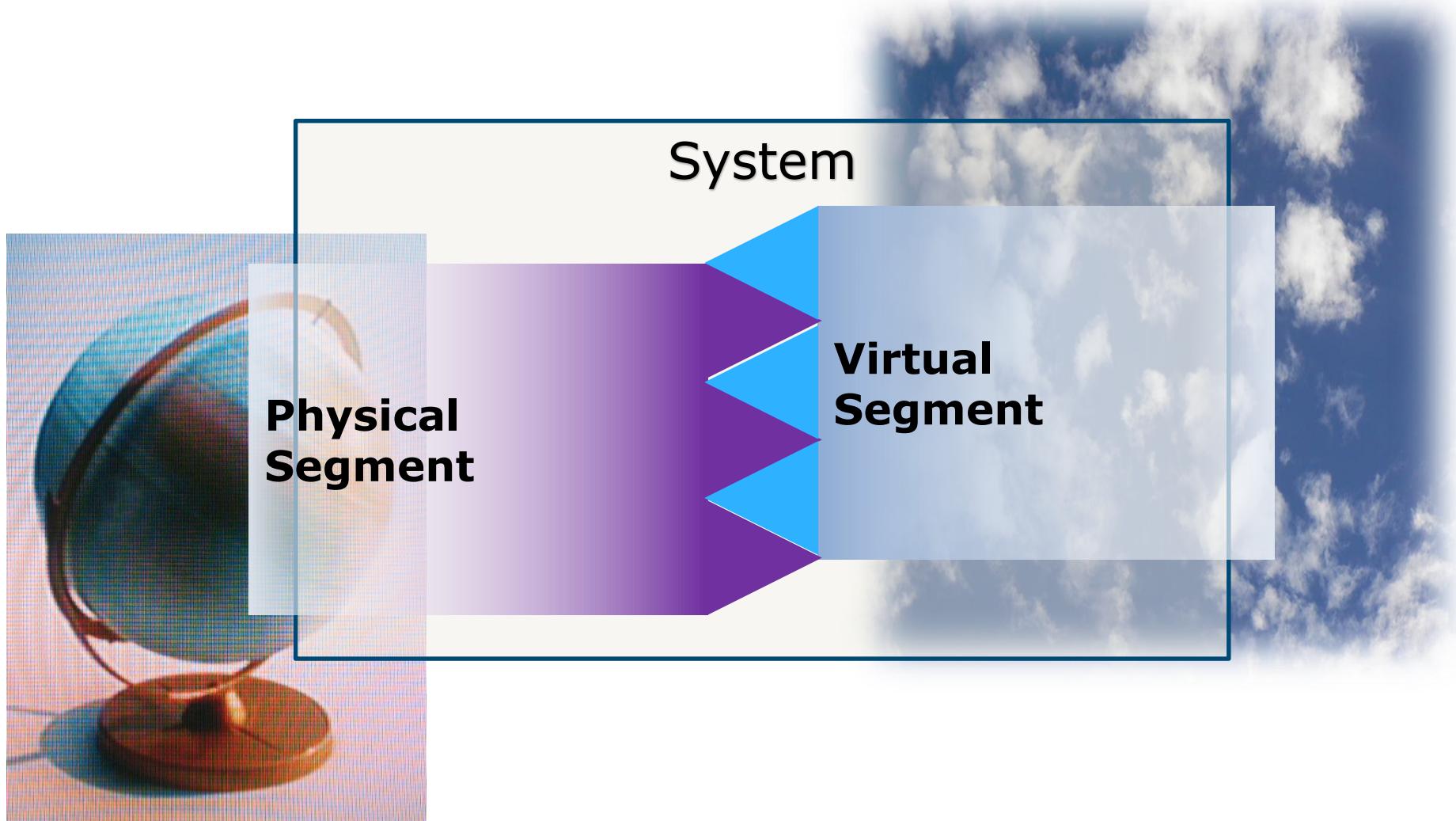
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Joint work with Prof. Dov Dori, INCOSE Fellow

February 2016

Cyber-Physical Systems



Cyber-Physical Challenges

**Cyber Security
and Safety**

**Information
Security and
Privacy**

Communication

Connectivity

Autonomy

Control

Interoperability

**Evolution and
Adaptability**

Sociability

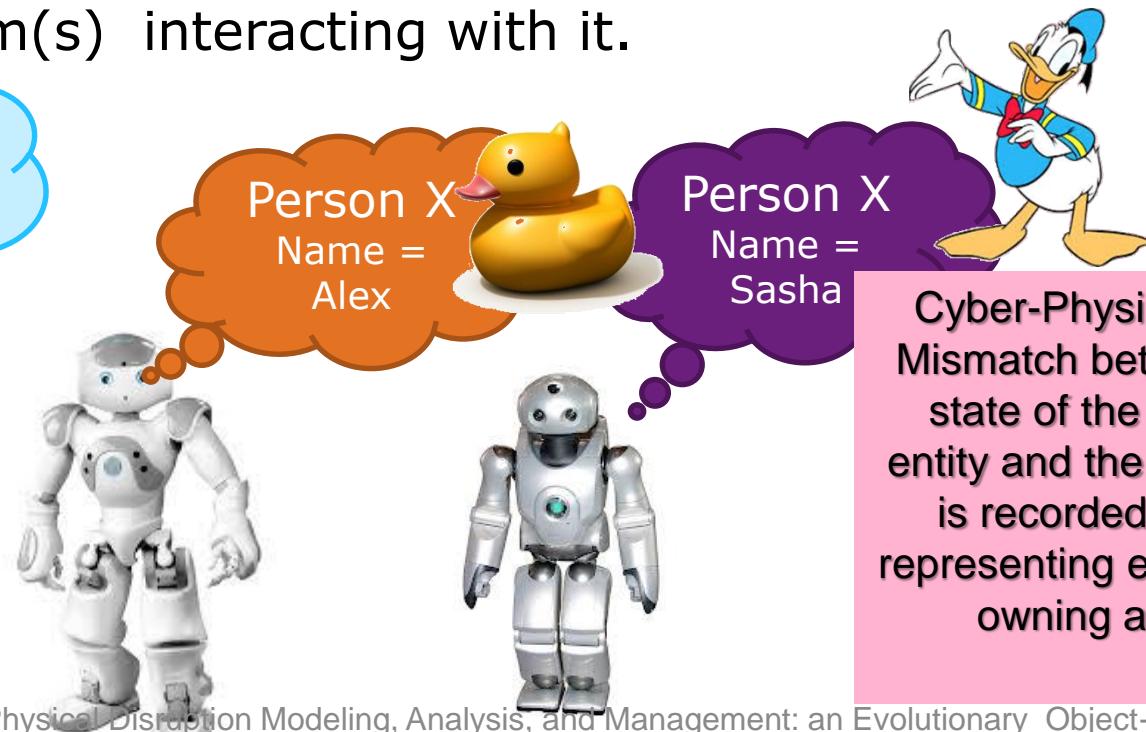
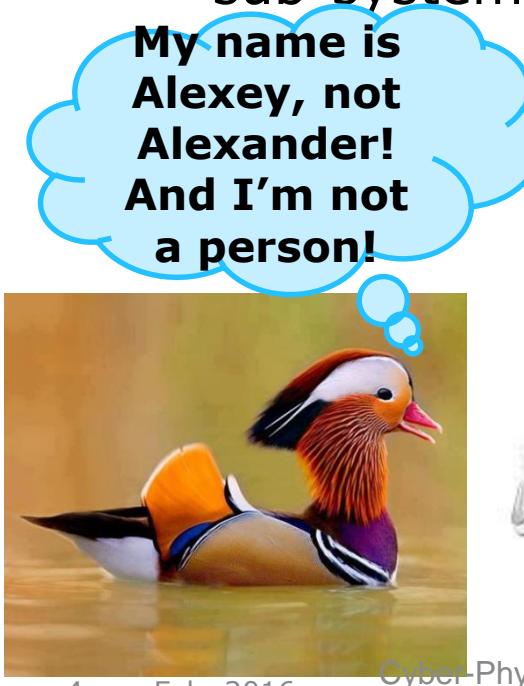
Data-scale

Sensing

Actuating

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.



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 informational 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.																	
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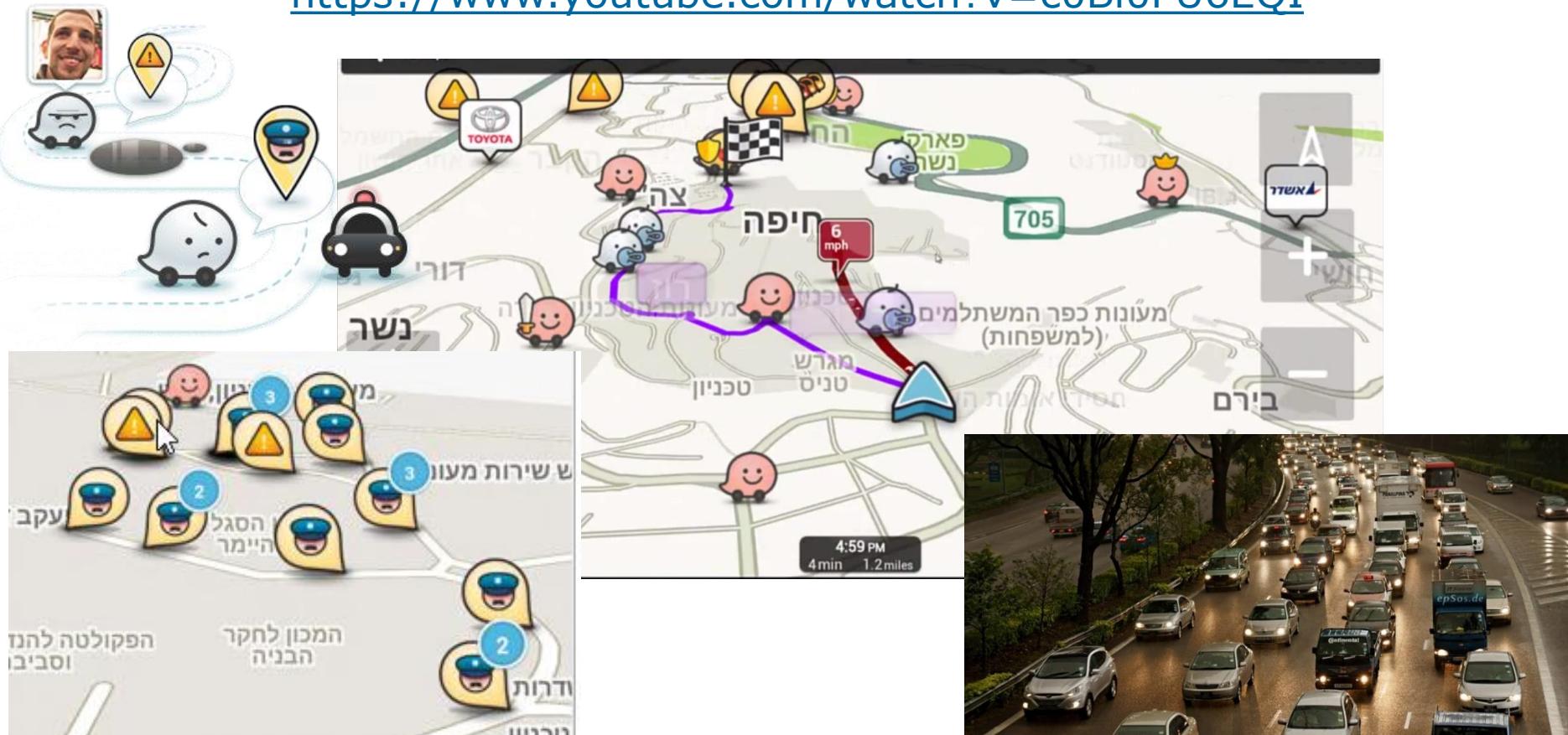
 Create success. Together.



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

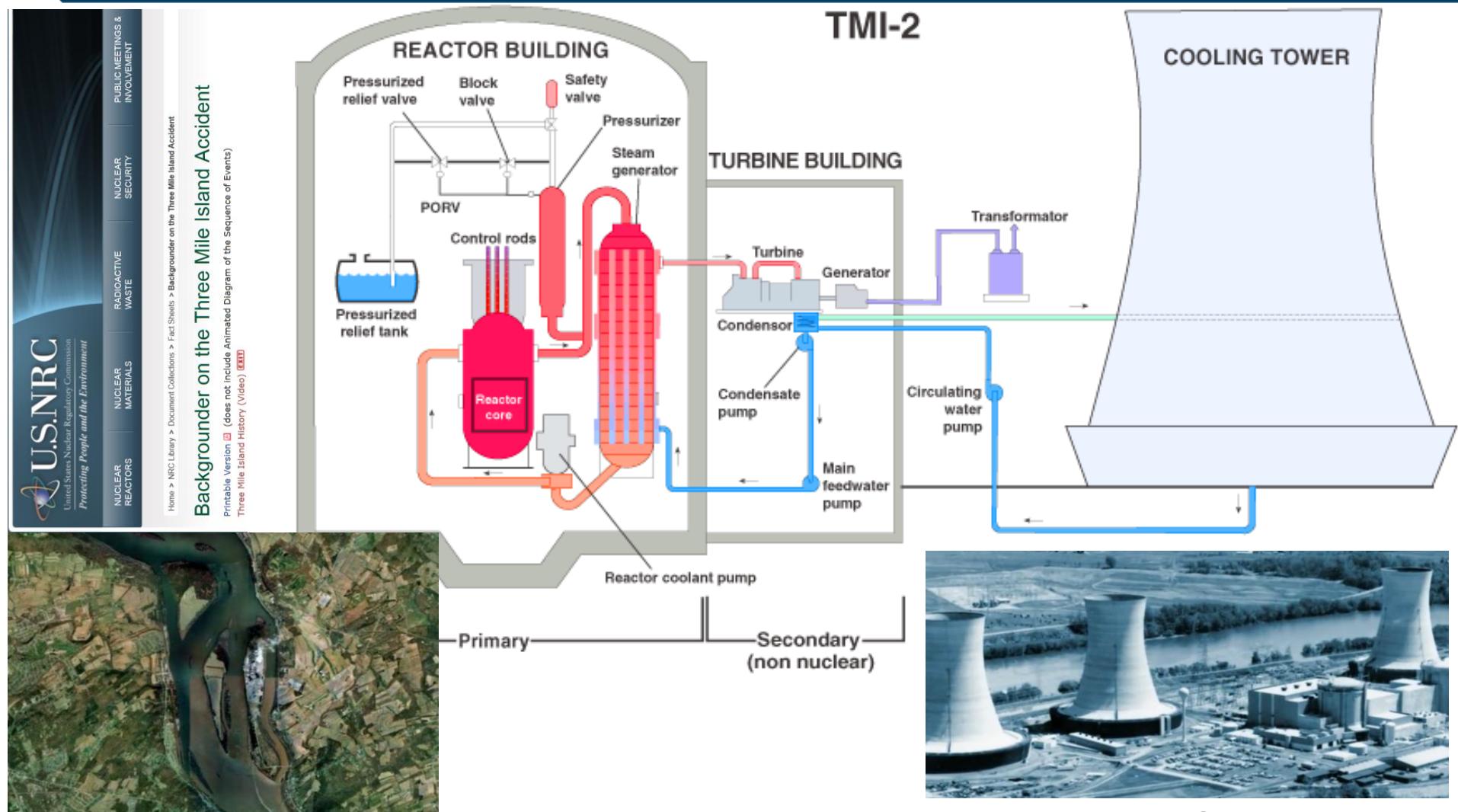
Date: 02/01/16
To: Al Spence, Directives Program Manager, AFS-110
From: John S. Duncan, Director, Flight Standards Service, AFS-1 *John S. Duncan* *BS*
Prepared by: Richard Mathews, Directive Management Officer, AFS-140
Subject: Cancellation of Advisory Circular AC 20-34D, Prevention of Retractable Landing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

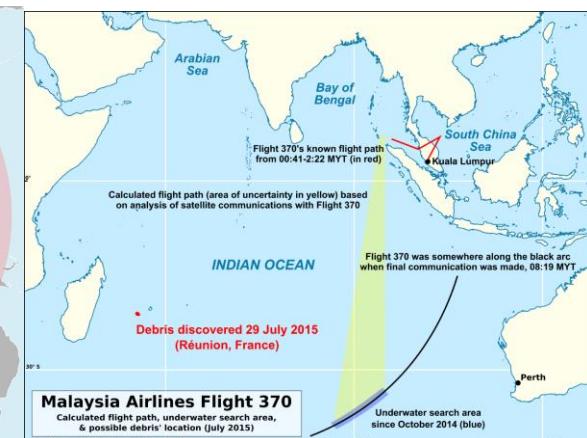
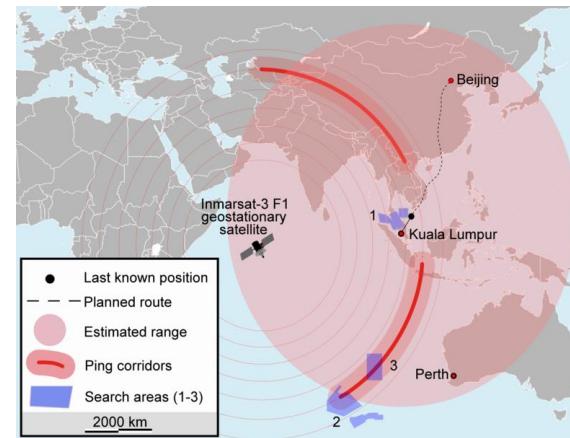
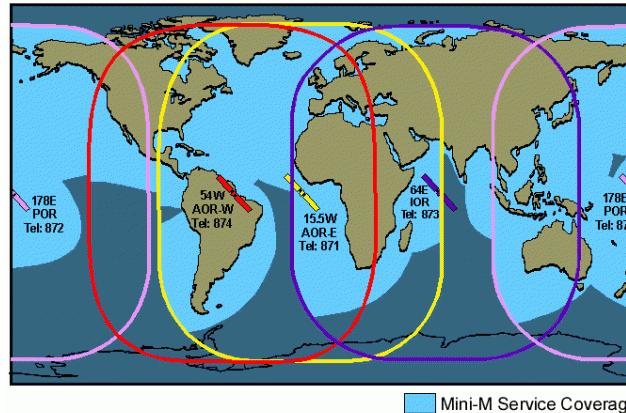
Three Mile Island 2 Accident

March 28, 1979

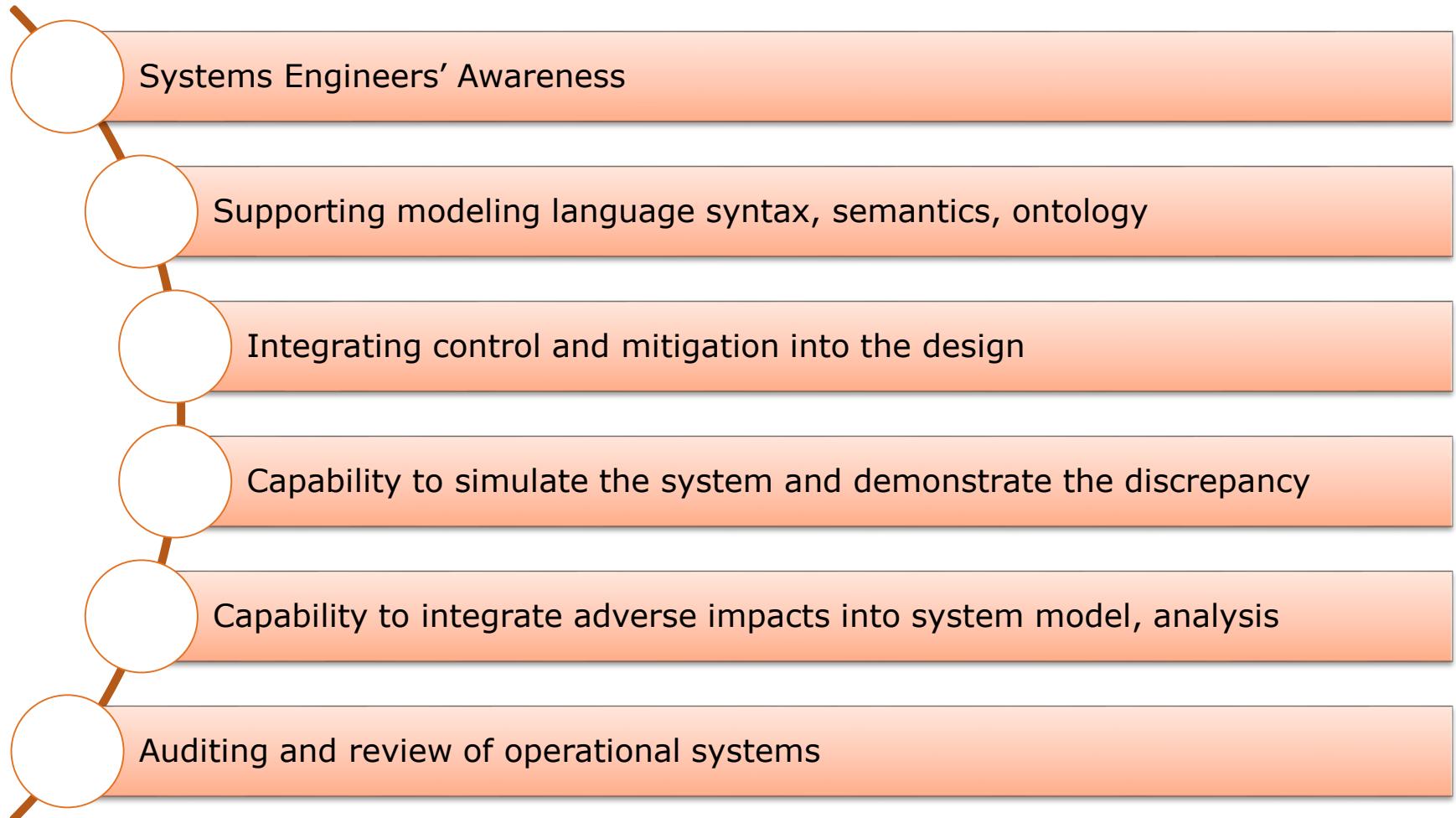
<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>



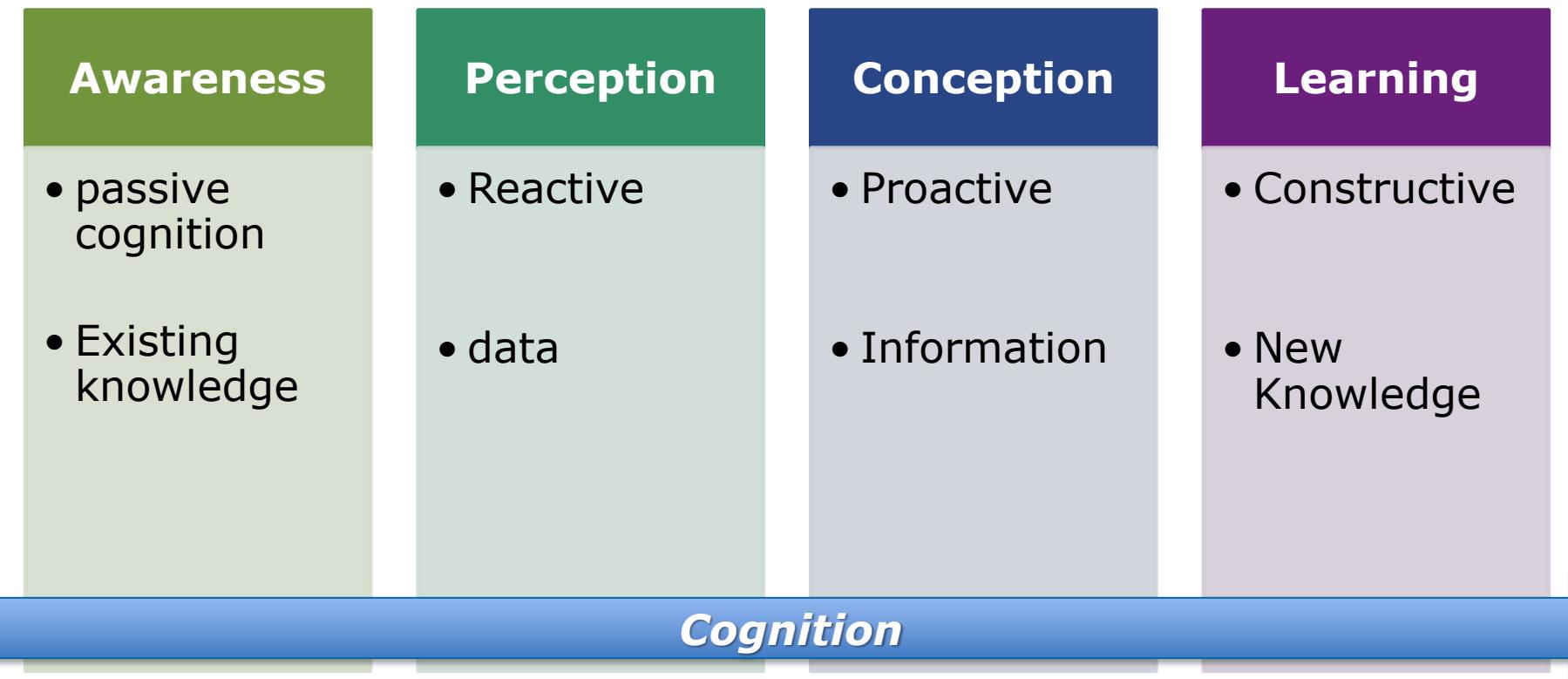
Malaysia Airlines Flight 370



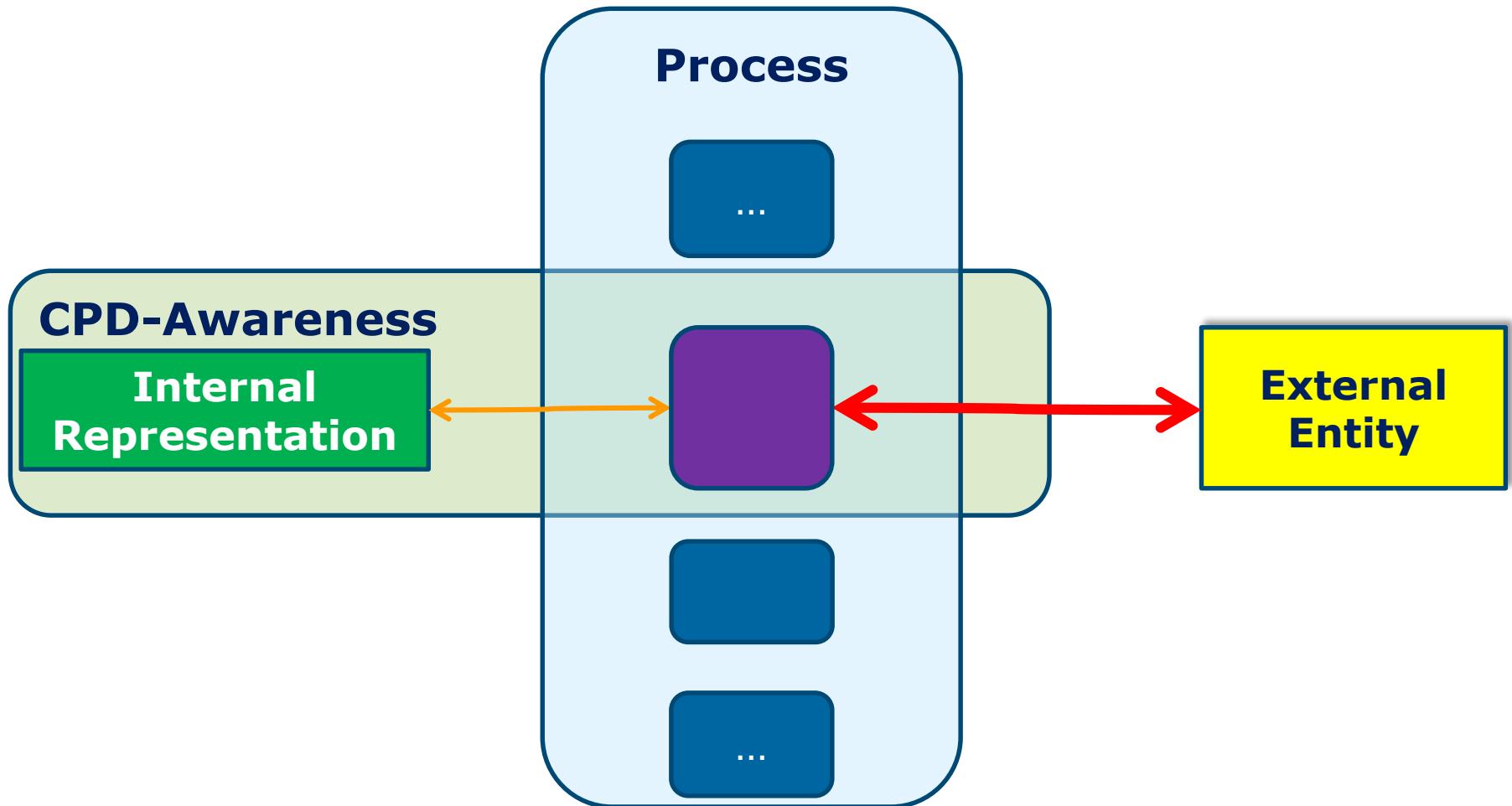
Mitigating the impact of the Cyber-Physical Gap



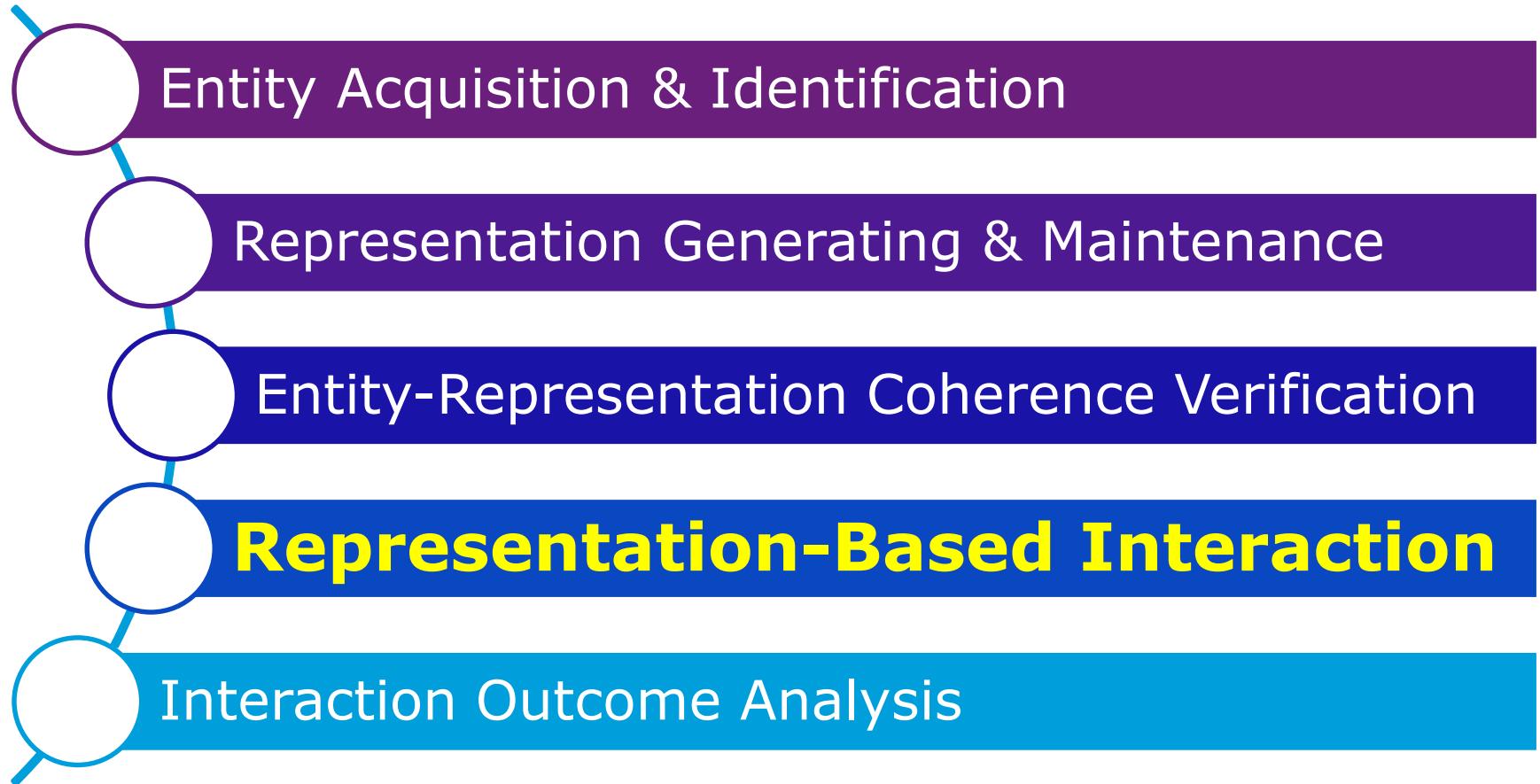
Cognitive levels



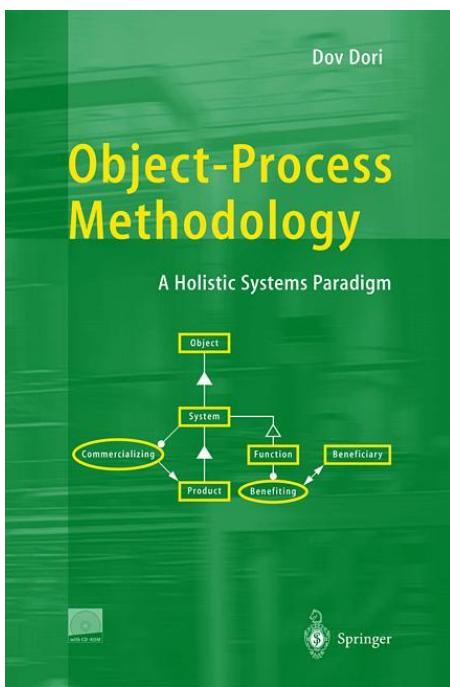
CPD-Aware System Modeling



CPD-Aware Modeling Principles

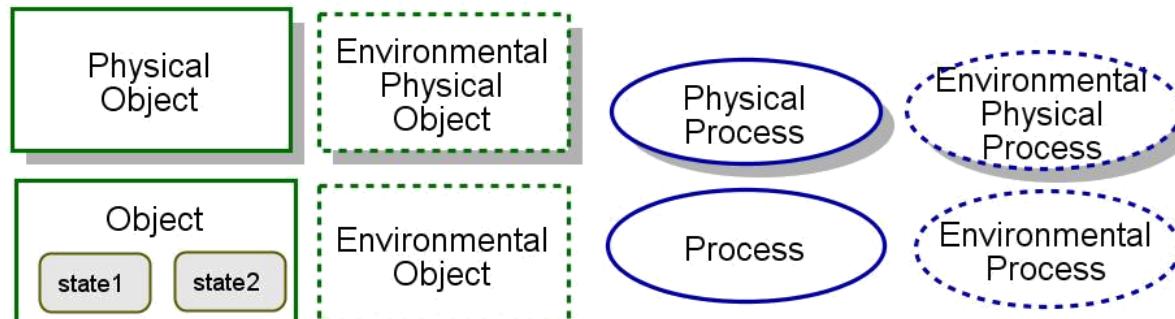


Object-Process Methodology: A Disruption-Accommodating Modeling Language



➤ **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

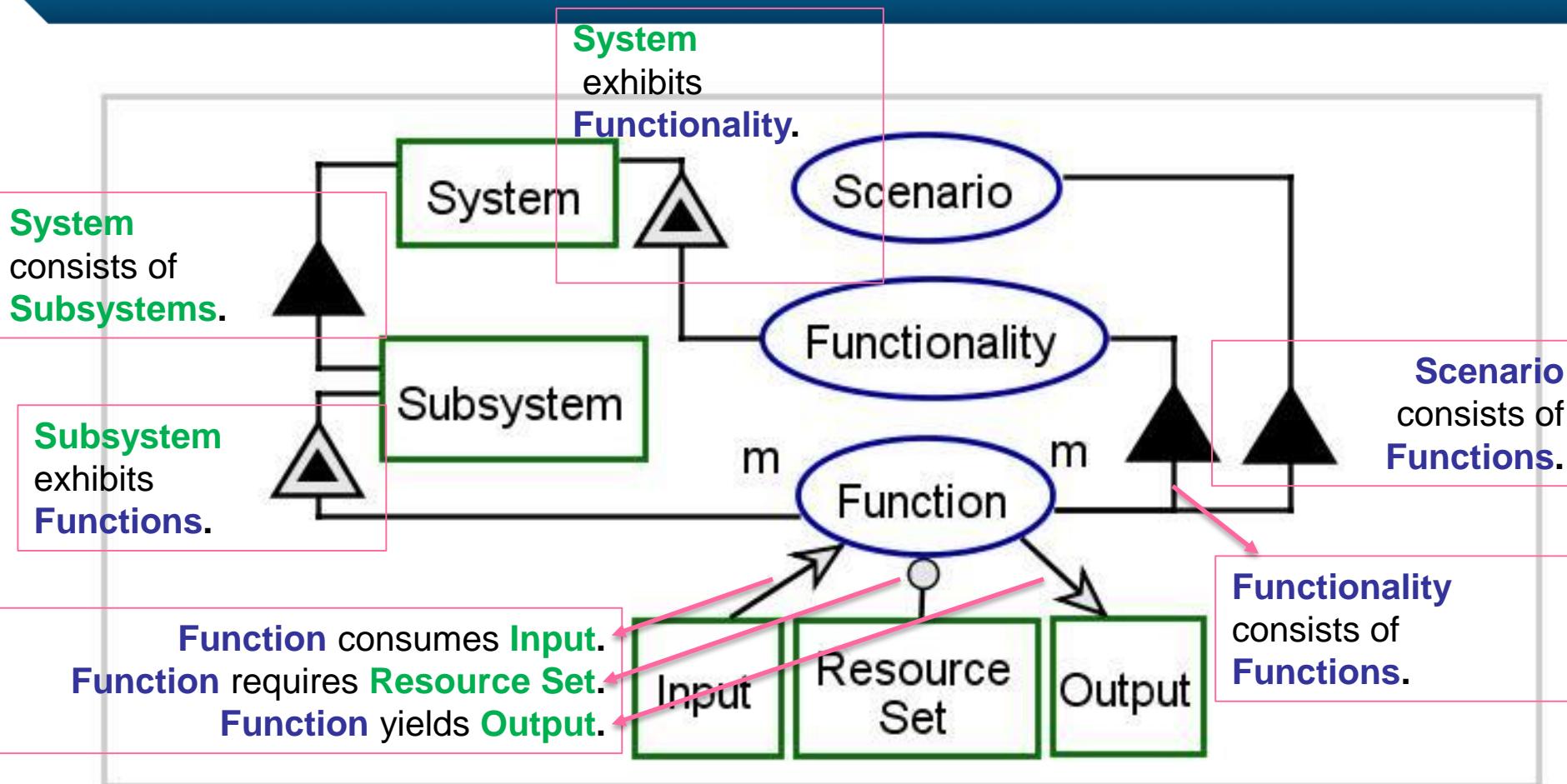
Has one diagram kind that expresses structural, functional, and procedural aspects

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?

Informational/
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

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!
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