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PANEL
ICONS/ EMBEDDED / ICDT / SPACOMM / RESENS

Complexity and Safety in Communication Systems

MODERATOR
Petre Dini, Concordia University, Canada | China Space Agency Center, China

Panel structure

- **Moderator**
  Andy Snow, Ohio University, USA
- **Panelists**

Pål Ellingsen, *Bergen University College, Norway*

Timothy Pham, *Jet Propulsion Laboratory / California Institute of Technology, USA*

Nataša Živić, *University of Siegen, Germany*

Kamal Harb, *KFUPM, Saudi Arabia*

Marko Jäntti, *University of Eastern Finland, Finland*

Roberto Sebastian Legaspi, *Transdisciplinary Research Integration Center | Research Organization of Information and System, Japan*

Open discussion

Open Discussion

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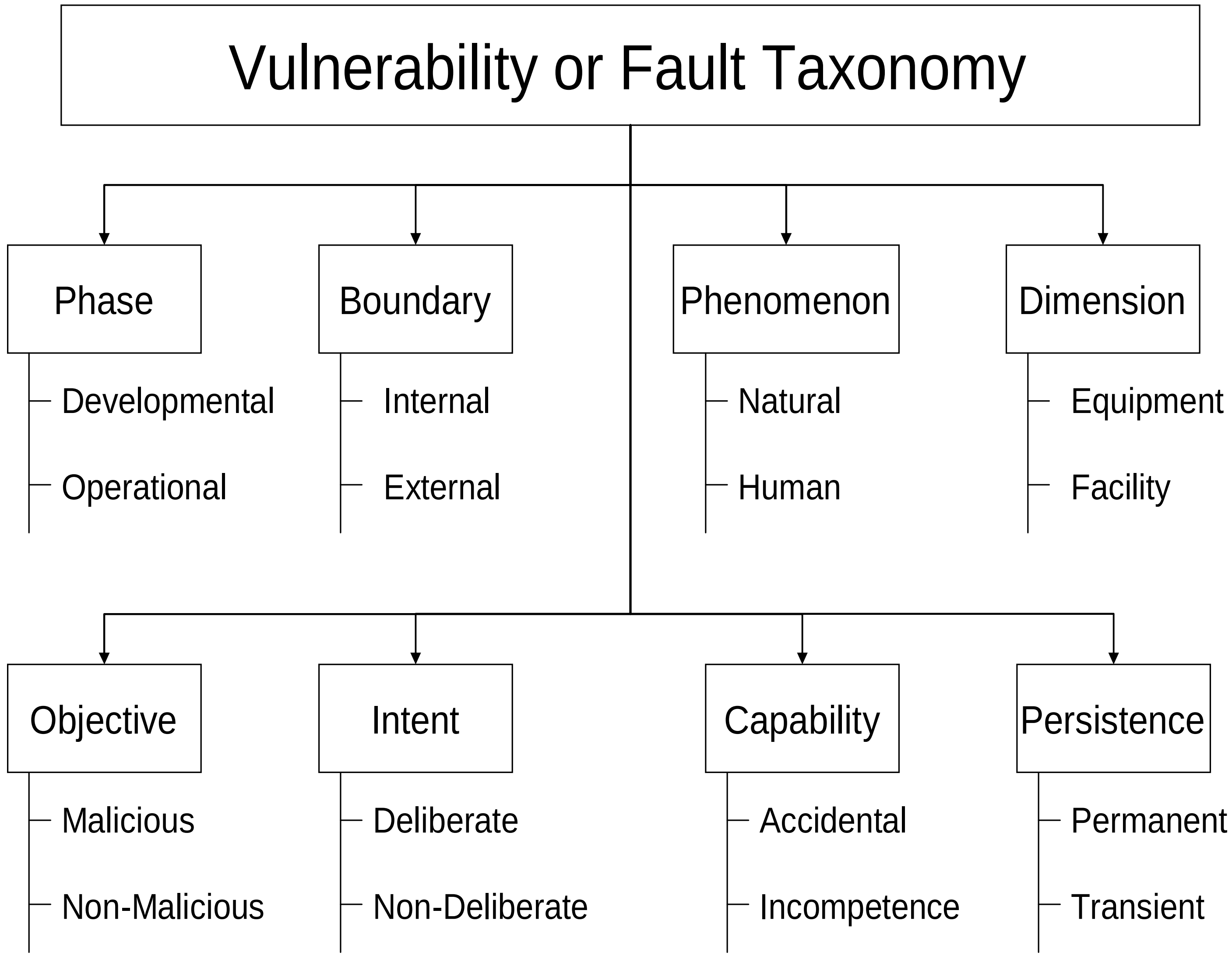
Complexity and Safety in Communication Systems

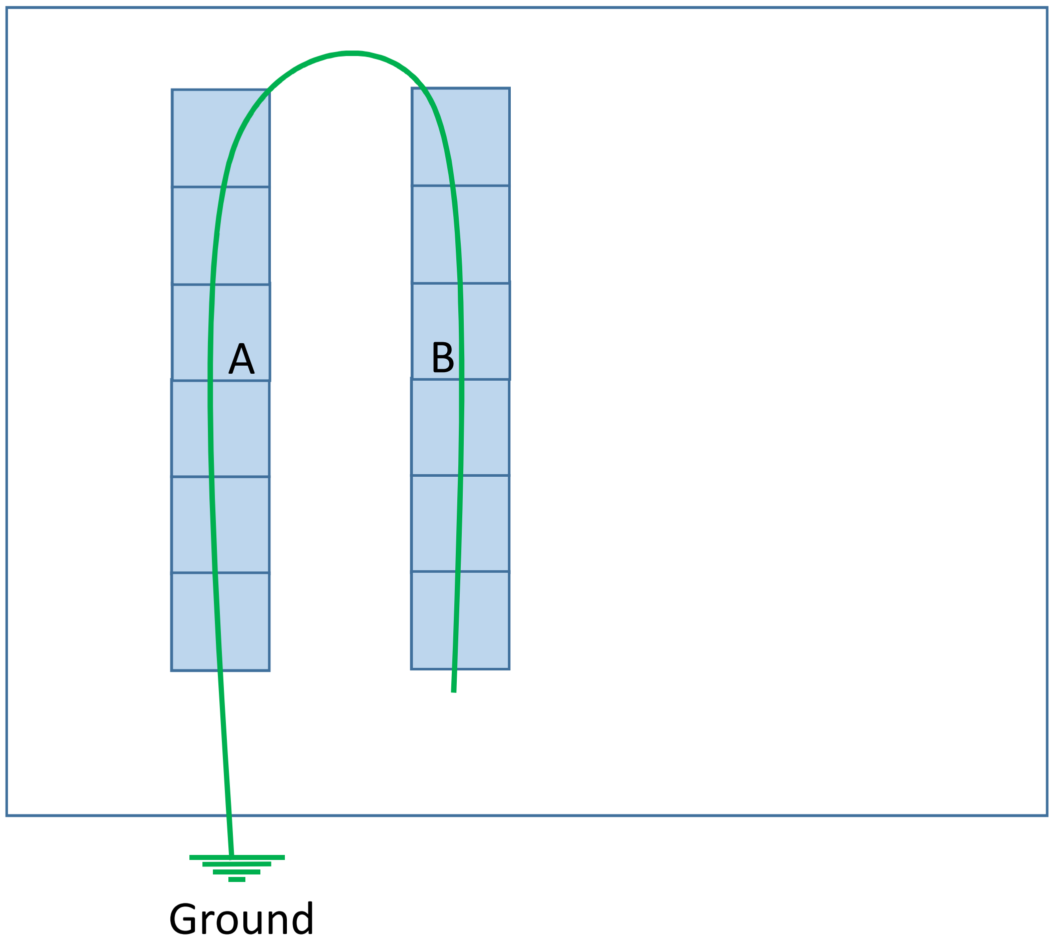
Andy Snow
Ohio University

Reference

- A. Avizienis, et al, “Basic Concepts & Taxonomy of Dependable & Secure Computing”, *IEEE Transactions on Dependable & Secure Computing*, 2004.
  - Reliability
  - Maintainability
  - Availability
  - Safety
  - Confidentiality
  - Data Integrity

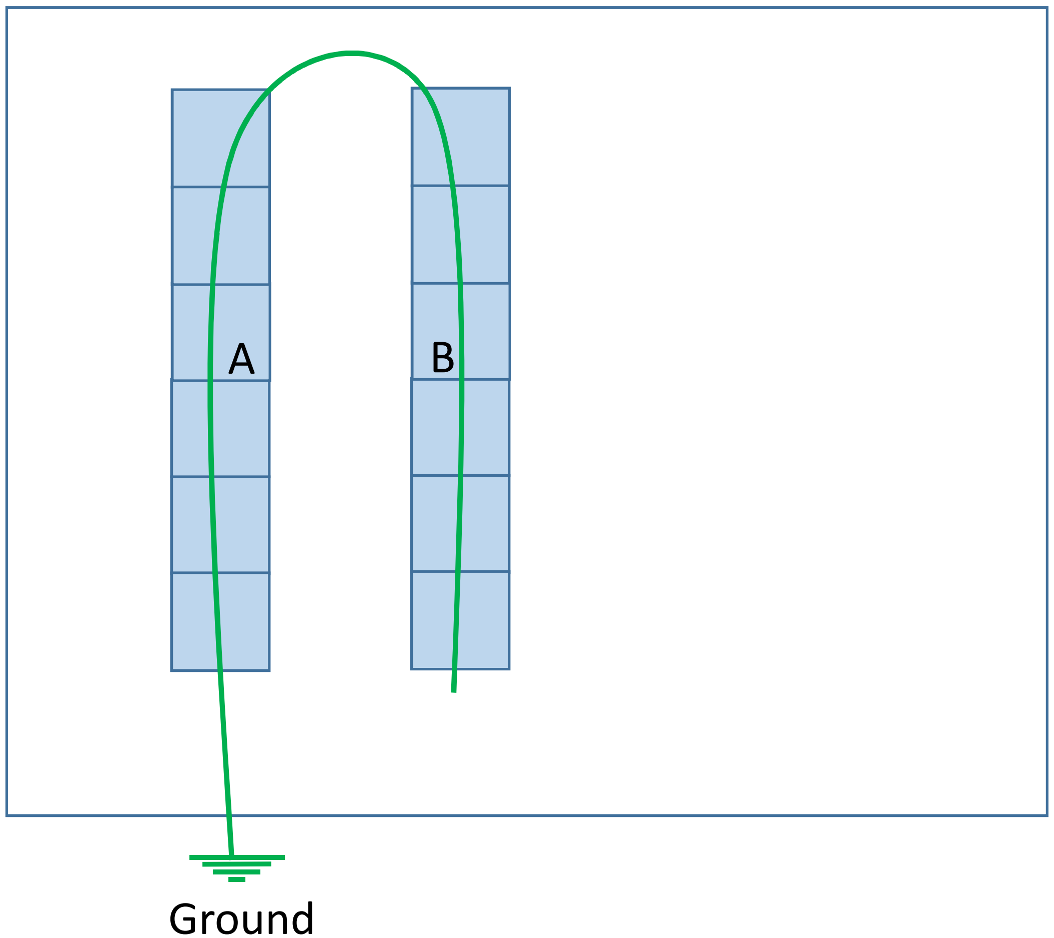

Vulnerability or Fault Taxonomy
Phase
Developmental
Operational
Boundary
Internal
External
Phenomenon
Natural
Human
Dimension
Equipment
Facility
Objective
Malicious
Non-Malicious
Intent
Deliberate
Non-Deliberate
Capability
Accidental
Incompetence
Persistence
Permanent
Transient

Lightning Safety



- Ground wire is AWG 00
  - 0.38 inches dia.
  - 0.85 cm dia.
- Assume 10 m of wire from point A and B
  - Inductance (L) is 1.54 uH

Lightning



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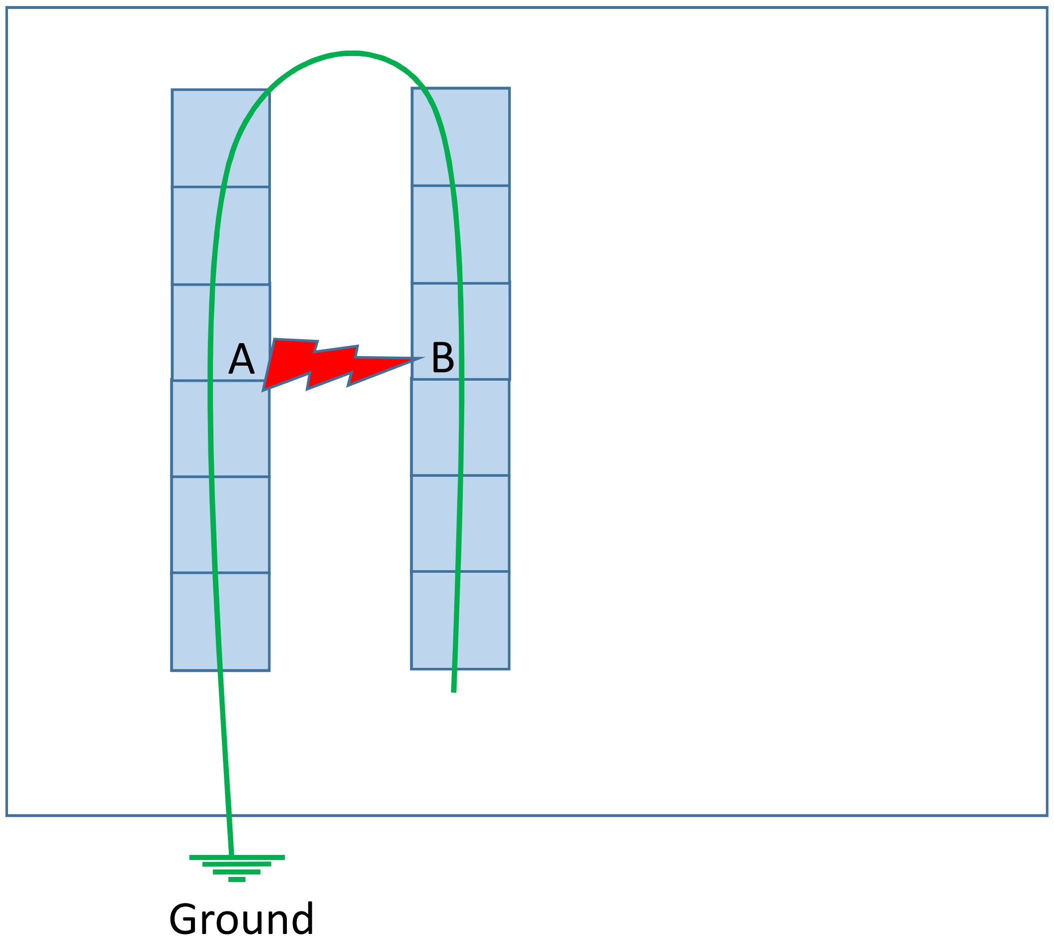
- V_{AB} = L* dI/dt
- For lightning
  - dI/dt = 10,000 amps/usec
  - V_{AB} = 15,400 Volts

Lightning



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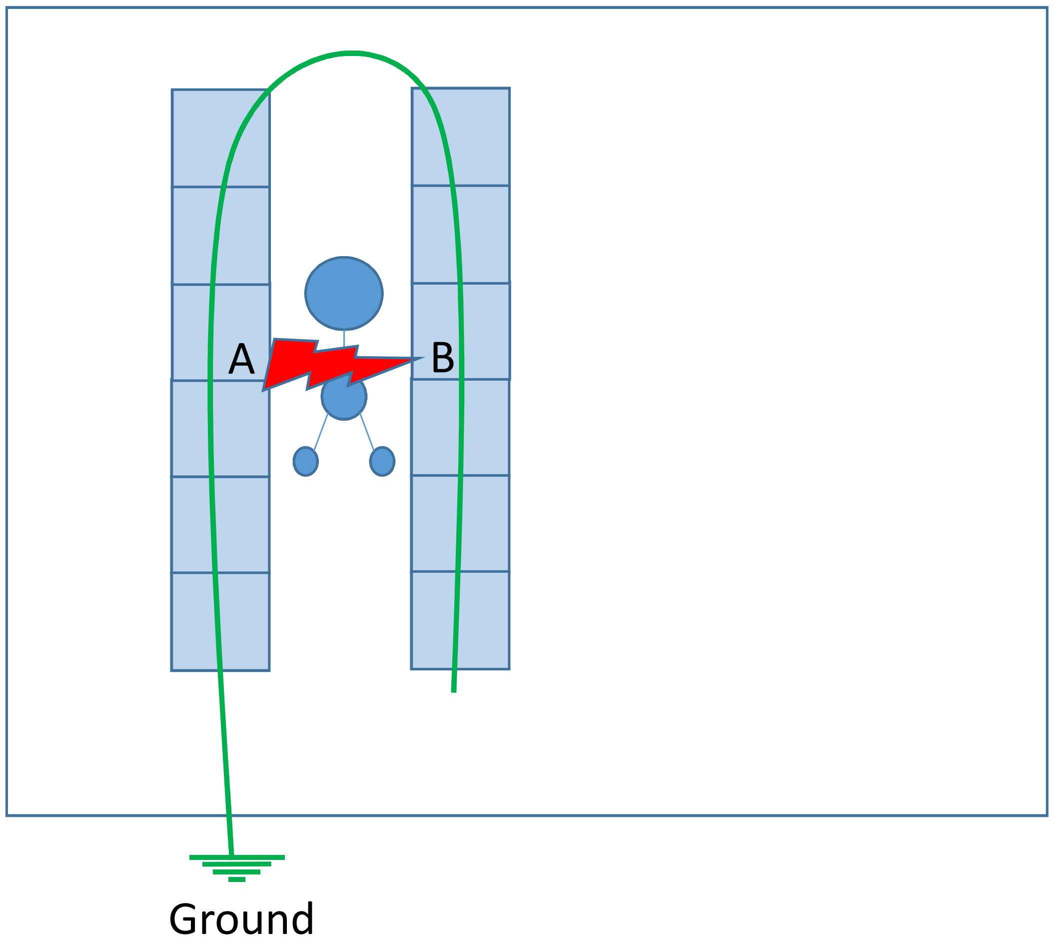

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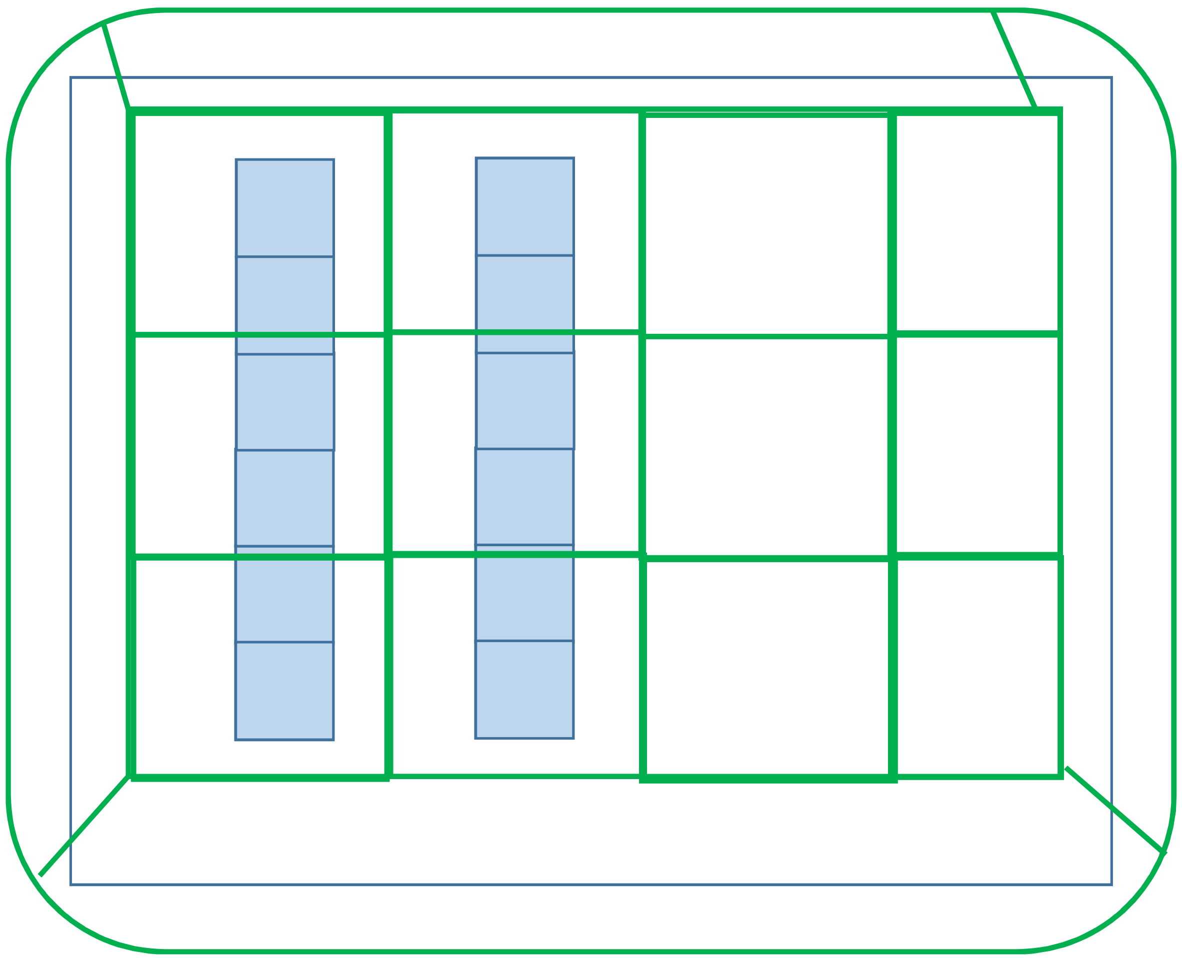


Ground

- Outer buried ring connected to inner ring of ground wire

“Normal Accidents” to be Expected?

- **Normal Accidents: Living with High Risk Technologies Updated Edition** Charles Perrow

Accidents are inevitable in Complex Systems

"*Normal Accidents* **analyzes the social side of technological risk**. Charles Perrow argues that the conventional engineering approach to ensuring safety--building in more warnings and safeguards--fails because systems complexity makes failures inevitable.

He asserts that typical precautions, by adding to complexity, may help create new categories of accidents. (At Chernobyl, tests of a new safety system helped produce the meltdown and subsequent fire.)
By recognizing two dimensions of risk--complex versus linear interactions, and tight versus loose coupling--this book provides a powerful framework for analyzing risks and the organizations that insist we run them."

11th International Conference on Systems

February 21-25, 2016

Lisbon, Portugal

Panel on ICONS/EMBEDDED/ICDT/SPACOMM/RESENS

Resilience of Complex Socio-Technical Systems

Roberto Legaspi, PhD

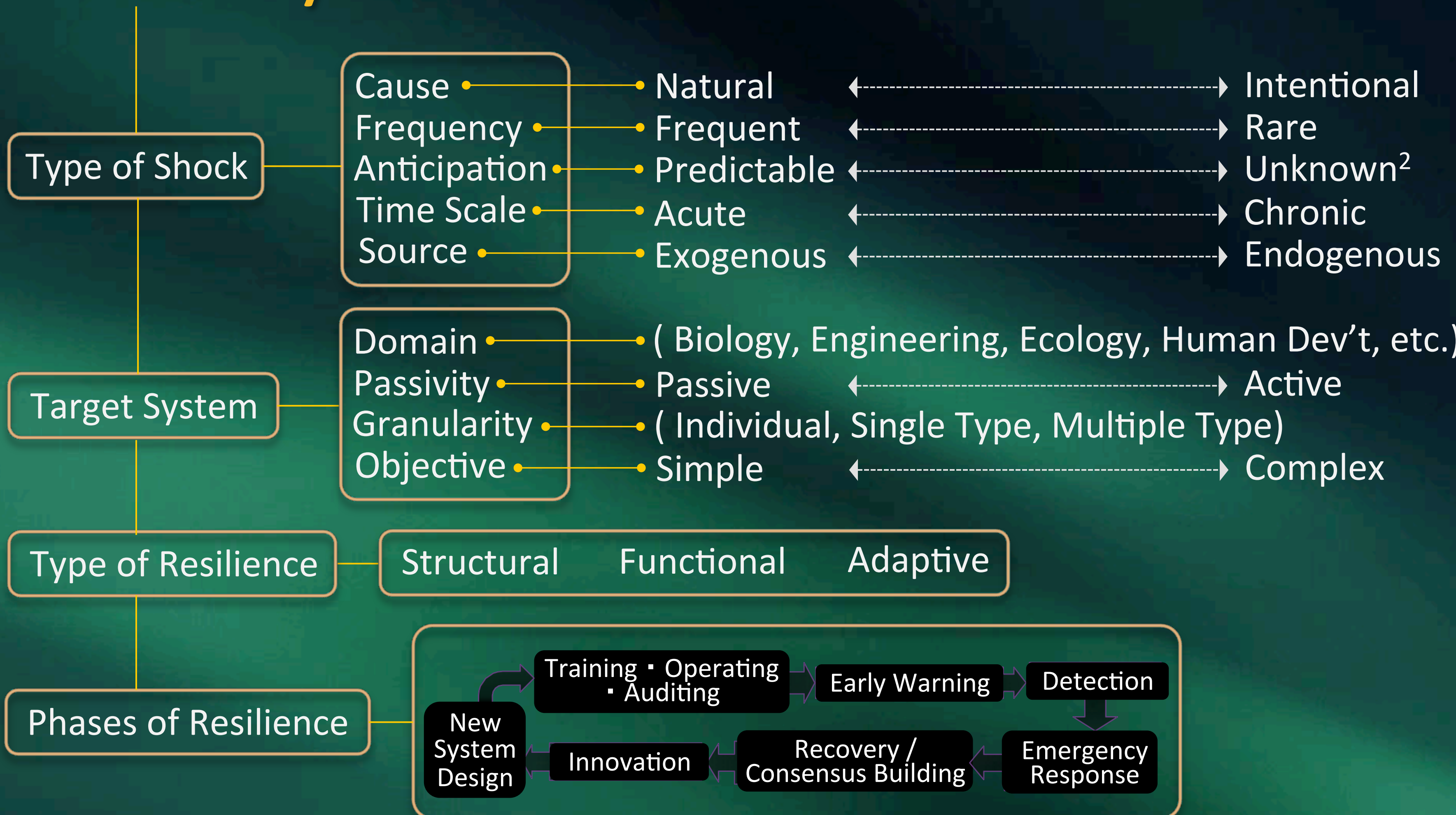
大学共同利用機関法人 情報・システム研究機構 Research Organization of Information and Systems

新領域融合研究センター Transdisciplinary Research Integration Center

Research Organization of Information and Systems The Institute of Statistical Mathematics

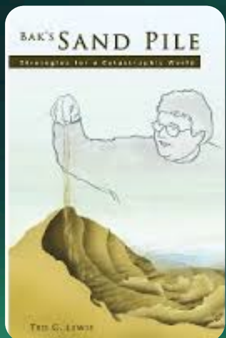
Transdisciplinary Research Integration Center

Taxonomy for General Resilience



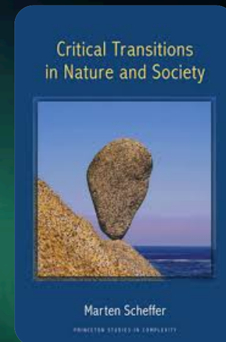
H. Maruyama, R. Legaspi, K. Minami and Y. Yamagata (2014), "General Resilience: Taxonomy and Strategies," Proc. International Conference and Utility Exhibition 2014 on Green Energy for Sustainable Development

Complexity and Resilience Thinking

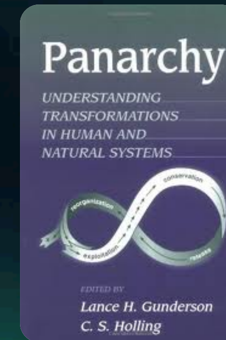


Lewis, T.G. (2011) Bak's Sand Pile – Strategies for a Catastrophic World

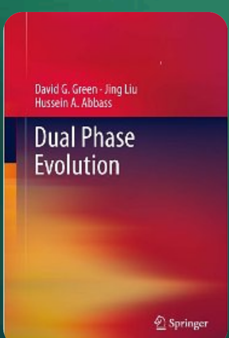
Page, S.E. (2011) Diversity and Complexity



Scheffer, M. (2009) Critical Transitions in Nature and Society

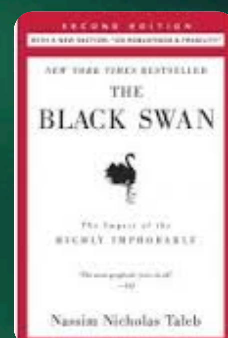



Gunderson, L.H. and Holling, C.S. (2002) Panarchy – Understanding Transformations in Human and Natural Systems

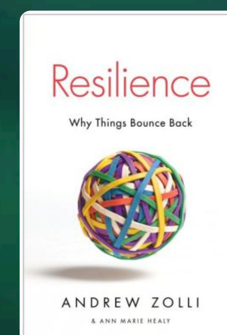


Green, D.G. et al (2014) Dual Phase Evolution

Casti, J. (2012) X-Events – The Collapse of Everything

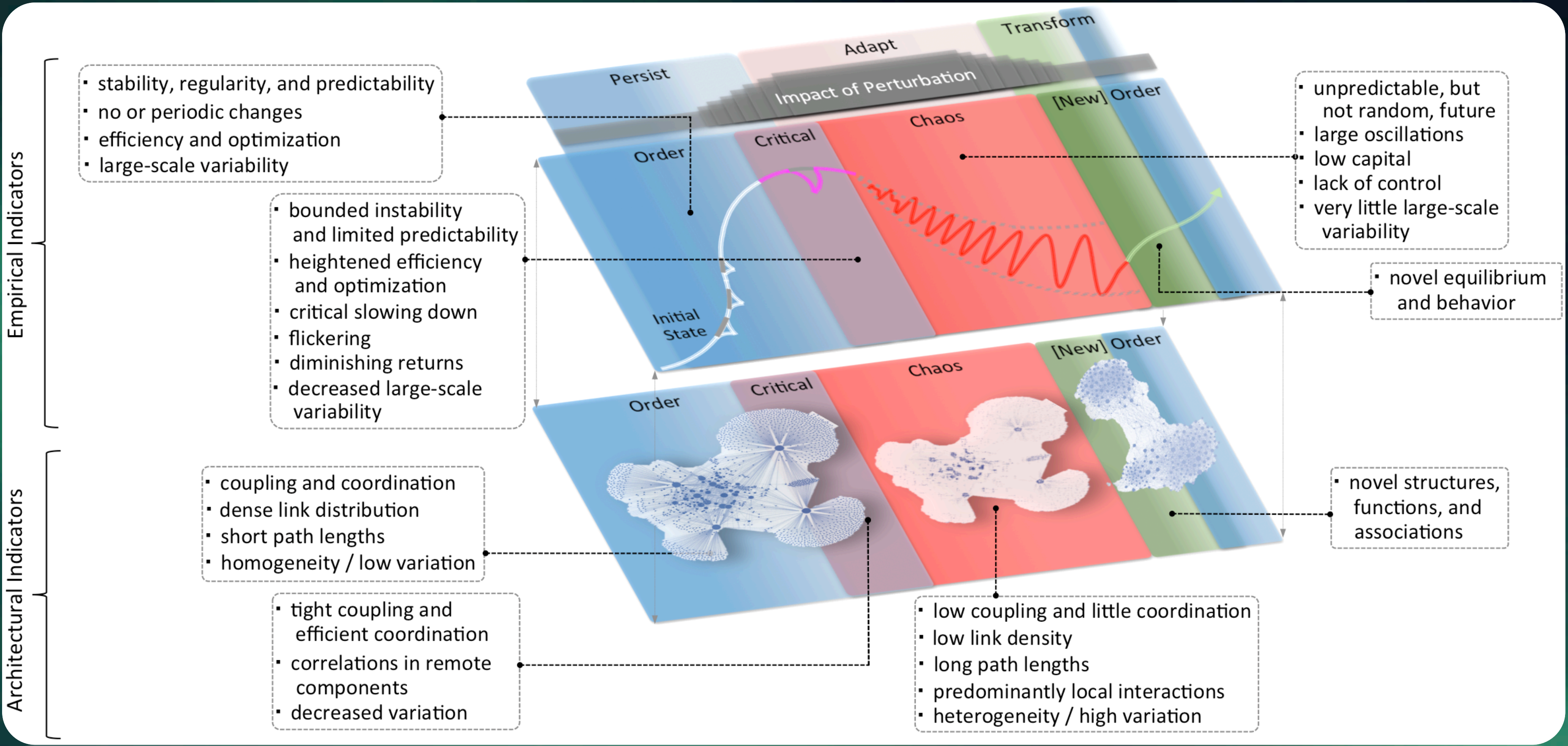


Taleb, N.N. (2007,2010) The Black Swan – The Impact of the Highly Improbable



Zolli, A. and Healey, A.M. (2012) Resilience – Why Things Bounce Back

Complex Systems Behavior and Resilience



R. Legaspi and H. Maruyama (2015), "Meta-Theorizing and Machine Intelligent Modeling a Complex Adaptive System that is Poised for Resilience Using Architectural and Empirical Indicators," International Journal on Advances in Systems and Measurements, vol. 8, nos. 3 & 4, 2015.

Robust Yet Fragile Complex Socio-Technical Systems

- The Electric Power Grid – the largest machine in the world (IEEE) and supreme engineering achievement of the 20th century (NAE)
  - Efficiency/Robustness: Steadily increasing loads (more consumption), economic optimization (maximizing profits), routine maintenance procedures (N-1 testing), and continuously increasing transmission line reliability
  - Criticality: Enormous number (~2.5 billion) of things that can go wrong
  - Vulnerability: increasing power outages

In: Lewis, T.G. (2011), "Bak's Sand Pile – Strategies for a Catastrophic World"

Robust Yet Fragile Complex Socio-Technical Systems

- Communication System – bigger than the Grid (?)
  - Efficiency/Robustness: Peering of multiple service providers resulting to Telecom Hotels (e.g., One Wilshire Boulevard)
  - Criticality: Extreme concentration of switching equipment in a relatively small number of telecom hotels – these are hubs in a scale-free network
  - Vulnerability: increasing massive cascade failures and major telecom outages

In: Lewis, T.G. (2011), "Bak's Sand Pile – Strategies for a Catastrophic World"

Complexity-based Resilience Thinking

- Anticipate and break the efficient self-organization to criticality (Lewis, 2011)
  - Provide systems intelligence
    - "Propriocepting", self-monitoring, self-healing, and self-repairing (Zolli and Healey, 2012)
  - Restructure
    - From scale-free to clustered network topology of the communications systems (Lewis, 2011)
    - Islanding the grid – reduce the spectral radius (link density vis-à-vis node connectivity) (Lewis, 2011)
  - Self-inflict creative chaos
    - Like the Simian Monkeys (Netflix) and GameDay (Amazon and Google) (Maruyama, Legaspi, et al., 2014)

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ICONS PANEL: COMPLEXITY AND SAFETY IN COMMUNICATION SYSTEMS

The European Union Seventh Framework Programme (FP7/2007-2013) under the Grant Agreement nº 606796 | Soteria

UNIVERSITY OF EASTERN FINLAND

Complexity in Communication Systems

- Reducing complexity in emergency management systems may save people's lives
- SOTERIA project aims at exploring, testing and evaluating social media emergency management tools in various emergency scenarios
- Finnish Campaign of Experimentation: February 16, 2016
  - Lost tourists scenario
  - Temperature below 0 C
  - A storm and fallen tree caused "accident"

False information? Trolls?

112

Validity of Infor-mation

Emergency Web Portal Information Processing

Complexity in Communication Systems

Complexity in social media based emergency management systems

- Massive amounts of unstructured data cause challenges for emergency data analysis tools
- Increased complexity may lead to decreased reliability, availability and usability
- The Campaign of Experimentation showed complexity & reliability challenges related to location-based services
- Need for simple & reliable social media tools that enable direct (private) communication

Figure: A closed Twitter-based platform (Citizens' tools)

Figure: Survivors

Thank you!!!

Questions, comments?

Marko Jäntti, Head of Research, PhD.

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School of Computing

Kuopio campus

UNIVERSITY OF
EASTERN FINLAND

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Panel discussion

Complexity and Safety in Communication Systems

Topic:

DUSA Layering for Safety Satellite Communications

Kamal M. Harb

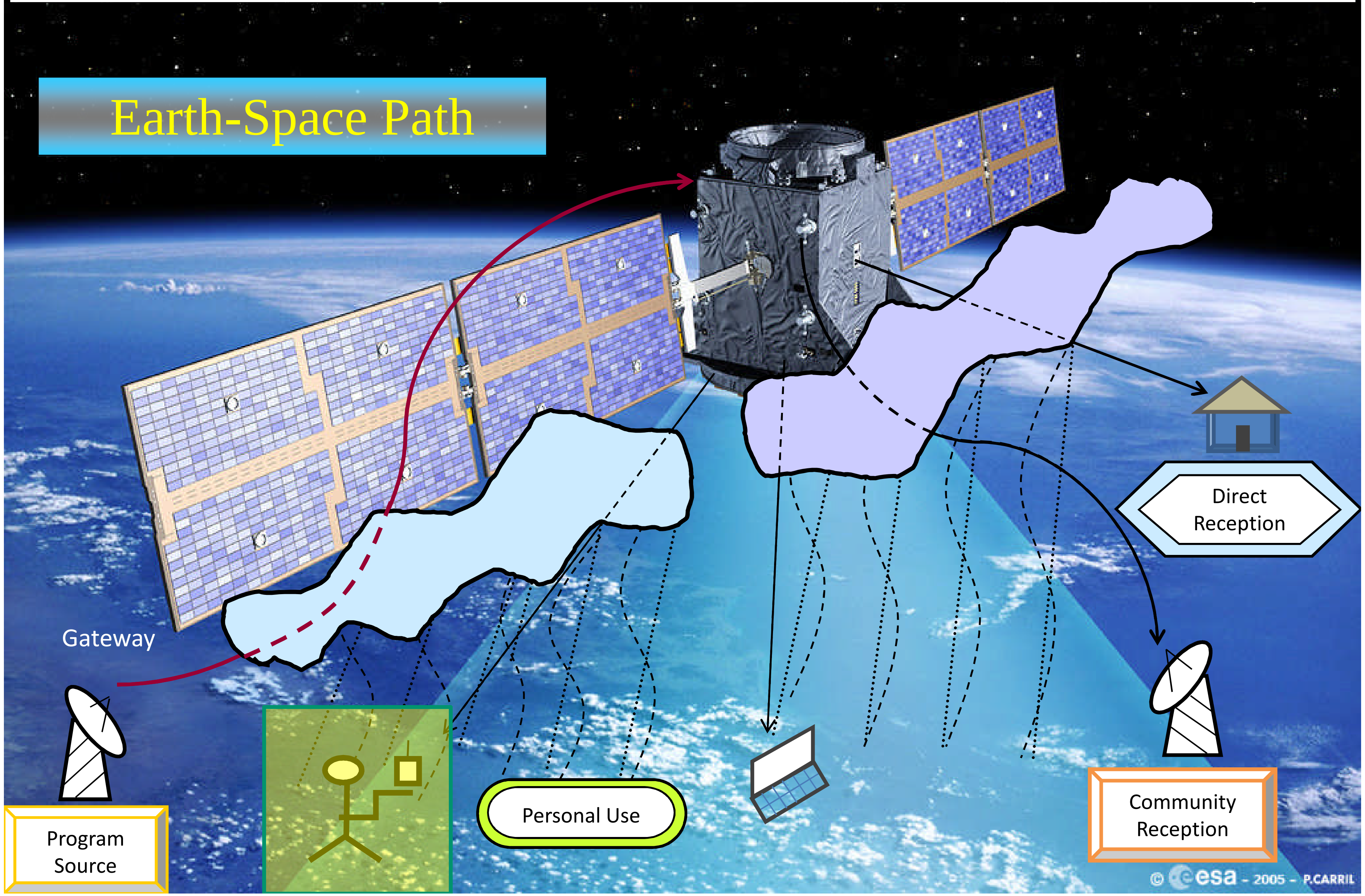
NexComm 2016

Feb. 22nd, 2016, Lisbon, Portugal

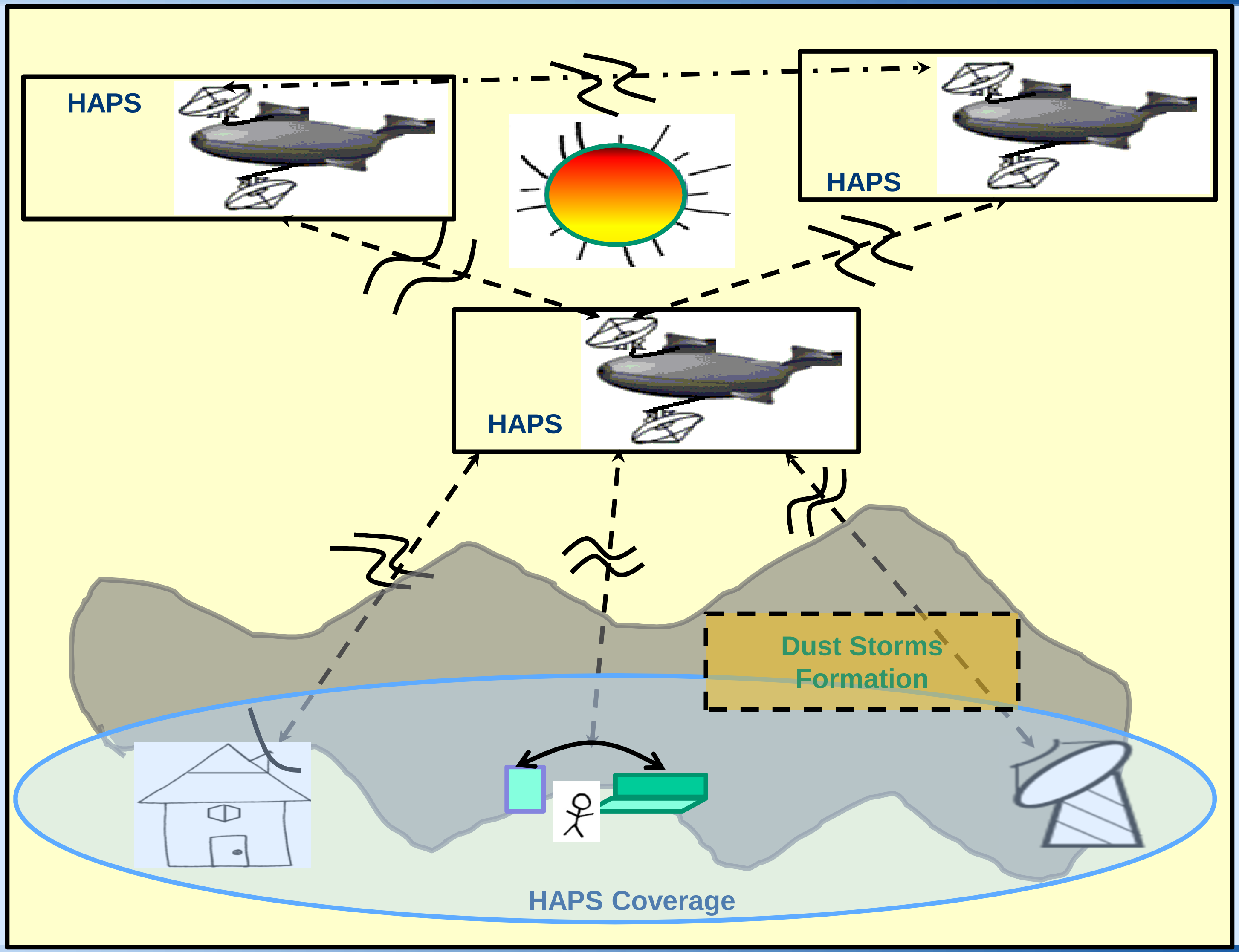
Overview

- High Altitude Platform (HAPS)
- DUSA Storm Modeling for Safety Satellite Communications
- Methodology
- Research methods
- Conclusion

Signal Propagation



HAPs Communications under DUSA Storms



Challenging

The propagation loss on Earth-space path caused by different atmospheric attenuations limit satellite's QoS links and system availability for satellite network especially for that operate at frequencies above Ku-band.

These attenuations are represented by:

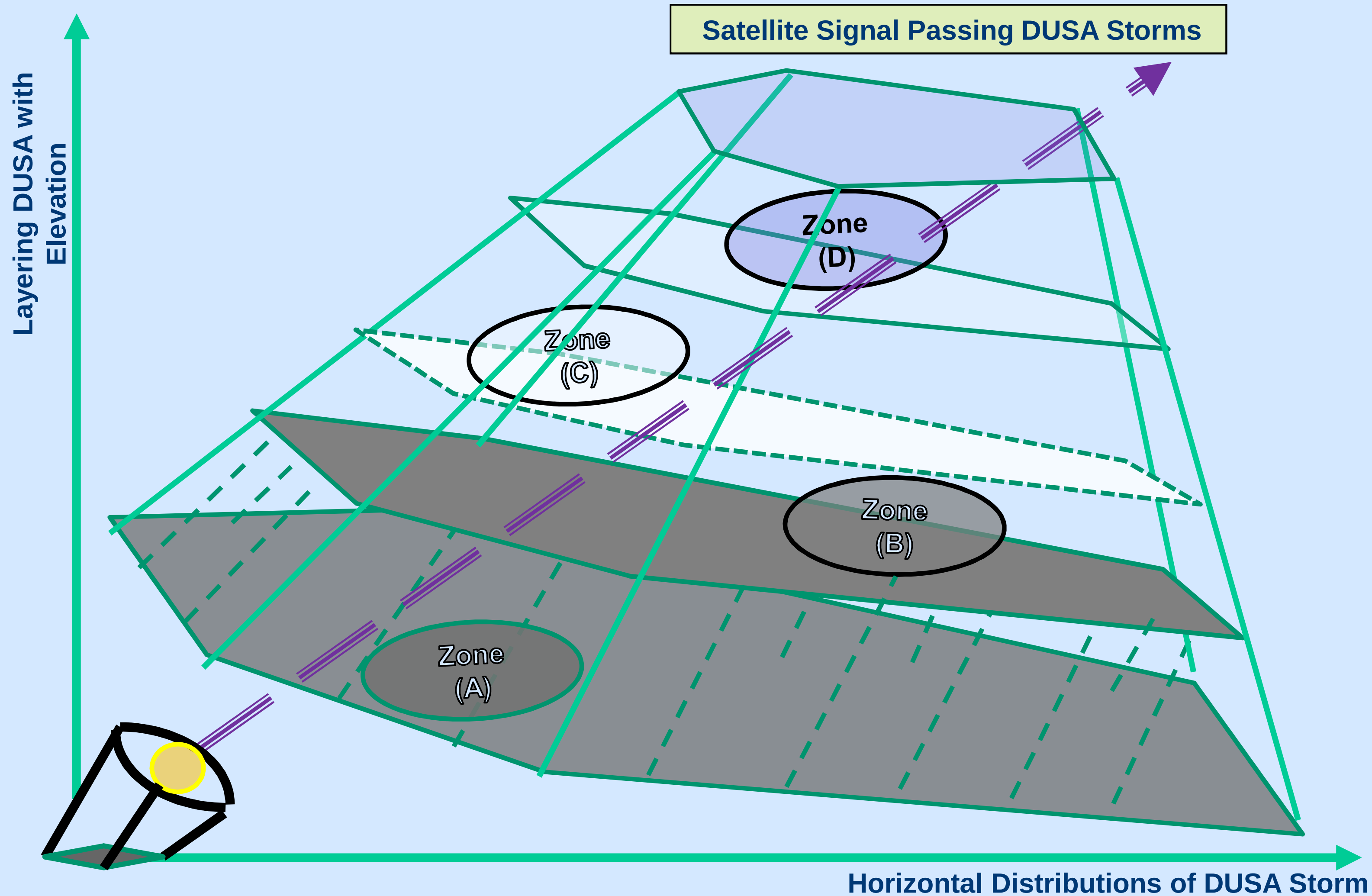
- Rain Attenuation,
- Atmospheric Gases Attenuation,
- Fog and Clouds Attenuations,
- Dust and Sand (DUSA) Attenuations,
- Free Space Attenuation.

HAPS Advantages

– Great coverage area.
– Transmission is independent of the distance from the center of the coverage area.
– HAP stays up in the air operating on airplane, airship, or balloon for like 20 to 25 Km away from earth.
– Provide a very precise and secure communications.
– Higher Bandwidths are available for users.

DUSA Storm at Hafr Al-Batin

DUSA Storm Layering



Summary

- HAPS communication is useful to cover a crowded area.
- Proposed of DUSA layering model.
- Link margin dropped tremendously with DUSA storm and rainfall in general.
- Proposed intelligent technique to maintain link reliability during DUSA storm.
- Although, the system at this level can be considered operational but only an extra attenuation of around 0.5dB can make the system unreliable.

Norwegian Public Emergency Network (NEN)

Safety and Complexity Issues

Nødnett – the Norwegian Public Emergency Network (NEN)

- NEN is a separate radio network, built specifically for rescue and emergency users.
- NEN is built to be used by all the emergency services.
- NEN was built with focus on security. Communication is secured in several ways, including encrypted conversations.
- The network is designed to be very robust.
  - Essential network components are designed and built with redundancy in order to reduce the possibility that a single fault can result in failures of the network.
  - The transmission lines between major network components such as base stations and switches are also redundant.
  - Backup power solutions have been implemented for essential network components securing network availability in the most difficult situations.

TETRA

- NEN is built over the TETRA standard. A TETRA network offer secure, encrypted radio communications in talk groups and in direct one-to-one communications. It is also possible to transfer data at low speeds.
- As TETRA is a standard, it was more likely that equipment such as radios and accessories can be procured from many vendors. TETRA technology is in use in many countries throughout the world, both in public security and in businesses with high demands for reliable communication.

Complexity Issues

- Imposes extra complexity because of different requirements from services:
  - Coverage inside structures (fire)
  - Coverage in remote areas (police)
  - Integration with other information systems (health)
- Primarily intended for speech, not data
- Integration with Swedish emergency network (RAKEL) through ISI (Inter System Interoperability)

Safety issues

- Coverage
  - Inside structures/building
  - In remote areas
- Uptime
  - Essential for emergency services
- Tunnels
  - Coverage is critical
  - High number of problematic (> 500m) tunnels.
- Radiation
  - Identical to ordinary mobile base station radiation
  - Public concern because of placement of new base stations

Conclusions

- Failure to gather all relevant requirements (health services in particular).
- Failure to predict user needs (data traffic)
- Underestimated complexity of fulfilling all requirements.
- Safety issues were underestimated in the planning process.

Panel discussion:
Complexity and Safety in Communication Systems

Topic:

No Safety without Security and Robustness

Nataša Živić

NexComm 2016

22.2.2016, Lisbon, Portugal

Safety and Criticality

- Safety
  Reliability, Availability, Timeliness and Correctness
  for vital systems, i.e. elevators, railways, air traffic, (autonomous) cars, medical devices

- Critical Systems

- Multicritical Systems
  Critical Systems with more than one critical application with different (levels of) safety requirements

Existing Safety Services

- Correctness and Authentication

  Provided by Cryptographic Services and Mechanisms
  „No safety without security“

- Reliability and Robustness

  Provided by Improved Coding Techniques
  „Soft is better than hard“ with cross-layer and feedback evaluations

Challenging Safety Services

- Availability and Timeliness
- Protection against Impacts of Sabotage, Failures and Delays
- Immediate Recognition of Events
- Switch to Backup Service
- Re-Switch to Regular Service
- Protocol based
- Multiple Routes
- Backup Communication Systems

Summary

- Security Services and Mechanisms exist, but:
  - More Research is needed for Safety
  - Complexity of challenges of multicritical systems supporting safety is rapidly increasing
  - Risks and Dangers of sabotage against systems with national importance increase, i.e. Smart Grids, Transport Systems
  - Actions and Research must be strengthened

Operational Complexity in Deep Space Communications

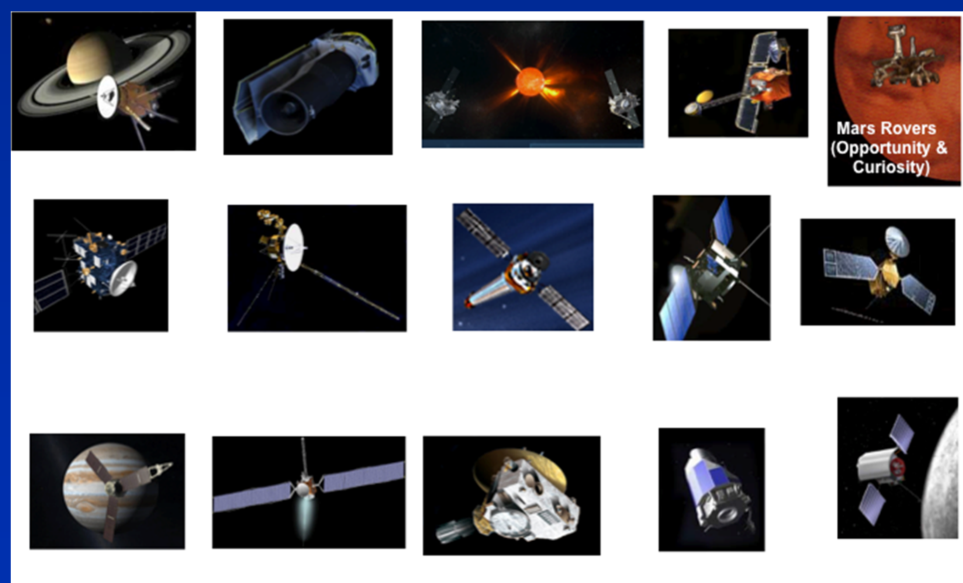
Tim Pham

Jet Propulsion Laboratory

California Institute of Technology

Deep Space Communications

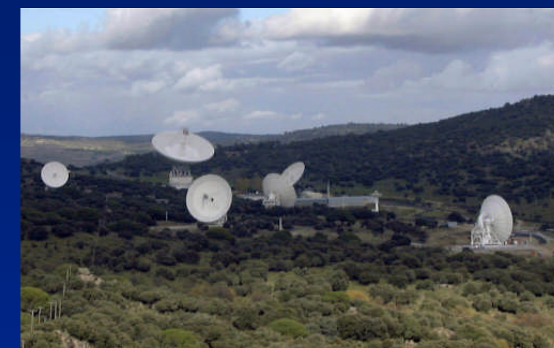
- Deep space - Interplanetary communications
  – Extended to the edge of Solar System
    - Voyager spacecraft ~130 AU
- Difference between deep space and LEO communications
  – LEO: ~1000 km
  – Deep space: ~400,000 km – ~120 AU

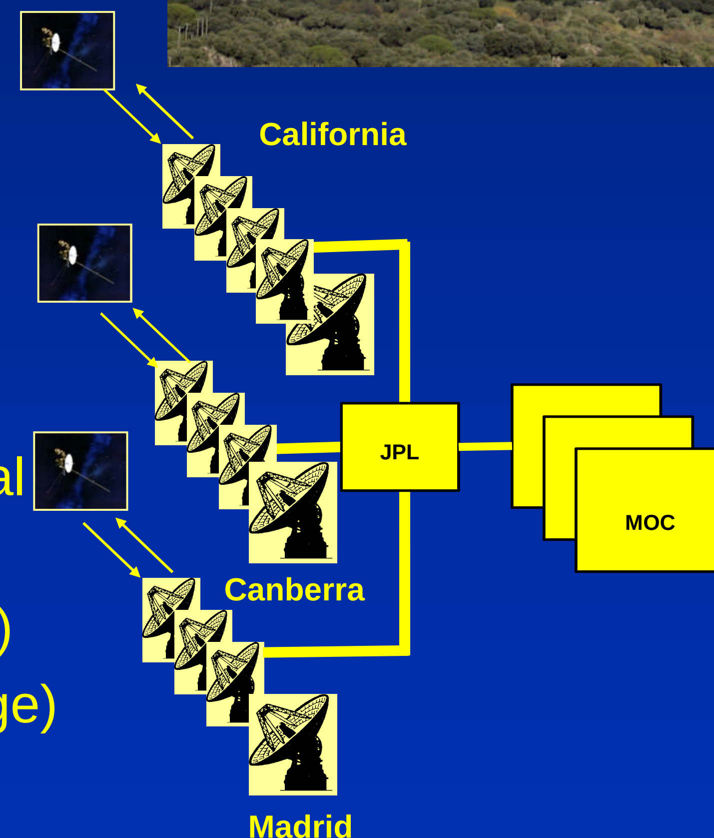


Distance	Power reduction
Moon	1.5E+05
Larange points	2.3E+06
Mars	2.3E+10
Jupiter	6.1E+11
Saturn	2.0E+12
Pluto	2.0E+13
Heliosphere	3.3E+14

NASA Deep Space Network

- Provide global coverage at 3 sites around the globe
    - One 70m and three-four 34m antennas at each site
- Support missions from HEO to edge of solar system
- Optimize high performance for deep space communications
    - Compared to typical 10m commercial tracking station
        - Low noise (~4x – 5x advantage)
        - High gain (~10x – 50x advantage)





Drivers of Operational Complexity

- Long distance
- Operational cost constraints

Effects of Long Distance

- Long RTLT
  - Pre-planned operations
    - Mission critical events, e.g., orbit insertion, EDL
    - Automation vs. Interactive changes
- Limited assets
  - Common equipment reconfigured for each mission
    - Large range of supported data rates/power (10 bps – 100 Mbps)
  - Schedule efficiency
    - Packed schedule to meet user’s desire/needs
    - Adaptive response to changes, with minimal impact

Effects of Operational Cost Constraints

- Do more with less resources
  - Packed configurations
    - Multiple spacecraft per antenna (when in beam)
    - Multiple links per operator
      - Require good design on human interfaces to minimize errors
  - Increasing reliance on automatic monitor and detection of failures
    - Lessen operator work loads
    - Dependent on equipment's accurate measurements and correct interpretation of events