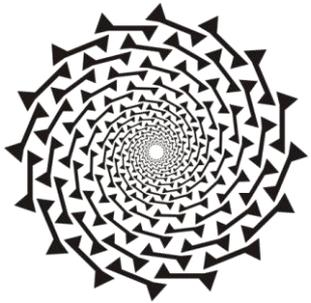


1st USP Conference on Engineering – Oct 25/26, 2011

# COMPLEX SYSTEMS ENGINEERING FOR THE XXI CENTURY

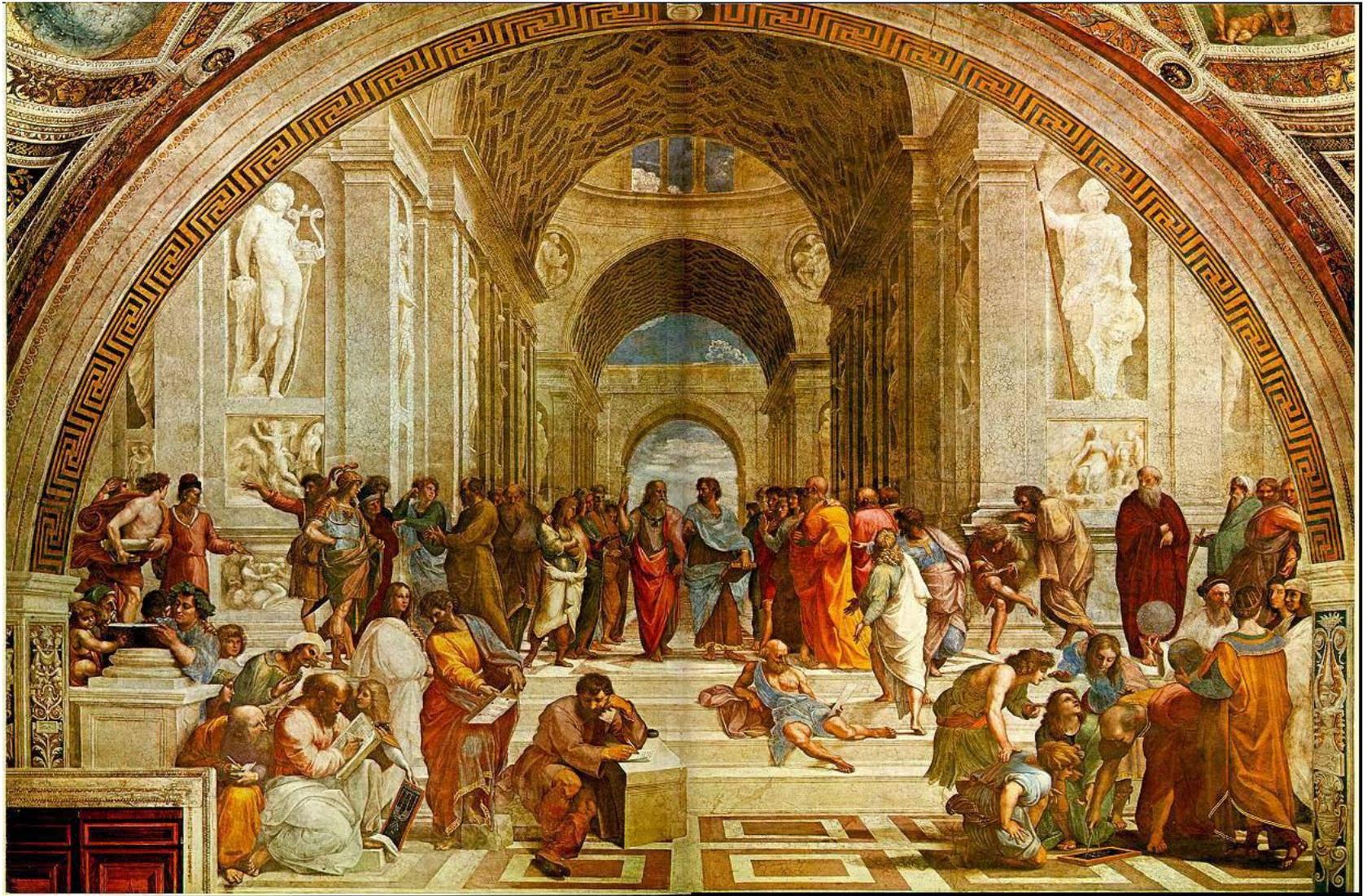
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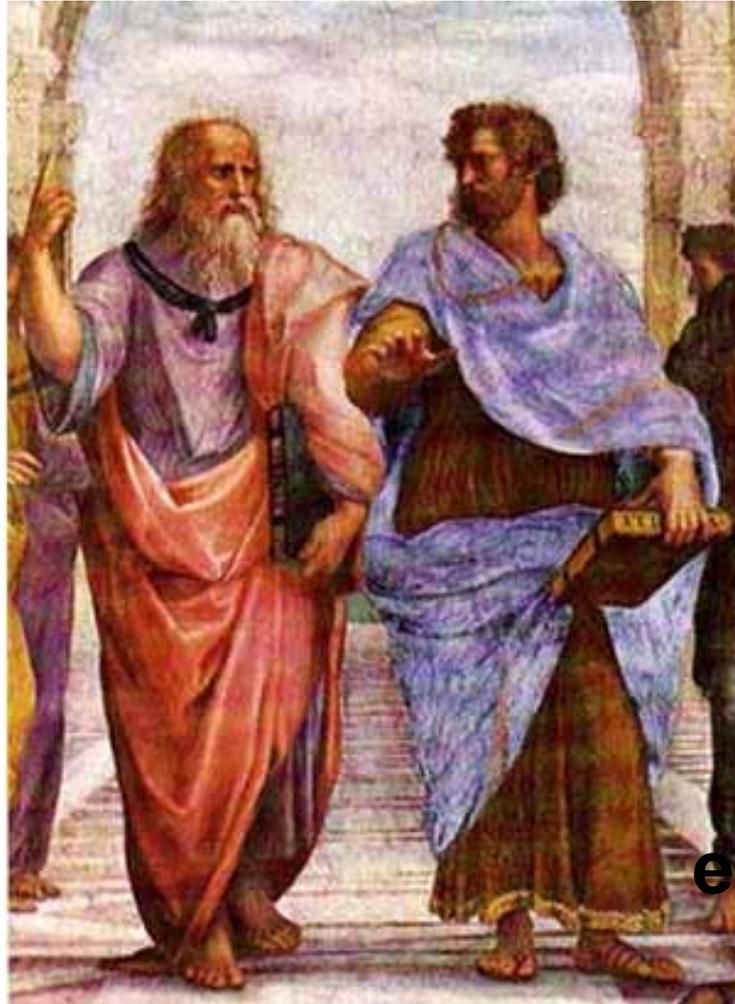
Prof. Sergio Mascarenhas  
Janaina M H Costa, PhD

University of São Paulo at São Carlos

# School of Athens – Raphael, 1511



# Pax Philosophica



**Plato:  
World of  
ideas**

**Aristotle:  
World of  
experiments**

Plato and Aristotle

# Historical Motivation for this Proposal

1971

2011



Material  
Engineering  
In Brazil

Complex  
Systems  
Engineering

# Agenda

1. Past
2. Present - Fundamental concepts
3. Future Actions

PAST

---

# Examples of Institutions on Complex Systems Engineering

- Mitre Corporation (1958 – present)

MITRE

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EMPLOYMENT

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Applying **Systems Engineering and Advanced Technology** to Critical National Problems.

MITRE manages federally funded research and development centers (FFRDCs), partnering with government sponsors to support their crucial operational missions.

- **Aviation System Development**
- **Defense and Intelligence**
- **Federal Sector Modernization**
- **Homeland Security**

## MITRE DIGEST

**NEW** [Developing a High Performance Ecosystem"](#)

October 2011



The more we make ecosystems, MITRE makes the system he

# Examples of Institutions on Complex Systems Engineering

- New England Complex Systems Institute (NECSI)
  - NECSI is an independent academic research and educational institution with students, postdoctoral fellows and faculty.
  - In addition to the in-house research team, NECSI has co-faculty, students and affiliates from MIT, Harvard, Brandeis and other universities nationally and internationally.

COMPLEX SYSTEMS INSTITUTE  
problems of science and society

## Faculty and Co-Faculty

- Yaneer Bar-Yam - President, NECSI
- Albert-László Barabási - Northeastern University, Department of Physics
- Michel Baranger - MIT, Dept. of Physics
- Dan Braha - University of Massachusetts, Dartmouth
- Charles Cantor - Boston University, Center for Advanced Biotechnology
- Richard Cooper - Harvard University, Department of International Development Studies
- Terrence Deacon - Boston University, Department of Anthropology
- Irving Epstein - Brandeis University, Chemistry Dept.
- William Gelbart - Harvard University, Department of Molecular and Cellular Biology
- Ernest Hartmann - Tufts University Medical School and Newton North High School
- Jerome Kagan - Harvard University, Department of Psychology
- Mehran Kardar - MIT, Dept. of Physics
- Les Kaufman - Boston University, Dept. of Biology
- Eric Klopfer - MIT, Department of Urban Studies and Planning and Education Program
- Frannie Léautier - The Fezembat Group
- Blake LeBaron - Brandeis University, Graduate School of International Studies
- Seth Lloyd - MIT, Department of Mechanical Engineering
- Stuart Pimm - Duke University, Environmental Sciences and Policy Center
- Daniel Rothman - MIT, Department of Earth, Atmospheric, and Planetary Sciences

- Yaneer Bar-Yam - President, NECSI
- Albert-László Barabási - Northeastern University, Department of Physics
- Michel Baranger - MIT, Dept. of Physics
- Dan Braha - University of Massachusetts, Dartmouth
- Charles Cantor - Boston University, Center for Advanced Biotechnology (Director)

# Examples of Institutions on Complex Systems Engineering

- New England Complex Systems Institute (NECSI)
  - First International Conference on Complex Systems 1997
  - Eighth International Conference on Complex Systems 2011



International delay gap  
that Brazil has to  
cover:

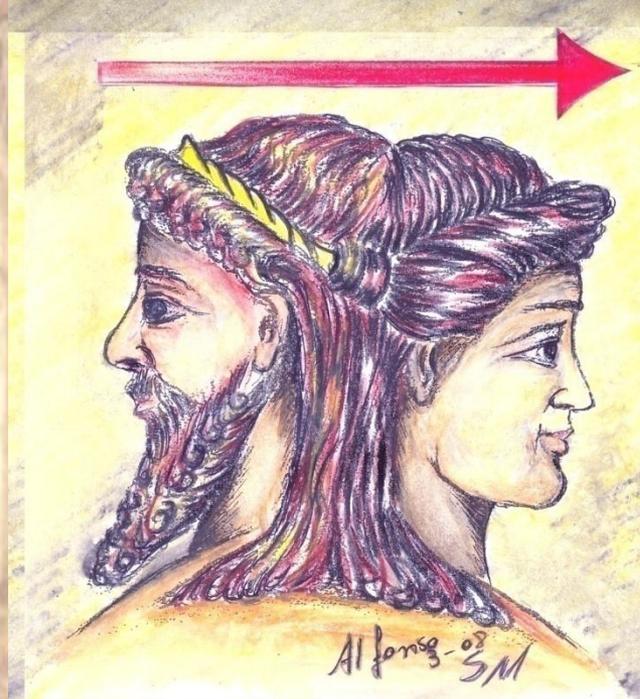
**15**  
**Years!!!**

# FUNDAMENTAL CONCEPTS

---

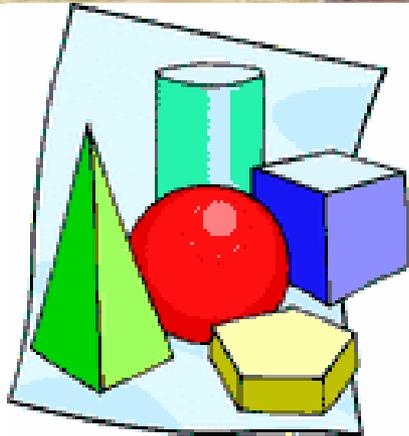


**Isaac Newton**

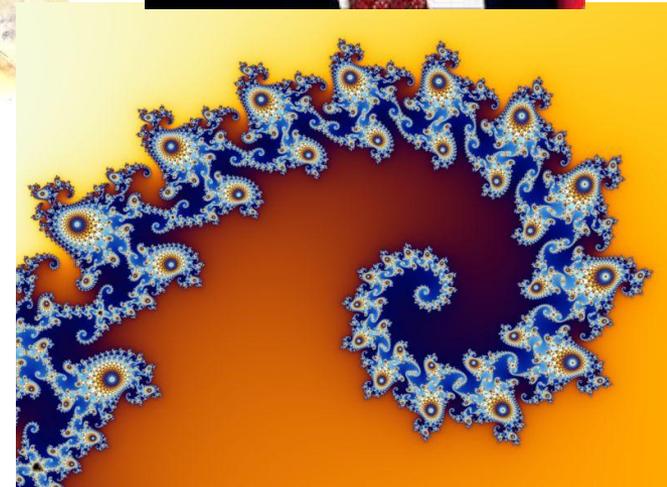
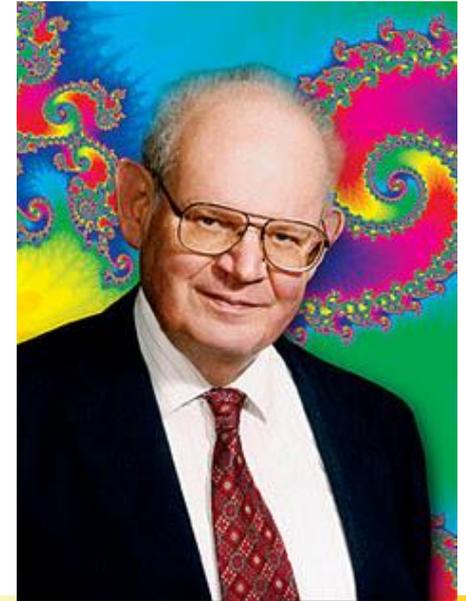
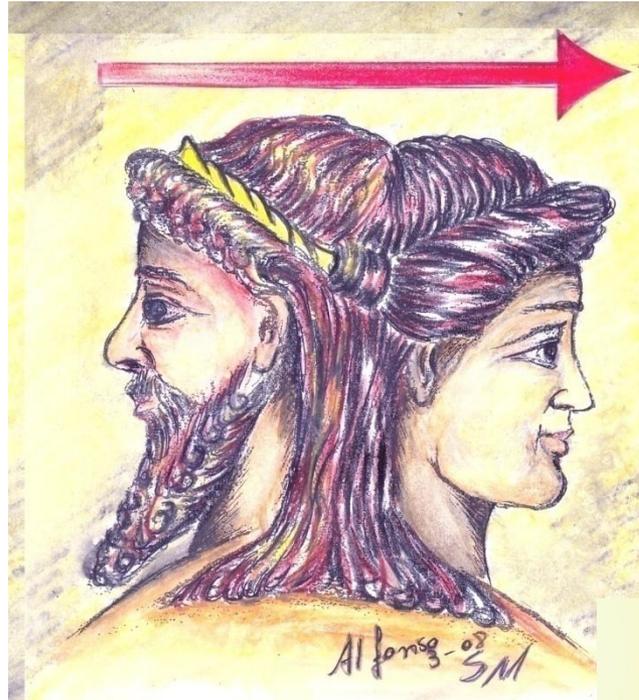


**Ilya  
Prigogine**

# Euclides



# Mandelbrot

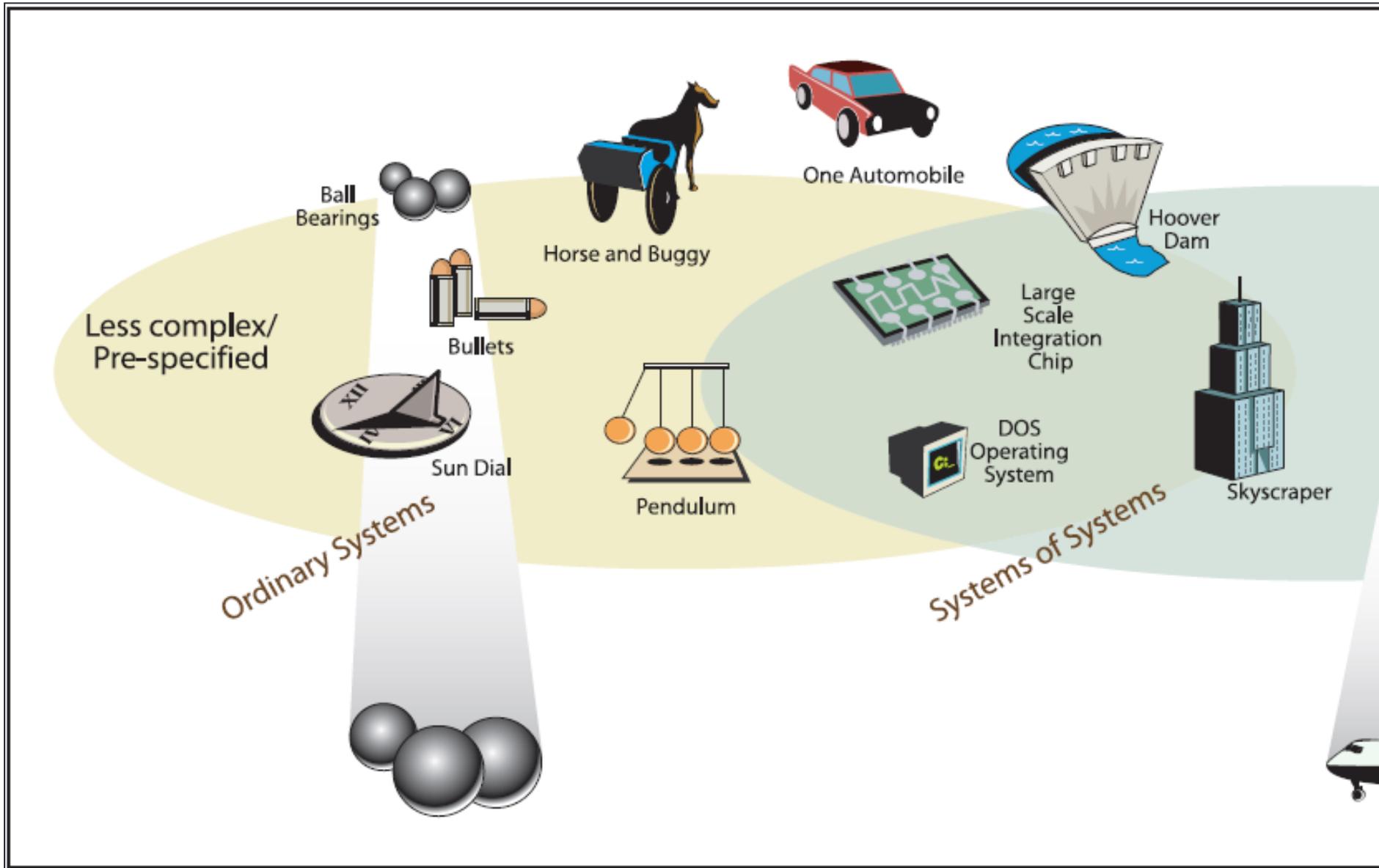


# General concept of Complex Systems Engineering

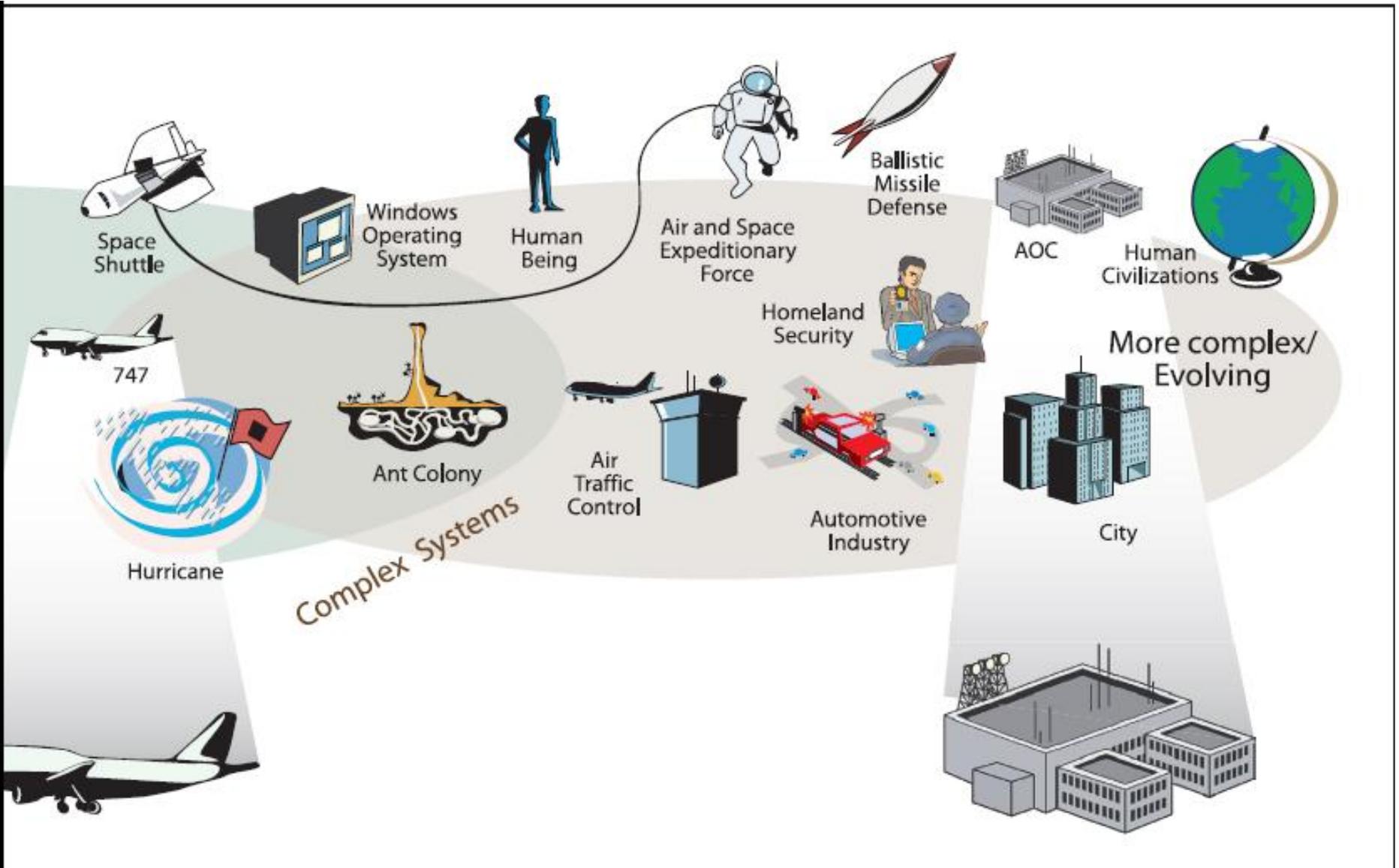
Sarah Sheard (2008) (Stevens Institute of Technology):

Complex systems are systems that do **not have a centralizing authority** and are **not designed from a known specification**, but instead involve **disparate stakeholders** creating systems that are functional for other **purposes and are only brought together in the complex system** because the individual “agents” of the system see such cooperation as being beneficial for them

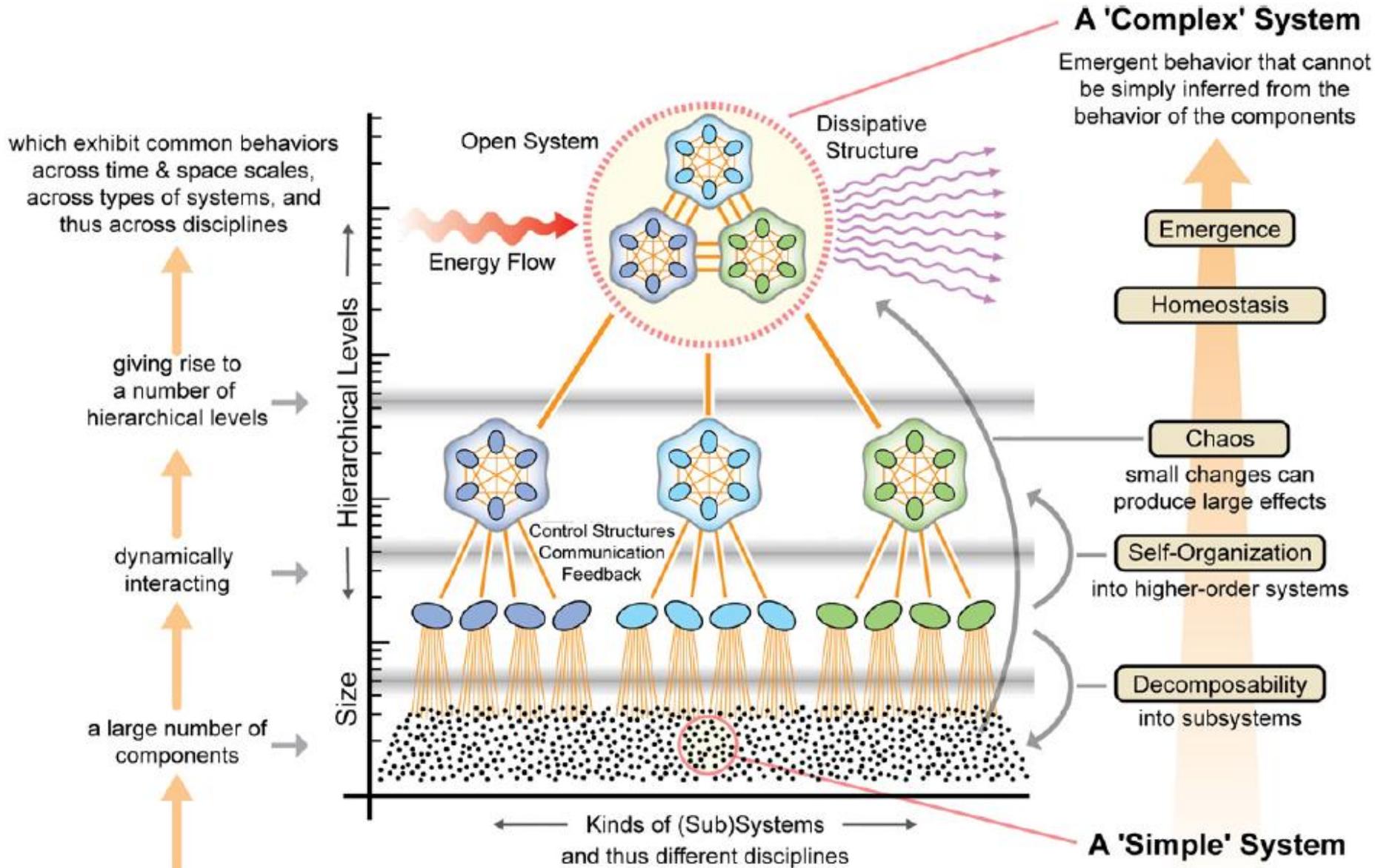
# Evolution toward complex systems



# Evolution toward complex systems



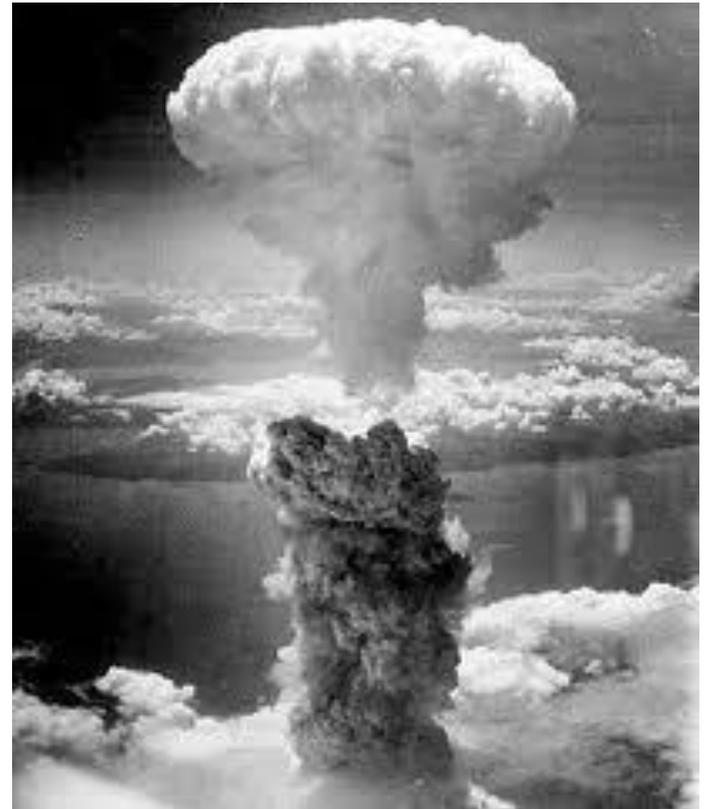
# Anatomy and physiology of Complex Systems Engineering



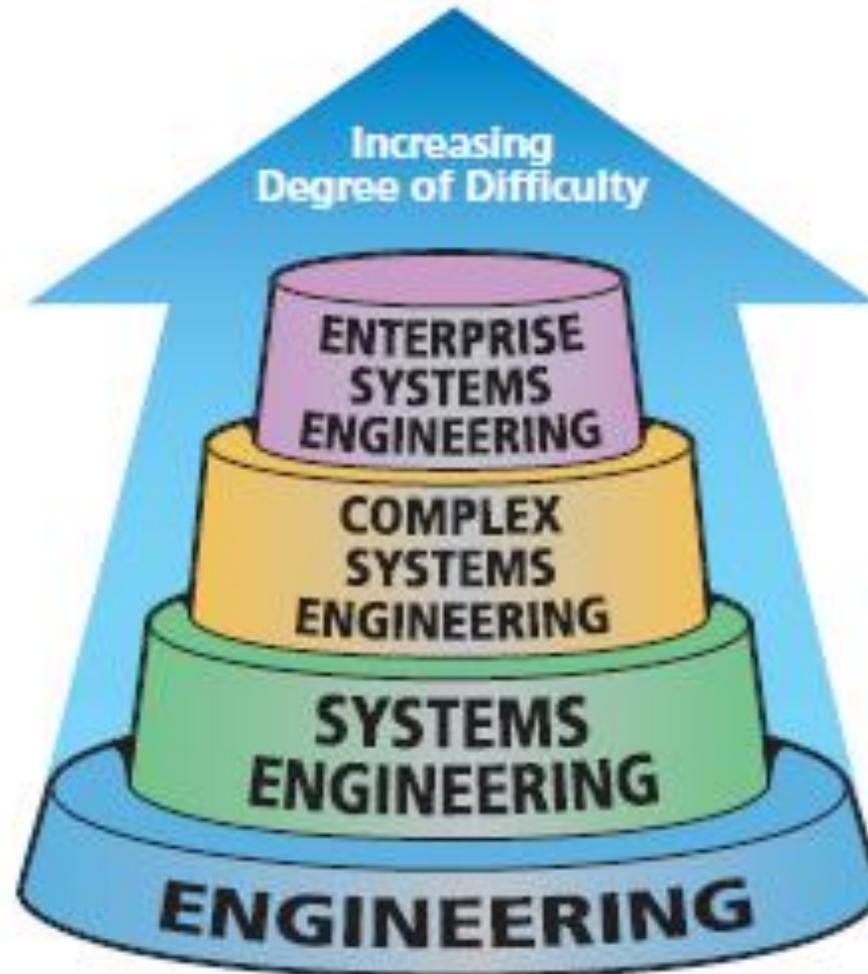
Complex Systems Involve

# Example of complex systems

- Military Systems
  - Recruitment
  - Weapons systems
  - Maintenance
  - Surveillance
  - Intelligence
  - Stewardship Services
  - Health
  - Weather and climate



# Engineering Discipline Sets



# PROPOSAL FOR FUTURE ACTIONS

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# Proposal of a Brazilian Complex Systems Engineering Network and Task Force

Management / Strategic Planning

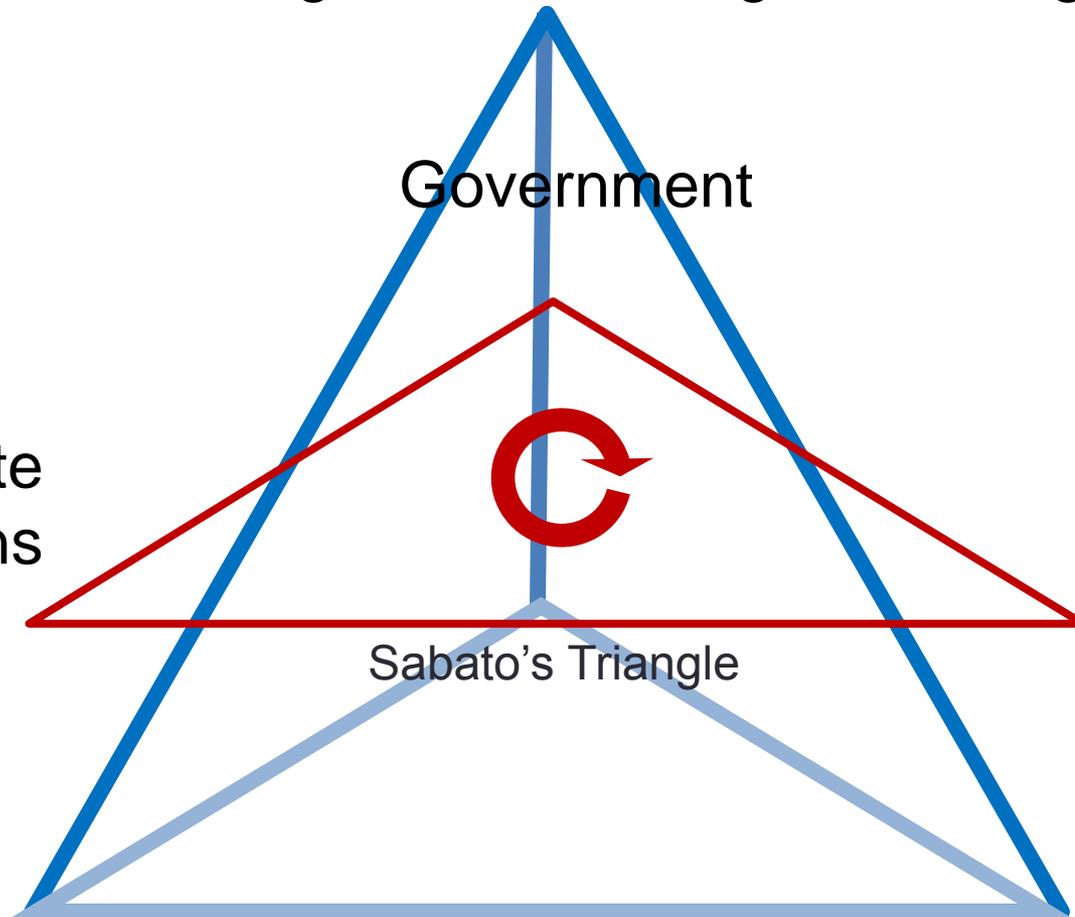
Government

Private  
Corporations

R&D  
Institutions



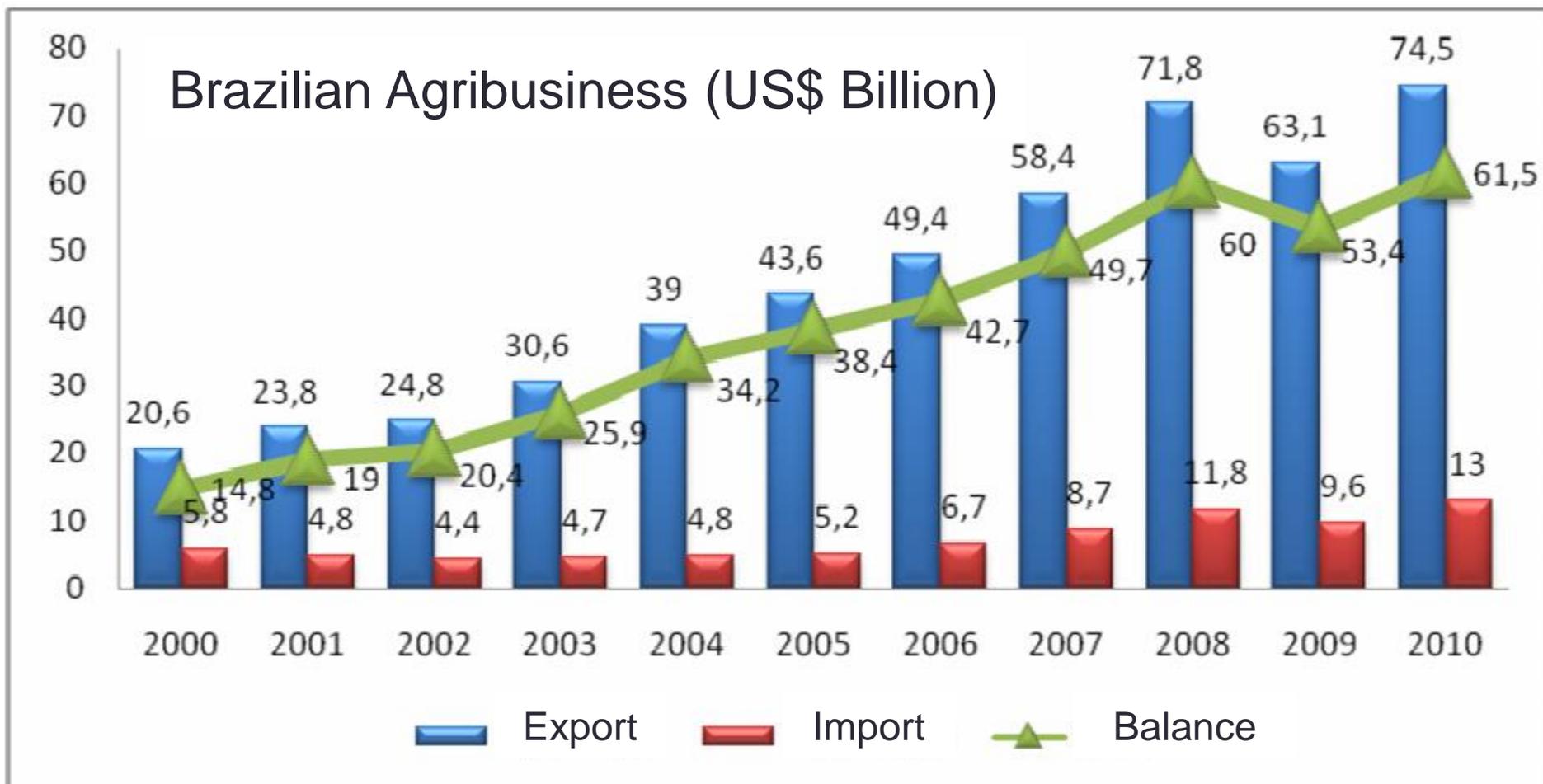
Sabato's Triangle



# Some Brazilian Problems requiring Complex Systems Engineering

- Public Health
- Transport and Logistics
- Hunger and Agriculture
- Education
- Energy and Environment
- Defense
- Territorial
  - Amazon, Coastal Ocean Territory, Border Frontiers
- Violence, Drugs and Frauds Control

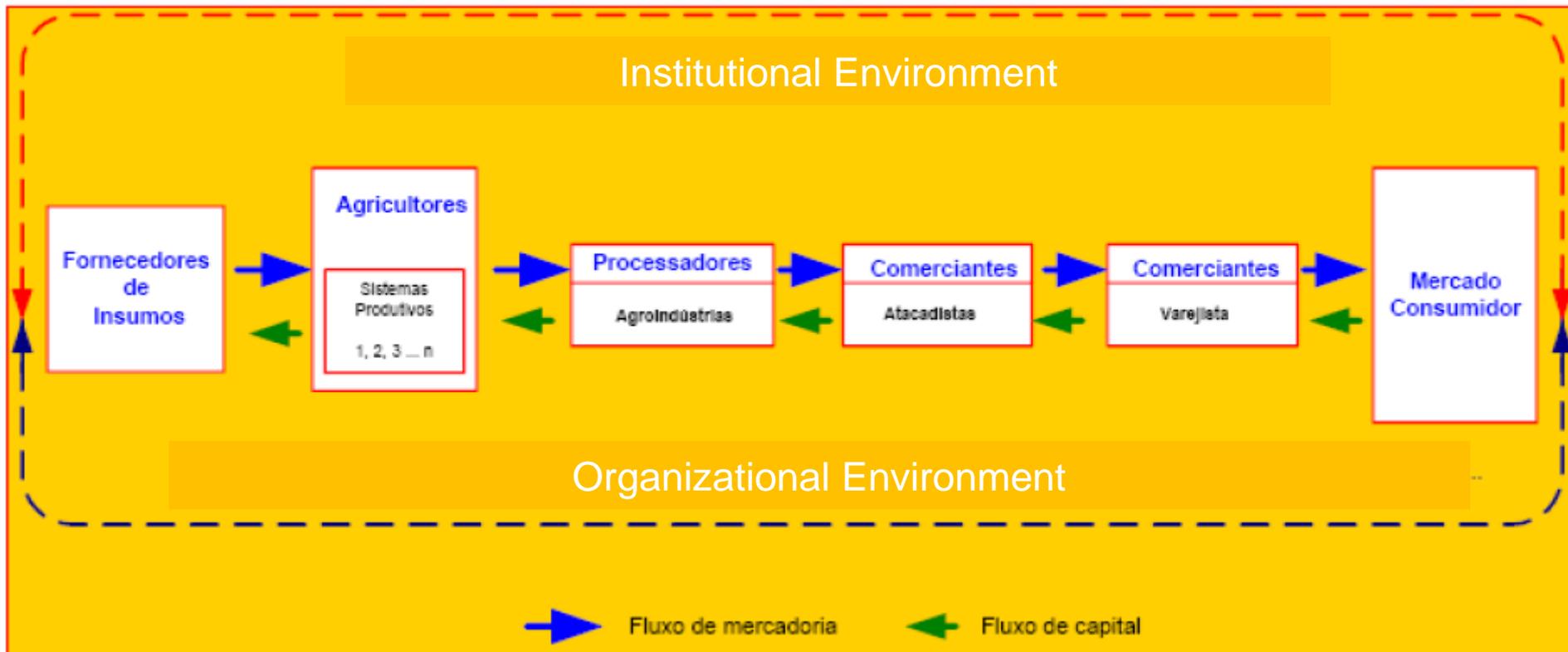
# Embrapa Case



**Evolução da balança comercial da agricultura brasileira no período 2000-2010.**  
**Fonte: SECEX.** From: S Crestana (2011)

# Embrapa Case (On-Going Research )

## Brazilian Agribusiness as a complex system



# Proposal of a Brazilian Complex Systems Engineering Network and Task Force

2011



2022

- Nucleation and Implantation of Brazilian Complex Systems Engineering Network

- PhD
- Post-Docs
- Innovation on Complex System
- Public/Private Initiatives



# Disciplines Toolbox

Math

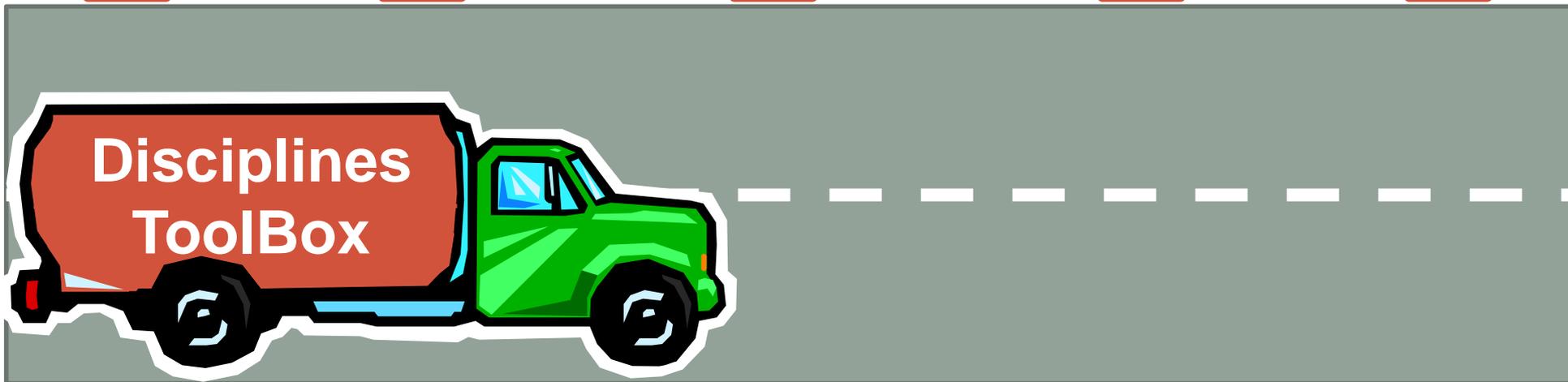
Statistics

Complexity

Computer  
Sciences

Etc

Disciplines  
ToolBox

A green truck with a red tank is driving on a grey road with a white dashed line. The tank is labeled 'Disciplines ToolBox'. Above the road, five signs on grey posts are arranged in a row. The signs are labeled 'Math', 'Statistics', 'Complexity', 'Computer Sciences', and 'Etc'. The truck is positioned at the bottom left, facing right towards the signs.

# International Cooperation

## Programs

- Reverse Brain Drain
- Direct Brain Gain

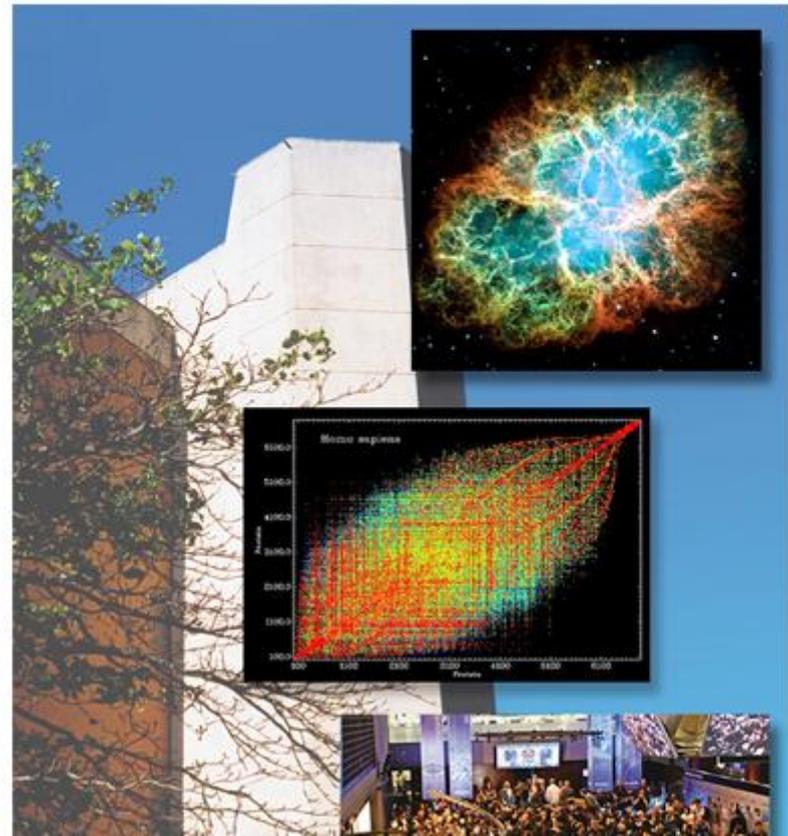


# On-Going Research in Brazil

- National Institute of Science and Technology of Complex Systems (INCT-SC / MCT)

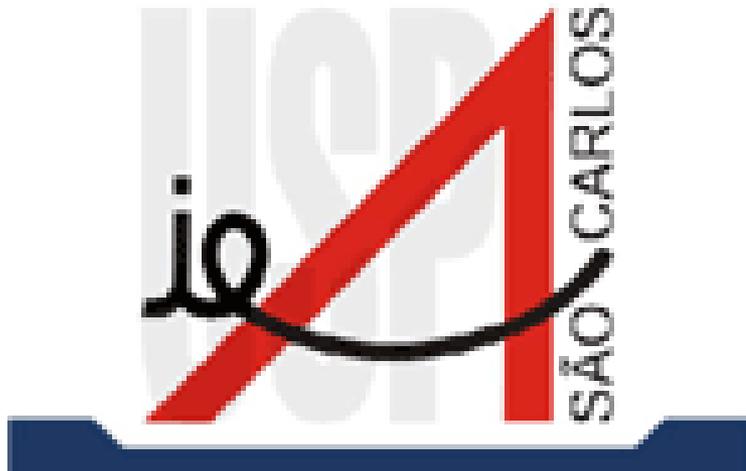
Instituto Nacional de Ciência e Tecnologia de Sistemas Complexos (INCT-SC)

National Institute of Science and Technology for Complex Systems



# On-Going Research in Brazil

- WG Complex Systems Institute for Advanced Studies (USP – SC) / Berlin / Seul / S.Carlos



# On-Going Research in Brazil

- Instituto nacional de ciência e tecnologia de matemática (INCT / MCT - IMPA)



# On-Going Research in Brazil

- Instituto de Estudos da Complexidade - IEC



**IEC**  
Instituto de Estudos da  
**COMPLEXIDADE**

**O que é o IEC** **O Pensamento Complexo** **Textos** **Projetos**

Fale Conosco → 

**APRESENTAÇÃO DO IEC\***

Fundado em 2003, o Instituto de Estudos da Complexidade é uma Associação Civil sem fins lucrativos, de caráter nacional e internacional, com sede na cidade do Rio de Janeiro, à Rua Miguel Lemos 44/204. Tem por objetivo a promoção, divulgação, difusão e desenvolvimento do Pensamento Complexo, realizando cursos, programas de estudo e pesquisa, atividades culturais, eventos, prestação de serviços, consultorias, assessorias e parcerias com instituições governamentais e particulares

\* Antigo Núcleo para o Pensamento Complexo do Rio de Janeiro, fundado em 1997.

**SAIBA MAIS...**

**Eventos e Cursos** **Fotos** **Clínica** **Consultoria** **Links** **Notícias** 

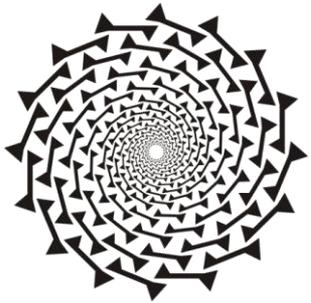
# How Complexity appears?

Human knowledge is like the  
radius of a sphere  
as it increases it also increases  
the contact with the unknown.

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*Isaac Newton*

1st USP Conference on Engineering – Oct 25/26, 2011



**THANK YOU!**

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Prof. Sergio Mascarenhas  
sergiomascarenhas28@gmail.com  
sm@usp.br

# List of Large Engineering Project Failures

System Function – Responsible Organization	Years of Work	Approx. Cost
Vehicle Registration, Drivers license – Calif. DMV	1987-1994	\$44M
Automated reservations, ticketing, flight scheduling, fuel delivery, kitchens and general administration – United Air Lines	Late 1960s– Early 1970s	\$50M
State wide Automated Child Support System (SACSS) – California	1991-1997	\$110M
Hotel reservations and flights – Hilton, Marriott, Budget, American Airlines	1988-1992	\$125M
Advanced Logistics System – Air Force	1968-1975	\$250M
Taurus Share trading system – British Stock Exchange	1990-1993	\$100– \$600M
London Ambulance Service Computer Aided Dispatch System	1991-1992	\$2.5M, 20 lives