UNIVERSIDAD DEL ROSARIO

WEEF 2013 CARTAGENA COLOMBIA

Septiembre 24 a 27

Innovation in research and engineering education: key factors for global competitiveness

Innovación en investigación y educación en ingeniería: factores claves para la competitividad global

Management of engineering complex systems
Review of present and future research

Prof. Leonardo Pineda Serna (PH.D)
Research Area Technological Change and Strategic Innovation
Business School, Universidad del Rosario, Bogotá

The issues

- Research area on technological change and strategic innovation.
- Are innovations accelerating technological change?; or
- Are technological changes accelerating strategic innovations?
- Where engineering meets management?, or rather
- Where management meets engineering?

Universidad del Rosario

SCOPE

- In the very near future, the study of engineering complex systems is of paramount importance not only to engineering education, but also to business education, more specifically in terms of strategic management of science, technology and innovation

Universidad del Rosario

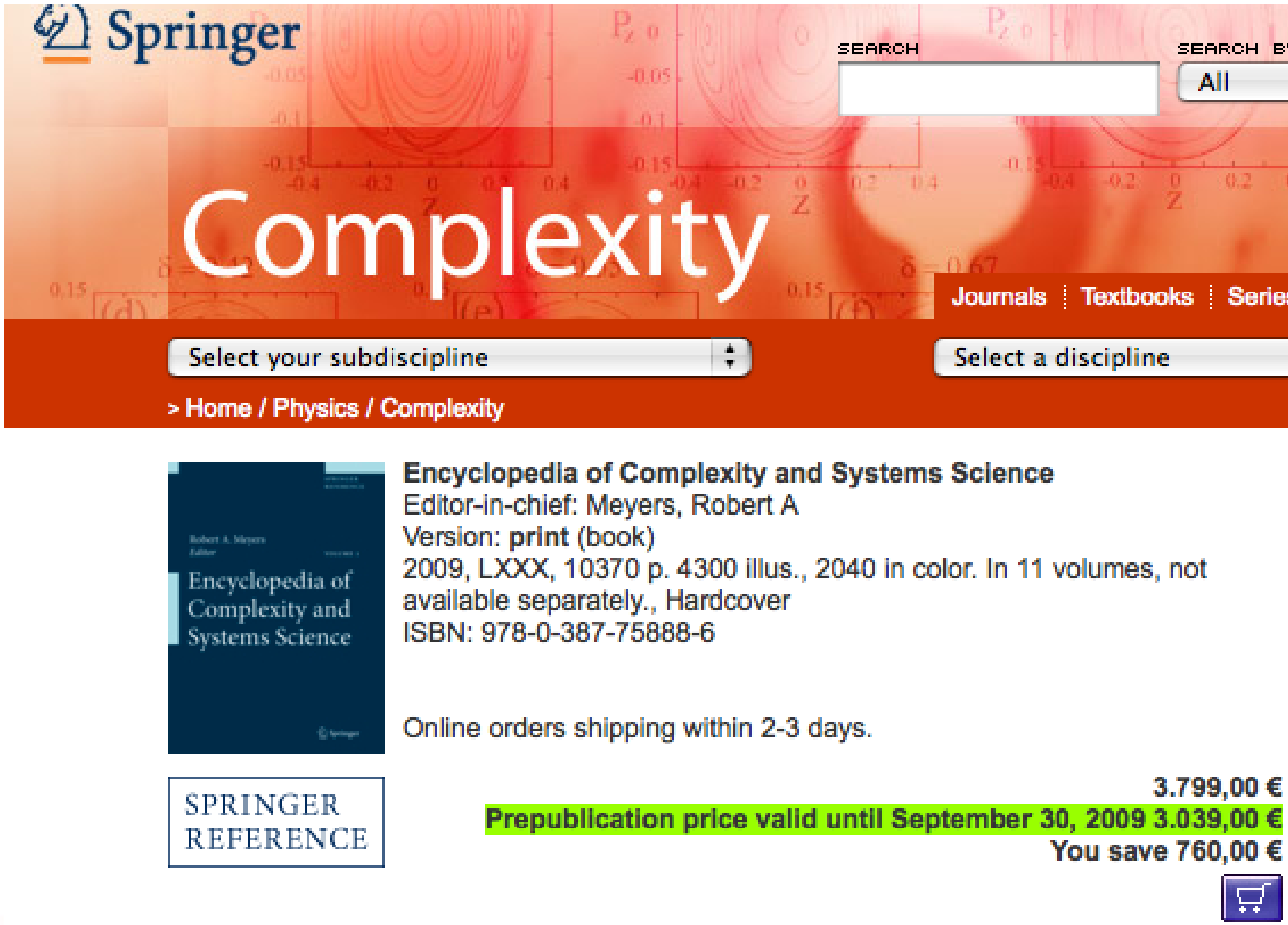
Complex Systems and Complexity Sciences

- **«I think the next century will be the century of complexity (S.Hawking, 2001) »**
- As reported by Chui, G. (2000). "'Unified Theory' is Getting Closer, Hawking Predicts."
- **"In the twenty-first century complexity is not a vague science buzzword any longer, but an equally pressing challenge for everything from the economy to cell biology."**
- Albert-Laszlo Barabásí (2003). Linked: How Everything is Connected to Everything Else and What it Means for Business, Science and Everyday Life. New York: Plume.
- **"Make things as simple as possible, but no simpler." Albert Einstein**
  - *But no formal definition (yet).*
  - *No recognised complexity science (yet)*
  - *A broad range af multidisciplinary approaches*

Universidad del Rosario

DRUCKER
FORUM
2013

Encyclopedia of Complexity and System Science, Springer Verlag 2009, 11 Volumes, 10370 pages.



Universidad del Rosario

Complex Systems Modelling.
…and Engineering?

International Conference on Complex Systems Engineering, ENIM, Metz, September 21st, 2010

Dr. Edith Perrier

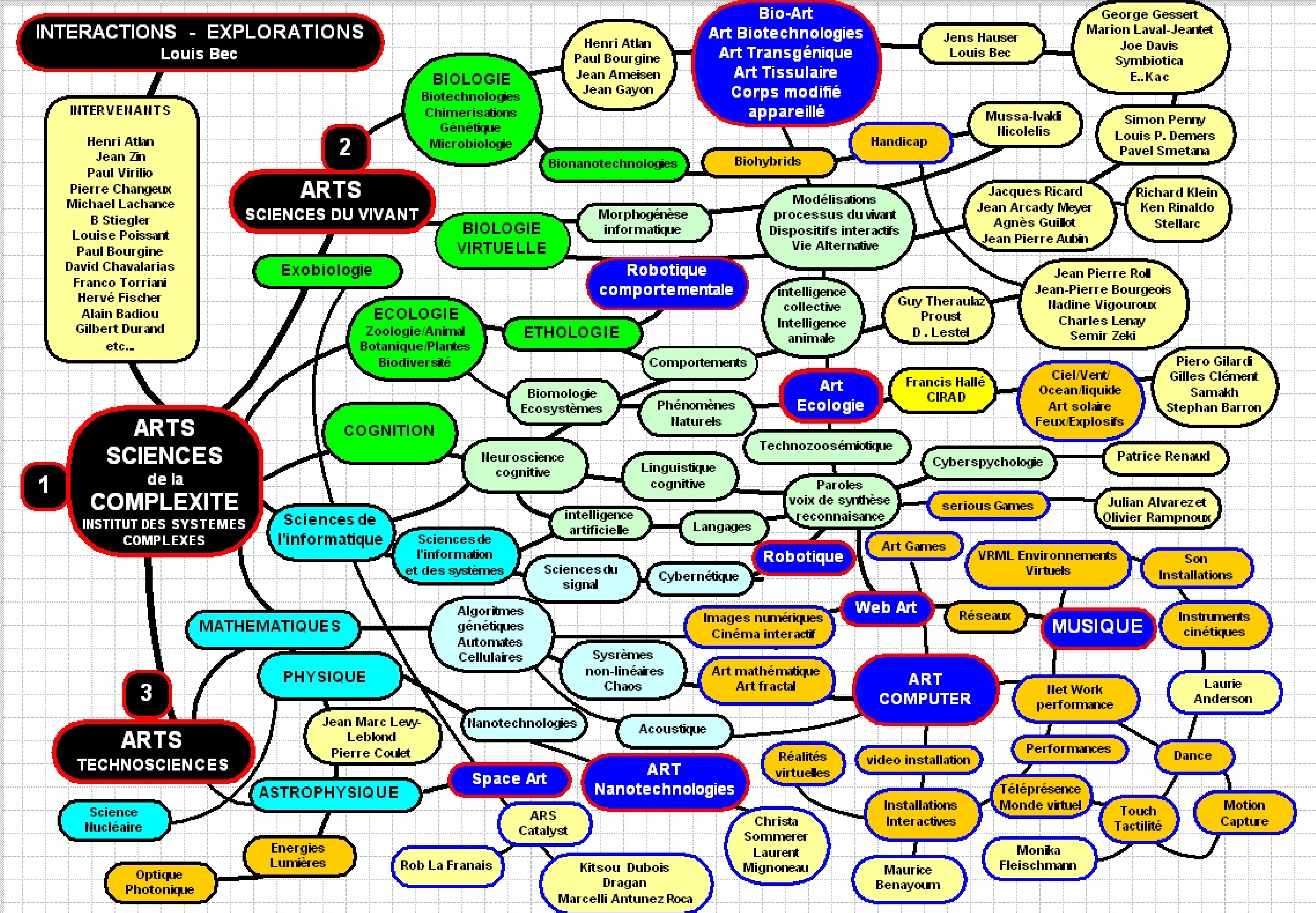
Director of Research at UMI UMMISCO, IRD

Head of the French National Network for Complex Systems

Institut de recherche pour le développement

UMMISCO
Unite Mixte Internationale

RNSC


INTERACTIONS - EXPLORATIONS
Louis Bec
INTERVENANTS
Henri Atlan
Jean Zin
Paul Virilio
Pierre Changeux
Michael Lachance
B Stiegler
Louise Poissant
Paul Bourgine
David Chavalarias
Franco Torriani
Hervé Fischer
Alain Badiou
Gilbert Durand
etc..
1
ARTS
SCIENCES
de la
COMPLEXITE
INSTITUT DES SYSTEMES COMPLEXES
2
ARTS
SCIENCES DU VIVANT
3
ARTS
TECHNOSCIENCES
BIOLOGIE
Biotechnologies
Chimerisations
Génétique
Microbiologie
Henri Atlan
Paul Bourgine
Jean Ameisen
Jean Gayon
Bio-Art
Art Biotechnologies
Art Transgénique
Art Tissulaire
Corps modifié
appareillé
Jens Hauser
Louis Bec
George Gessert
Marion Laval-Jeantet
Joe Davis
Symbiotica
E..Kac
Bionanotechnologies
Biohybrids
Handicap
Mussa-Ivaldi
Nicolelis
Simon Penny
Louis P. Demers
Pavel Smetana
BIOLOGIE
VIRTUELLE
Morphogénèse
informatique
Modélisations
processus du vivant
Dispositifs interactifs
Vie Alternative
Jacques Ricard
Jean Arcady Meyer
Agnès Guillot
Jean Pierre Aubin
Richard Klein
Ken Rinaldo
Stellarc
Exobiologie
Robotique
comportementale
intelligence
collective
Intelligence
animale
Guy Theraulaz
Proust
D . Lestel
Jean Pierre Roll
Jean-Pierre Bourgeois
Nadine Vigouroux
Charles Lenay
Semir Zeki
ECOLOGIE
Zoologie/Animal
Botanique/Plantes
Biodiversité
ETHOLOGIE
Comportements
Biomologie
Ecosystèmes
Phénomènes
Naturels
Art
Ecologie
Francis Hallé
CIRAD
Ciel/Vent/
Ocean/liquide
Art solaire
Feux/Explosifs
Piero Gilardi
Gilles Clément
Samakh
Stephan Barron
COGNITION
Neuroscience
cognitive
Technozoosémiotique
Linguistique
cognitive
Cyberspychologie
Patrice Renaud
Paroles
voix de synthèse
reconnaisance
serious Games
Julian Alvarez et
Olivier Rampnoux
Sciences de
l'informatique
Sciences de
l'information
et des systèmes
intelligence
artificielle
Langages
Robotique
Art Games
VRML Environnements
Virtuels
Son
Installations
Sciences du
signal
Cybernétique
Web Art
Réseaux
MUSIQUE
Instruments
cinétiques
MATHEMATIQUES
Algoritmes
génétiques
Automates
Cellulaires
Images numériques
Cinéma interactif
Sysrèmes
non-linéaires
Chaos
Art mathématique
Art fractal
ART
COMPUTER
Net Work
performance
Laurie
Anderson
PHYSIQUE
Jean Marc Levy-
Leblond
Pierre Coulet
Nanotechnologies
Acoustique
Réalités
virtuelles
video installation
Performances
Dance
Space Art
ART
Nanotechnologies
ASTROPHYSIQUE
Science
Nucléaire
ARS
Catalyst
Christa
Sommerer
Laurent
Mignoneau
Installations
Interactives
Téléprésence
Monde virtuel
Touch
Tactilité
Motion
Capture
Energies
Lumières
Optique
Photonique
Rob La Franais
Kitsou Dubois
Dragan
Marcelli Antunez Roca
Maurice
Benayoum
Monika
Fleischmann

The French "roadmap" toward complex systems science

- ✓ another way to circumscribe complex systems is to list "big (horizontal) questions" and "big (vertical) objects", and cross them

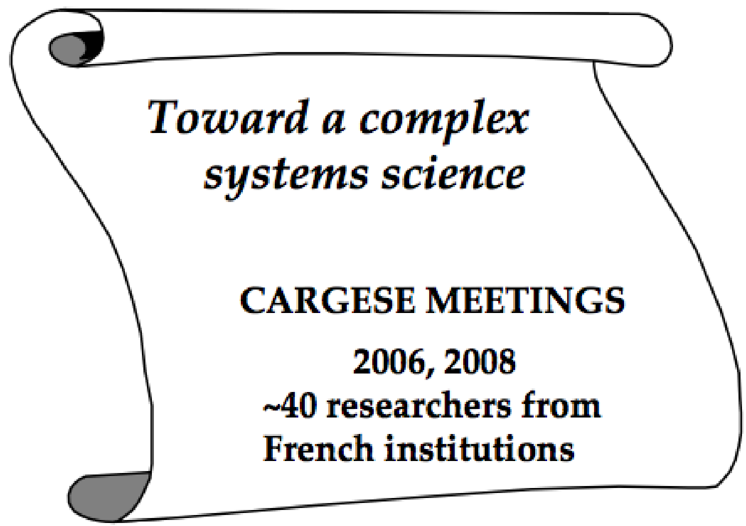
×

Big objects

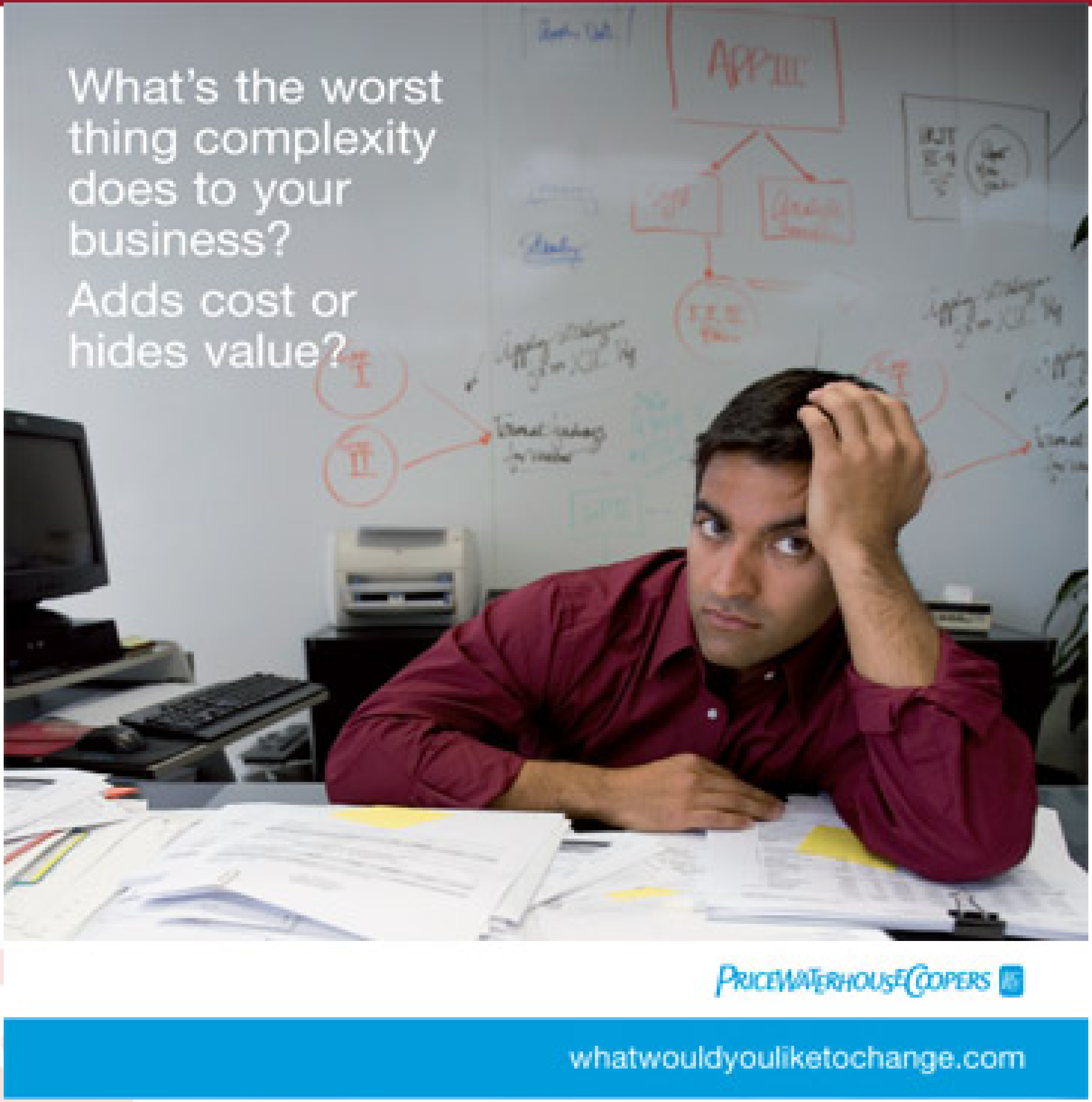
- subcellular
- multicellular development
- physiology
- indiv. & social cognition
- ecosystems
- territorial intell. & sustainability
- ubiquitous computing

Big questions

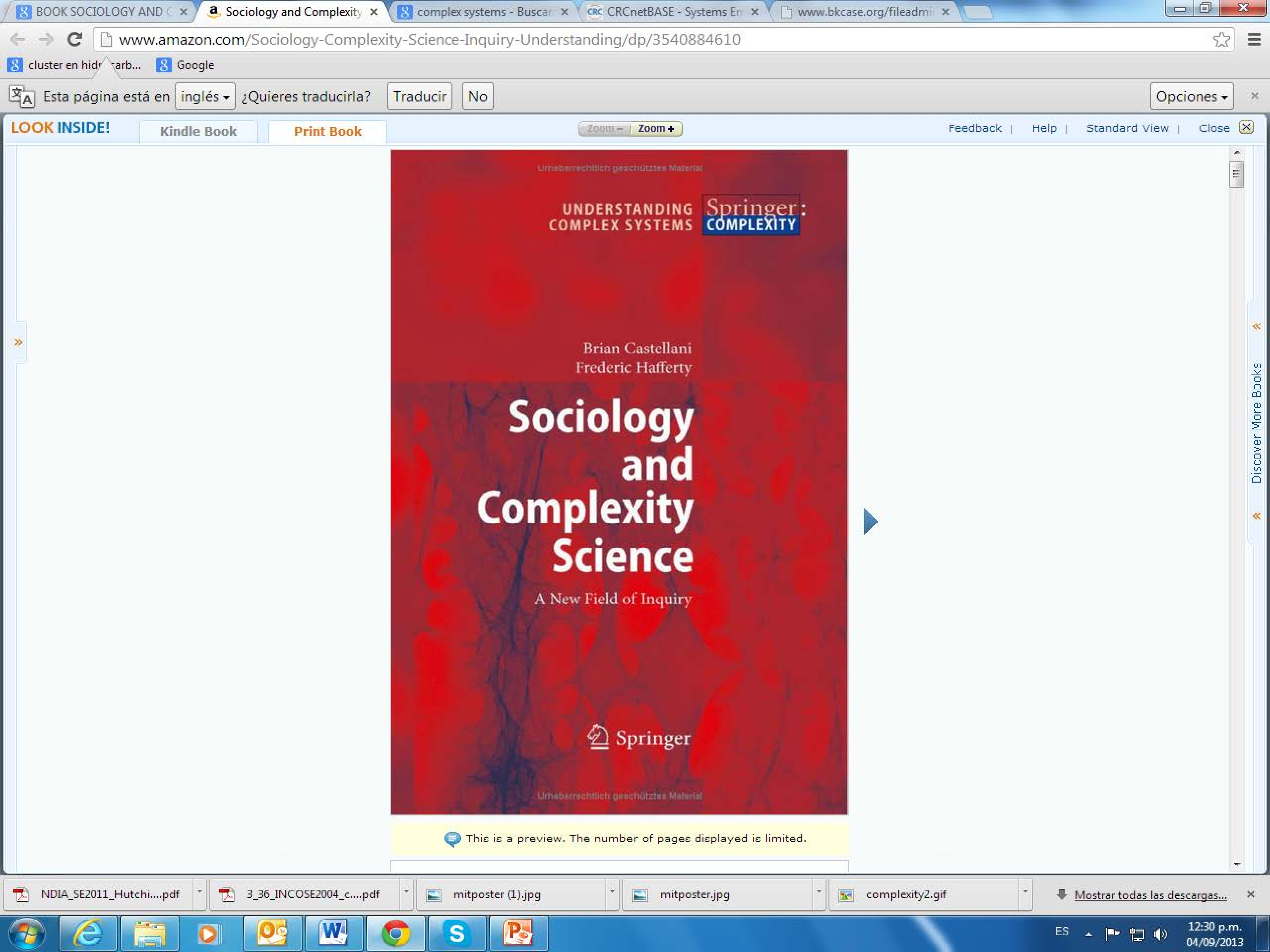
- reconstruct multiscale dynam.
- emergence & immergence
- spatiotemp. morphodynamics
- optimal control & steering
- artificial design
- fluctuations out-of-equilib.
- adaptation, learning, evolution

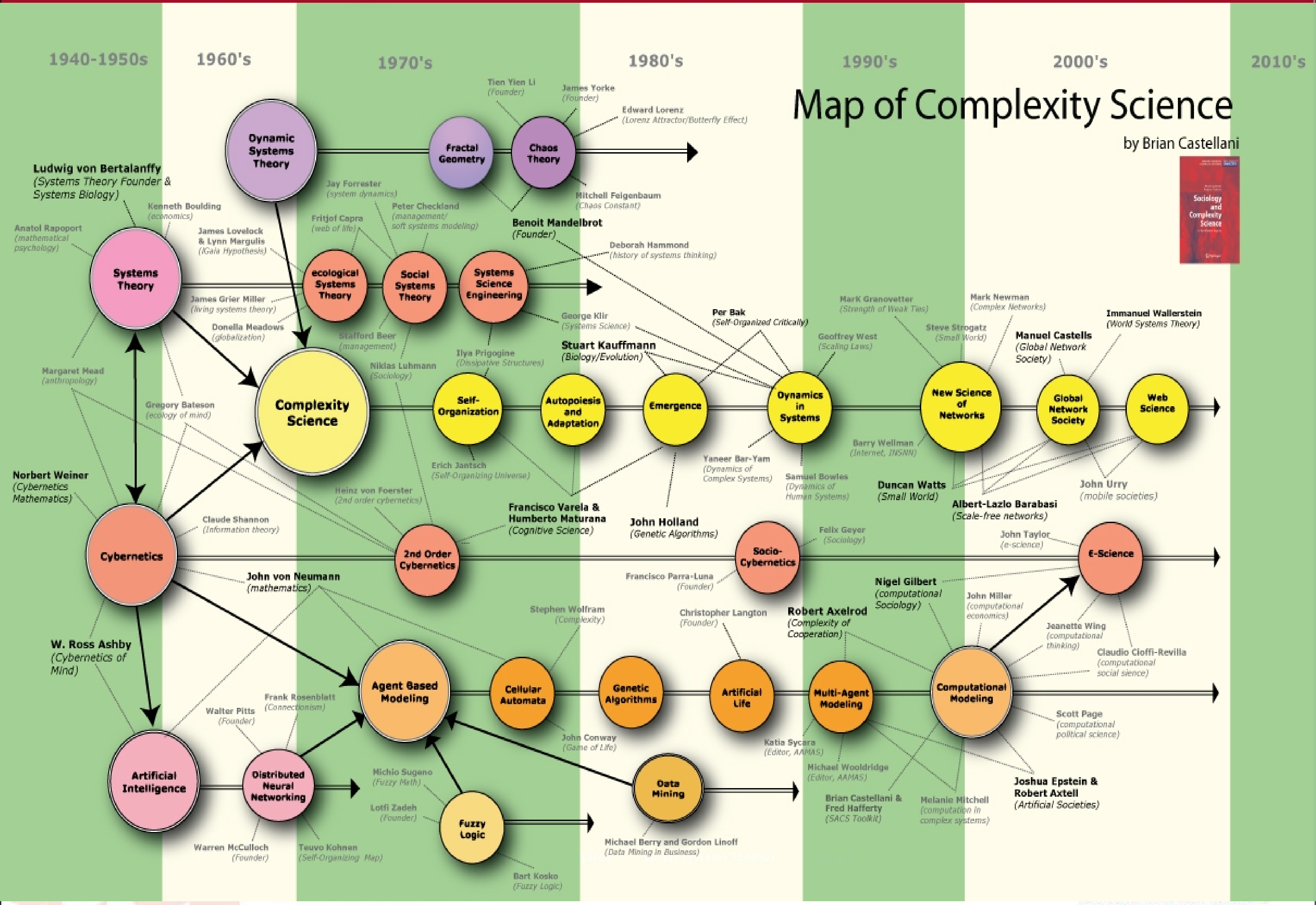


Universidad del Rosario



UNIVERSIDAD DEL ROSARIO


www.amazon.com/Sociology-Complexity-Science-Inquiry-Understanding/dp/3540884610
LOOK INSIDE!
Kindle Book
Print Book
UNDERSTANDING COMPLEX SYSTEMS
Springer Complexity
Brian Castellani
Frederic Hafferty
Sociology and Complexity Science
A New Field of Inquiry
Springer
This is a preview. The number of pages displayed is limited.


Map of Complexity Science
by Brian Castellani
1940-1950s
1960's
1970's
1980's
1990's
2000's
2010's
Dynamic Systems Theory
Fractal Geometry
Chaos Theory
Tien Yien Li (Founder)
James Yorke (Founder)
Edward Lorenz (Lorenz Attractor/Butterfly Effect)
Mitchell Feigenbaum (Chaos Constant)
Benoit Mandelbrot (Founder)
Ludwig von Bertalanffy (Systems Theory Founder & Systems Biology)
Kenneth Boulding (economics)
Anatol Rapoport (mathematical psychology)
James Lovelock & Lynn Margulis (Gaia Hypothesis)
Jay Forrester (system dynamics)
Fritjof Capra (web of life)
Peter Checkland (management/ soft systems modeling)
Deborah Hammond (history of systems thinking)
Systems Theory
ecological Systems Theory
Social Systems Theory
Systems Science Engineering
James Grier Miller (living systems theory)
Donella Meadows (globalization)
Stafford Beer (management)
George Klir (Systems Science)
Niklas Luhmann (Sociology)
Ilya Prigogine (Dissipative Structures)
Stuart Kauffmann (Biology/Evolution)
Per Bak (Self-Organized Criticality)
Mark Granovetter (Strength of Weak Ties)
Mark Newman (Complex Networks)
Immanuel Wallerstein (World Systems Theory)
Steve Strogatz (Small World)
Geoffrey West (Scaling Laws)
Manuel Castells (Global Network Society)
Margaret Mead (anthropology)
Gregory Bateson (ecology of mind)
Complexity Science
Self-Organization
Autopoiesis and Adaptation
Emergence
Dynamics in Systems
New Science of Networks
Global Network Society
Web Science
Erich Jantsch (Self-Organizing Universe)
Yaneer Bar-Yam (Dynamics of Complex Systems)
Samuel Bowles (Dynamics of Human Systems)
Barry Wellman (Internet, INSNA)
Duncan Watts (Small World)
Albert-Lazlo Barabasi (Scale-free networks)
John Urry (mobile societies)
Norbert Weiner (Cybernetics Mathematics)
Heinz von Foerster (2nd order cybernetics)
Claude Shannon (Information theory)
Francisco Varela & Humberto Maturana (Cognitive Science)
John Holland (Genetic Algorithms)
Felix Geyer (Sociology)
John Taylor (e-science)
Cybernetics
2nd Order Cybernetics
Socio-Cybernetics
E-Science
John von Neumann (mathematics)
Francisco Parra-Luna (Founder)
Nigel Gilbert (computational Sociology)
John Miller (computational economics)
Stephen Wolfram (Complexity)
Christopher Langton (Founder)
Robert Axelrod (Complexity of Cooperation)
Jeanette Wing (computational thinking)
Claudio Cioffi-Revilla (computational social sience)
W. Ross Ashby (Cybernetics of Mind)
Frank Rosenblatt (Connectionism)
Walter Pitts (Founder)
Agent Based Modeling
Cellular Automata
Genetic Algorithms
Artificial Life
Multi-Agent Modeling
Computational Modeling
Scott Page (computational political science)
John Conway (Game of Life)
Katia Sycara (Editor, AAMAS)
Michael Wooldridge (Editor, AAMAS)
Artificial Intelligence
Distributed Neural Networking
Michio Sugeno (Fuzzy Math)
Lotfi Zadeh (Founder)
Data Mining
Joshua Epstein & Robert Axtell (Artificial Societies)
Brian Castellani & Fred Hafferty (SACS Toolkit)
Melanie Mitchell (computation in complex systems)
Fuzzy Logic
Warren McCulloch (Founder)
Teuvo Kohnen (Self-Organizing Map)
Michael Berry and Gordon Linoff (Data Mining in Business)
Bart Kosko (Fuzzy Logic)
Sociology and Complexity Science

Complexity aspects	*Founding Scholar*
Complex systems, systems	Ludwig von Bertalanffy (biology), Kenneth Boulding (economics, philosophy of science, etc.)
Complex adaptive systems	John Holland, Murray Gell-Mann
Nonlinear Dynamics	Henri Poincare, Edward Lorenz, Christopher Langton
Networks	Stuart Pimm, Steven Strogatz, Albert-Lazslo Barabasi
Feedback	Claude Bernard, Norbert Wiener
Hierarchy	Simon Levin, Timothy Allen
Emergence	Numerous predecessors* and recently John Holland, Harold Morowitz
Self-organized criticality	Per Bak
Self-organization = order ←→disorder	Ernst Mayr, Ludwig von Bertalanffy, W. Ross Ashby, John von Neumann

Table 2.4. Key Complexity Terms and Founders in those fields

* One could name: Alfred North Whitehead, Henri Bergson, Georges Canguilhem, Arthur Lovejoy, Rene Thom[20]

Universidad del Rosario

RESEARCHERS

- In the late 1960's cyberneticians such as Heinz Von Foerster of the United States, . . .
- . . . Humberto Maturana of Chile, . . .
- . . . Gordon Pask and, . . .
- . . . Stafford Beer of Great Britain . . . defined cybernetics as, ***“the science of effective organization.”***
- Edgar Morin calls, *generalized complexity*, it seems that a significant philosophical wedge was levied under the entire enterprise of the social sciences and is slowly altering the position and attitude of discourse.

Universidad del Rosario

FIRST AND SECOND ORDER CYBENETICS

- Whereas, **first-order cybernetics** dealt with **controlled systems**,
- **second-order cybernetics** deals with **autonomous** systems.
- Applying cybernetic principles to social systems calls attention to the role of the observer of a system who, . . .
- . . . while attempting to study and understand a social system, is not able to separate himself from the system or prevent himself from having an effect on it.

UNIVERSIDAD DEL ROSARIO

Ross Ashby
An introduction to cybernetics.1956.

- **The second peculiar virtue of cybernetics is that it offers a methods for the scientific treatment of the system in which complexity is outstanding** and too important to be ignored.
- Such systems are, as we all know, only too common in the biological world.
- But science today is also taking the first steps towards studying **“complexity” as a subject in its own right**.
- Cybernetics offers the hope of providing effective methods for the study and control, of systems that are intrinsically extremely complex.

UNIVERSIDAD DEL ROSARIO

Stafford Beer.
The Heart of Enterprise 1979

- Today, the stuff of ***management*** includes the four Ms (Men, Materials, Machinery and Money), but is best denoted as: ***COMPLEXITY*****.**
- Management at every level, from our management of ourselves through every size of aggregation to the management of the Earth is itself **'complexifying'** –and it receives complexifying interference from every other level too.
- Thus complexity proliferates; and it has become virtually ***inmanegeable with existing managerial tools.***

Universidad del Rosario

Definitions of Complex Systems

- A complex system is a highly structured system, which shows structure with variations (N. Goldenfeld and Kadanoff)
- A complex system is one whose evolution is very sensitive to initial conditions or to small perturbations, one in which the number of independent interacting components is large, or one in which there are multiple pathways by which the system can evolve (Whitesides and Ismagilov)
- A complex system is one that by design or function or both is difficult to understand and verify (Weng, Bhalla and Iyengar)
- A complex system is one in which there are multiple interactions between many different components (D. Rind)
- Complex systems are systems in process that constantly evolve and unfold over time (W. Brian Arthur)

Science, Special Issue Complex Systems, Vol. 284. No. 5411 (1999)

UNIVERSIDAD DEL ROSARIO

Guide to the Systems Engineering Body of Knowledge (SEBoK) version 1.0

Please note that this is a PDF extraction of the content from www.sebokwiki.org

Universidad del Rosario

SEBoK

- **Systems engineering** is "an **interdisciplinary approach** and means to enable the realization of successful systems" (INCOSE 2012). It focuses on holistically and concurrently understanding stakeholder needs; exploring opportunities; documenting requirements; and synthesizing, verifying, validating, and evolving solutions while considering the complete problem, from system concept exploration through system disposal.
- **A systems engineer** is "a **person** who practices systems engineering" as defined above, and whose systems engineering capabilities and experience include sustained practice, specialization, leadership or authority over systems engineering activities.
- **Systems engineering activities** may be conducted by any competent person regardless of job title or professional affiliation.

UNIVERSIDAD DEL ROSARIO

THE KNOWLEDGE ECOSYSTEM

The diagram below shows the flows and interconnections among elements of a "knowledge ecosystem" of systems theory and practice.

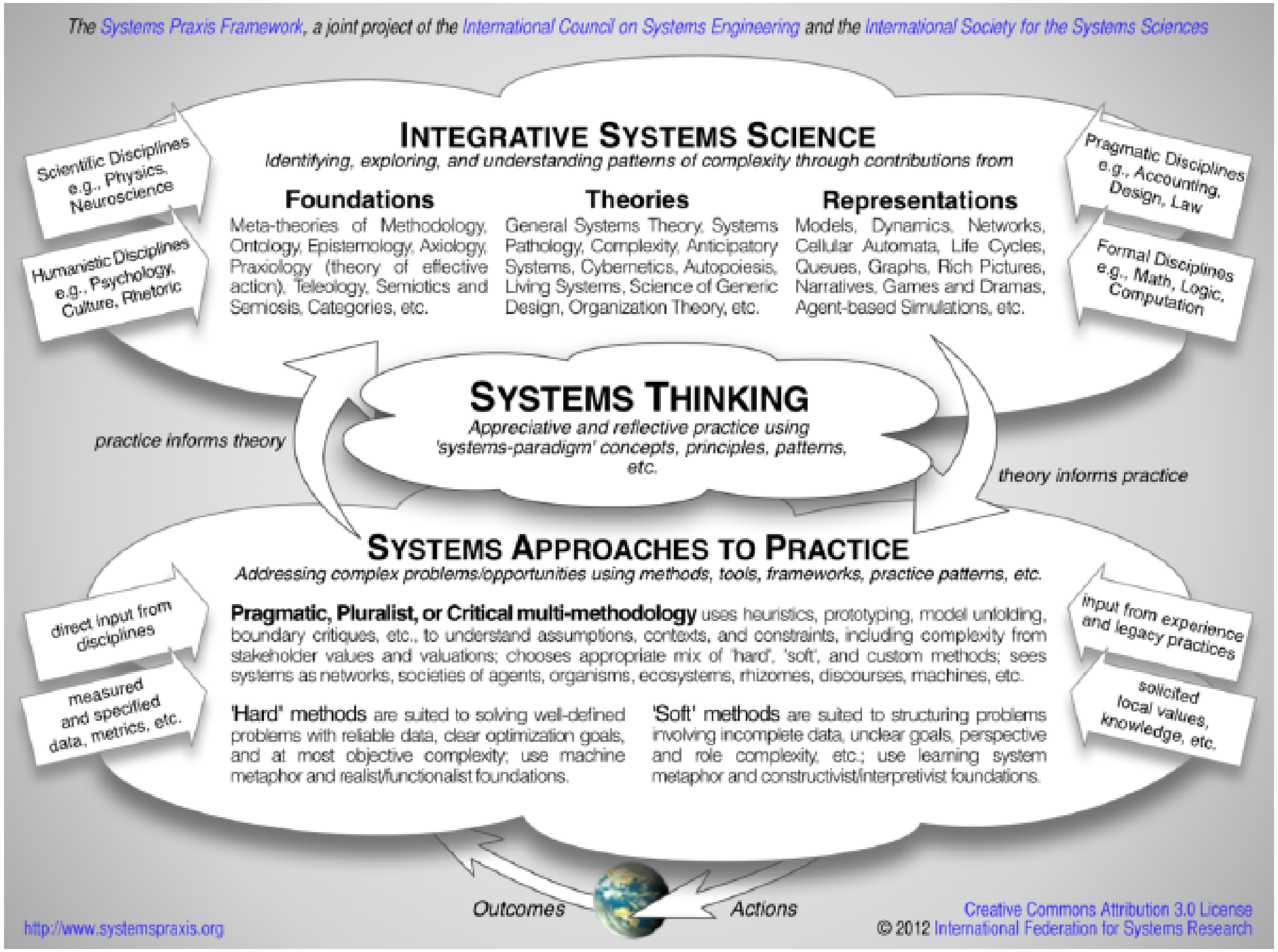


Figure 1. The Systems Praxis Framework, Developed as a Joint Project of INCOSE and ISSS. (© 2012 International Federation for Systems Research) Released under Creative Commons Attribution 3.0 License. Source is available at http://systemspraxis.org/framework.pdf.

RSIDAD DEL ROSARIO

The following diagram summarizes the way in which the knowledge in SEBoK Part 2 is organized.

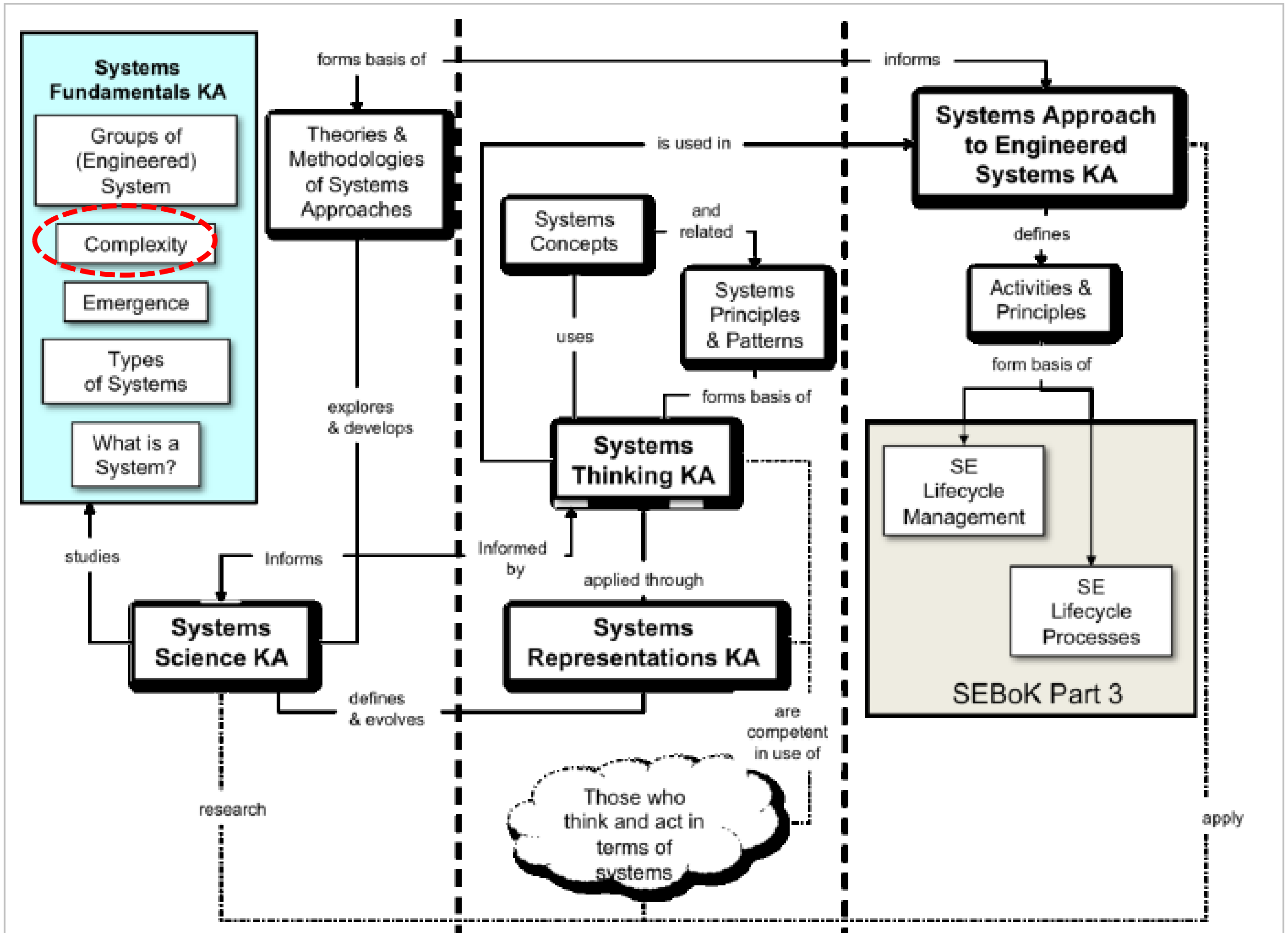


Figure 2. The Relationships between Key Systems Ideas and SE. (SEBoK Original)

Universidad del Rosario

Characteristics of system elements and relationships for objective systems complexity.

The following four features are given by Page (2009):

- 1. ***Independence***: Autonomous system elements which are able to make their own decisions; influenced by information from other elements and the adaptability algorithms it carries with it (Sheard and Mostashari 2009).
- 2. ***Interconnectedness***: System elements connect via a physical connection, shared data or simply a visual awareness of where the other elements are and what they are doing, as in the case of the flock of geese or the squadron of aircraft.

UNIVERSIDAD DEL ROSARIO

Characteristics of system elements and relationships for systems complexity.

- 3. ***Diversity***: System elements which are either technologically or functionally different in some way. For example, elements may be carrying different adaptability algorithms.
- 4. ***Adaptability***: Self-organizing system element which can do what it wants to do to support itself or the entire system in response to their environment (Sheard and Mostashari 2009). Adaptability is often achieved by human elements but can be achieved with software.
- Pollock and Hodgson (2004) describe how this can be done in a variety of complex system types, including ***power grids and enterprise systems.***

Universidad del Rosario

ATTRIBUTES OF COMPLEXITY

- Sheard and Mostashari (2011) sort the attributes of complexity into causes and effects.
- ***Attributes*** that cause complexity include being non-linear; emergent; chaotic; adaptive; tightly coupled; self-organized; decentralized; open; political (as opposed to scientific); and multi-scale; as well as having many pieces.
- The ***effects*** of those attributes which make a system be perceived as complex include being uncertain; difficult to understand; unpredictable; uncontrollable; unstable; unrepairable; unmaintainable and costly; having unclear cause and effect; and taking too long to build.

Universidad del Rosario

The Complexification of Engineering

Maldonado (2012) underlines that the complexification of engineering consists in:

(a) that shift throughout which engineering becomes a science;
(b) thus it ceases to be a (mere) praxis or profession;
(c) becoming a science, engineering can be considered as one of the sciences of complexity.

- In reality, the complexification of engineering is the process by which engineering can be studied, achieved, and understood in terms of knowledge, and not of goods and services any longer.
- Complex engineered systems and bio-inspired engineering are so far the two expressions of a complex engineering.

2011 Wiley Periodicals, Inc. Complexity 17: 8–15, 2012

Universidad del Rosario

The Complexification of Engineering

- The complexification of engineering is, however, not to be taken as a diversification of its fields and scopes neither in the use of a range of mathematical, technological, and computational tools.
- Something deeper and from a wider scope and reach is at stake both within engineering and in its relationships with other sciences and disciplines, namely management.
- What is truly going on affects the very nature of science and of nature, eventually.

Universidad del Rosario

The Complexification of Engineering

- In his paper Maldonado points out the trend of engineering to complexity.
- Thus, *"We consider how engineering becomes a* ***science on its own****. In so doing, we define the* ***relationship*** *between* ***engineering and complexity*** *and we claim that engineering is going through a radical change of its very nature, even though such a trend is far from being general or normal."*

Universidad del Rosario

The Complexification of Engineering

- More recently, a new conceptual field has been growing that focuses on systems or software that supports engineering activities.
- The importance of computing, modeling, and simulation and even more widely the significance of microelectronic systems and components have triggered the importance of meta-engineering.
- As indicated in the SEBoK.

Universidad del Rosario

The Complexification of Engineering

- Meta-engineering has been conceived as a sort of ‘‘engineering-engineering’’ with the help of software and/or systems that support all daily activities, choices and plans proposed or carried out by engineers.
- The focus here is placed on design, and design is conceived as the most fundamental part of engineering at large.

The Complexification of Engineering

- If classical engineering arose from its interest in controlling and superseding nature (from the 17th Century onwards), the new ‘‘nature’’ of engineering so to speak has become the world enterprises at large.
- ***“By this we do not merely mean industrial engineering or the like, but a new array of literally engineering society, economics, finances and management”***

UNIVERSIDAD DEL ROSARIO

The Complexification of Engineering

- Several authors speak about enterprise systems engineering, but is more to stress on system of systems engineering (SoSE).
- Our preference lies in the fact that the concept of ‘‘system of systems’’ is wider and deeper than ‘‘enterprise’’, which can be rightly conceived as an element of SoSE.

The Complexification of Engineering

- System of systems engineering (SoSE) represents not just a bifurcation within the engineering sciences but, more appropriately, a new territory for work and research.
- While it has being paying a debt to classical and conventional engineering, it heads up toward the recognition of information and computing as
- vital assets for engineering leaving in the backstage the traditional concern for matter and energy.

Universidad del Rosario

The Complexification of Engineering

- As the world introduces new materials and discovers a variety of different approaches, engineering becomes less attached to the knowledge introduced from a-far and starts to produce knowledge by itself.
- As a result, engineering crosses the boundary that separates engineering from science and heads up to the production of knowledge as a vital process in engineering.
- In such a transition, ***engineering becomes solidly a science*** and not just an application of knowledge produced elsewhere.

Universidad del Rosario

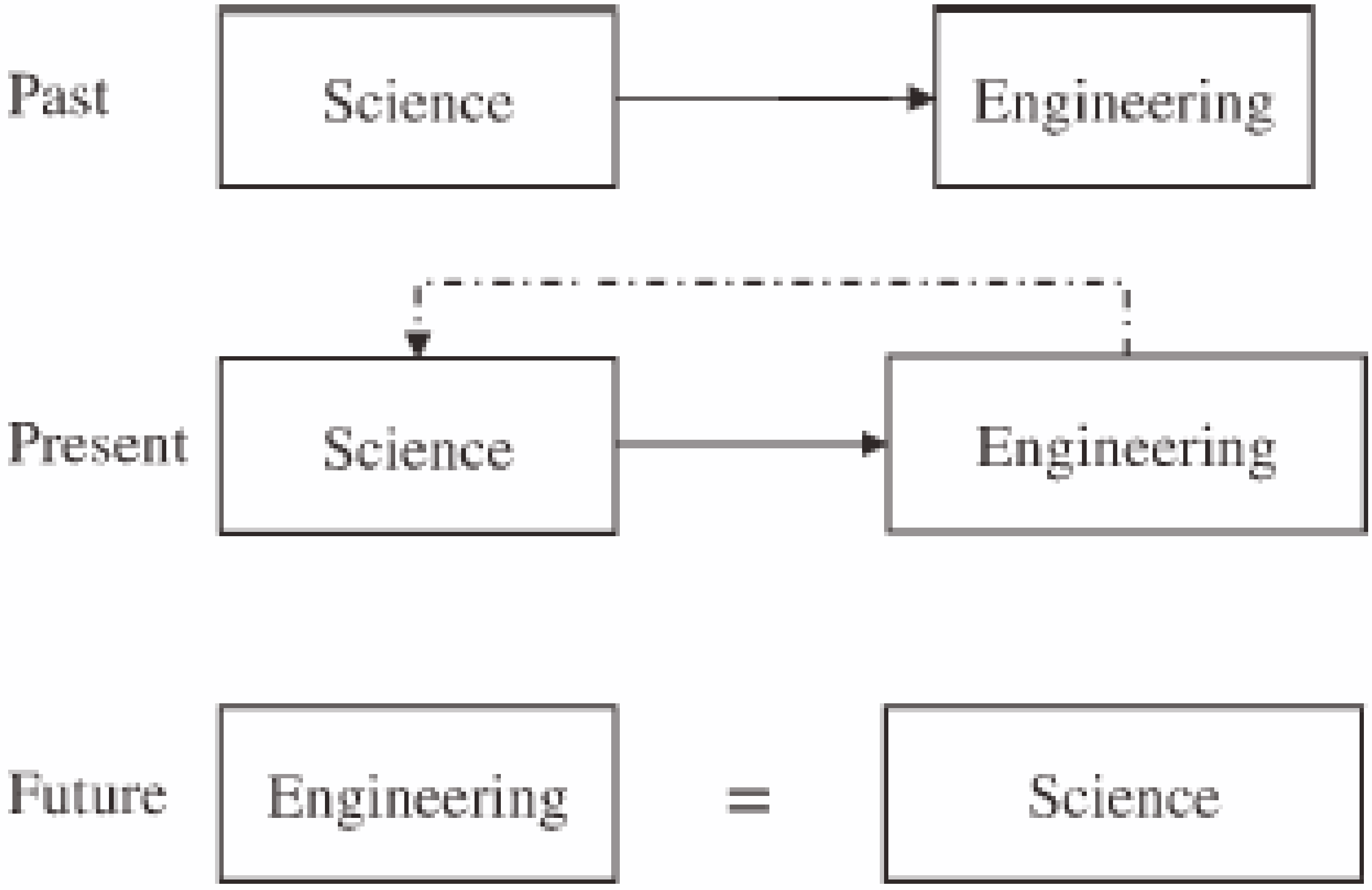
The Complexification of Engineering

- The definite complexification of engineering is introduced thanks to the development of complex engineered systems (CES).
- In this frame, the complexification is not to be taken as a complication of engineering sciences, but rather as the non-linearization of engineering, which entails the entrance into, or the transformation of engineering as, complex science.
- The Figure synthesizes the evolution of engineering in time and hence its relationship to science.

Universidad del Rosario

Example Areas of the Complexification of Engineering Including Rods and Leading Authors and References

Engineering paradigm	Areas	Methods and rods	Examples
Classical	Differential and integral calculus; Newtonian physics; classical (mathematical) logic; operational research	Analysis; linear control; mathematical optimization; goal-oriented design	Cars, aircraft, computers, buildings
Reverse	Reengineering, geometry	Abstraction; modularity; filter algorithms; geometric models; disassembly; decompilation	Reversing computer software (malicious software, cryptographic algorithms); electronic components; microcontrollers, industrial parts and designs
Conventional	Classical artificial intelligence; statistics; probability	Intelligent control; Bayesian probability; formal analysis; logic programming; mathematical optimization; decision theory; utility theory	Experts systems; rational agents; decision support systems; machine learning systems; intelligent robots; control systems
Meta	Reverse engineering; software engineering; systems engineering; requirements engineering; industrial engineering; management and information engineering	The same as classical and reverse engineering	Engineering decision support systems; meta-software engineering; meta-engineering software; engineering meta-methodologies; computer assisted engineering design; knowledge engineering to capture, represent and transmit engineering knowledge; designing engineering organizations; organizational engineering applied in engineering organizations
Unconventional	Control theory; cybernetics; dynamical systems theory; probability theory; numerical analysis	Non-linear control; robust control; dynamic control; numerical methods; differential geometry	Air-traffic; control systems; second generation robotics
System of systems	General systems theory; systems thinking; network theory; probabilistic robust design; object oriented programming; psychology; sociology; management; artificial intelligence	Strategic planning; multi-objective optimization; intelligent control	International space station; integrated defense system; national power supply networks; transportation systems; larger infrastructure constructions; production systems; software integration
Complex	Chaos theory; fractal theory; science of networks; computational intelligence; soft computing; machine learning; fuzzy logic	Fuzzy control; stochastic control; decentralized control; bottom-up simulation	World Wide Web; air and ground traffic networks; distributive manufacturing environments; globally distributed supply networks; self-organizing sensor networks; self-configuring robots; swarms of autonomous aircraft; smart materials and structures; self-organizing computers
Bio-inspired	Organic computing; natural computing; bio-inspired computing; biological computation (and hypercomputation); swarm robotics; evolutionary robotics; computational development; artificial life; synthetic biology; nano-bio.info-cogno-technologies	Bottom-up information processing; synthesis; metaheuristics; decentralized control (self-organization)	Self-organizing artificial systems; artificial life software; reconfigurable and evolvable hardware; autonomously self-reproducing robots; chemical protocells; hybrid electronic-chemical systems; life-like systems



Relationship between science and engineering in time.

DEL ROSARIO

The Complexification of Engineering

- One recent fast development to be taken into account is materials sciences— a concept that crosses or encompasses physics, chemistry, and engineering;
- material sciences are in fact frontier science.
- Development of composite materials, and completely new materials, including ceferene and graphene.

Universidad del Rosario

The Complexification of Engineering

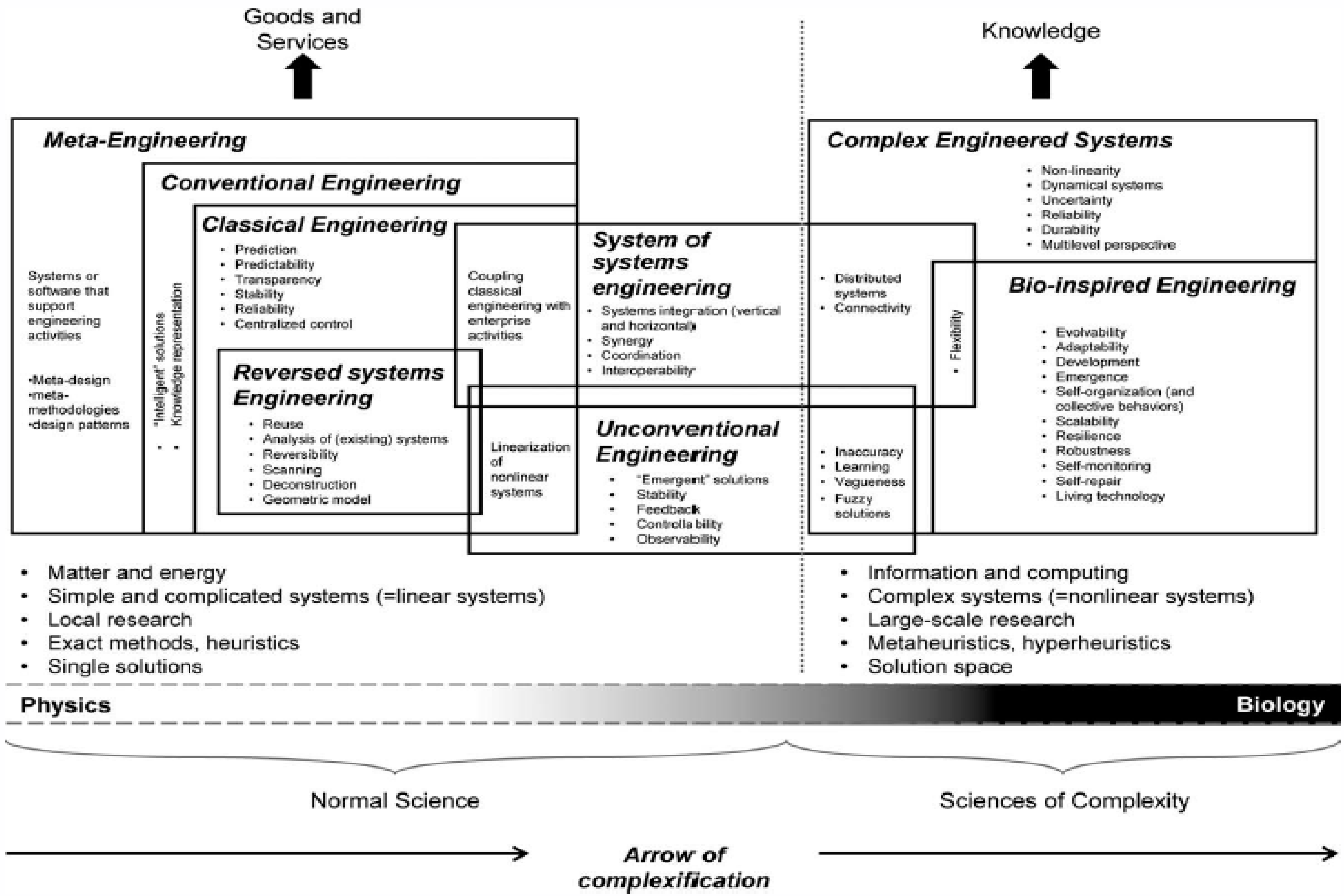
- Engineering complex systems consists in producing systems capable of adaptation, change and novelty, and not any longer systems defined by stability, predictability, reliability, and Control.
- This last is more "**management**" oriented at enterprise level

Universidad del Rosario

The Complexification of Engineering

- Two areas actively contributing to the development of complex engineered systems, namely living technology and synthetic biotechnology.
- It is our contention that such a theoretical framework can be provided by the other great component by which engineering becomes complex science: bioinspired engineering.
- The Figure explains itself.

Universidad del Rosario



Complexification of engineering sciences: key concepts.

The Complexification of Engineering

- What is the interest in tracing the map of the complexification of engineering?
- Three main reasons, namely

I. ***Understanding what engineering really is like is vital for the comprehension of technology.***

- To be sure, that is the subject of philosophy of technology;

UNIVERSIDAD DEL ROSARIO

The Complexification of Engineering

II. In the history of mankind the relationships between science and technology have never been so passionate, vital, and crucial. In an optimistic view of future our fate depends on knowledge and research, and the engineering sciences play a fundamental role then;

III acting upon nature and society is a matter of both sensitivity and intelligence.

Two ways how we act are science and technology, not to mention art at large.

Universidad del Rosario

Training in complex systems

- Present curricula at the university level are based, all over the world, on well-focused, disciplinary subject matters because the cumulative built-up of scientific knowledge in every field inevitably requires specialization and results in fragmentation.
- On the other hand, many experiences in research or management request interdisciplinary skills and viewpoints as well as integrated modelling tools accounting for multiscale data and multiple interacting processes: The need for new educational paradigms emerges.

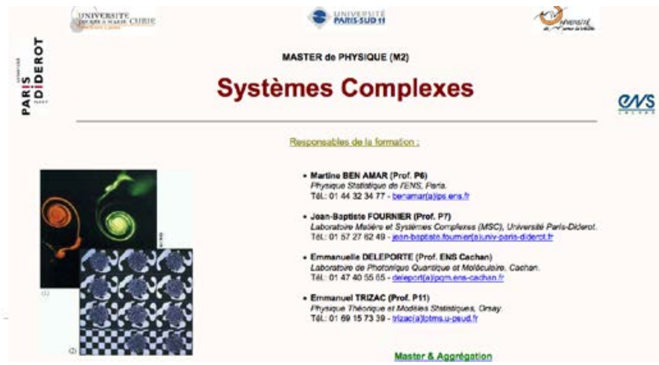
Training in complex systems

- The field of complex systems is not yet in a state to be taught in the same way as classical science at University, anyway many masters and PhD curriculum are now proposed to students to cross traditional boundaries .
- We give here some examples of educational programmes which are in development in France and in Europe in this context.

Universidad del Rosario

New Masters


IXXI
Master 2 recherche en « Modélisation des systèmes complexes »
S'initier aux approches des trois disciplines (informatique, mathématiques et physique)
Développer des compétences méthodologiques pour l'étude des systèmes complexes
Modéliser des systèmes biologiques ou sociaux en lien avec ces disciplines
Découvrir le monde de la recherche au cours d'un stage pluridisciplinaire
Les inscriptions se font au sein des Masters disciplinaires de l'Université de Lyon : Informatique fondamentale, Mathématiques et applications ou Sciences de la matière
Plus d'informations : ixxi.fr/M2/
INSA
Lyon 1
RhôneAlpes

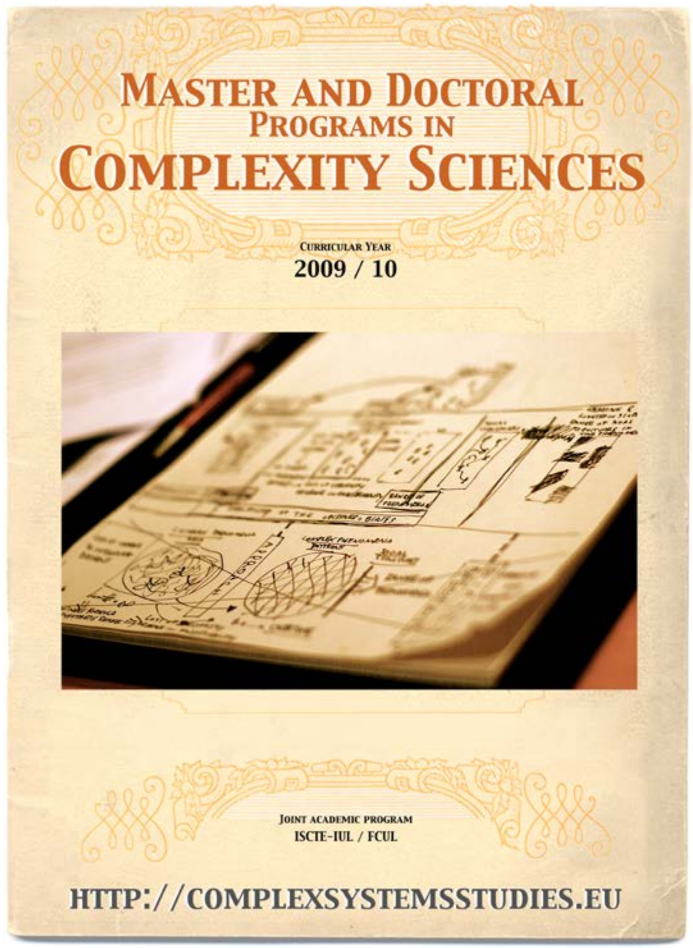

PARIS DIDEROT
MASTER de PHYSIQUE (M2)
Systèmes Complexes
ENS
Responsables de la formation :
Martine BEN AMAR (Prof. P6)
Physique Statistique de l'ENS, Paris
Tél.: 01 44 32 34 77
Jean-Baptiste FOURNIER (Prof. P7)
Laboratoire Matière et Systèmes Complexes (MSC), Université Paris-Diderot
Tél.: 01 57 27 62 49
Emmanuelle DELEPORTE (Prof. ENS Cachan)
Laboratoire de Photonique Quantique et Moléculaire, Cachan
Tél.: 01 47 40 55 65
Emmanuel TRIZAC (Prof. P11)
Physique Théorique et Modèles Statistiques, Orsay
Tél.: 01 69 15 73 39
Master & Agrégation


CHALMERS
COMPLEX ADAPTIVE SYSTEMS
Understanding complex systems in the world around us
Computer simulations, game theory, and statistical methods are used to describe and increase our understanding of complex systems in nature and society, such as gene-regulation networks, the motion of dust particles in turbulent air, or the dynamics of economic markets. But complex systems in nature are also a source of new ideas: genetic algorithms and genetic programming, for example, are based on evolutionary processes in nature.
The construction of artificial life, the designs of autonomous robots and software agents are based on the behaviour of living systems.
MASTER'S PROGRAMME
CHALMERS UNIVERSITY OF TECHNOLOGY, SWEDEN


UNIVERSITÉ DE RENNES 1
Systèmes Complexes Naturels et Industriels :
Description, simulation et prédictions
Présentation
Débouchés
Laboratoires associés
Contenu de la formation
Contrôle des connaissances
Stages
Inscription & Candidature
Liens utiles
Instabilités géologiques, risques industriels, fluides complexes, dynamique des populations...
Les systèmes complexes sont constitués d'un grand nombre d'entités en interaction et dont un observateur ne peut facilement prévoir le comportement ou l'évolution. La maîtrise de ces systèmes est essentielle pour l'industrie associée aux grands systèmes (transports, espace, finances, santé, énergie ...). Elle répond également à des enjeux sociétaux majeurs : prévision et gestion des risques naturels et industriels.
Une approche pluridisciplinaire s'est développée pour répondre à un besoin de compréhension et de modélisation des systèmes que l'on rencontre en :
Physique
Géophysique
Biologie
Économie
Sciences sociales, etc...
La plupart des théories et des méthodes utilisent des concepts transverses à ces disciplines. La science des systèmes complexes est donc intrinsèquement pluridisciplinaire et elle s'appuie sur des outils scientifiques et des démarches communes.
Responsable de la formation
Renaud Delannay
Institut de Physique de Rennes
Université de Rennes I
UMR CNRS 6251
263, av. général Leclerc
35042 Rennes cedex
FRANCE
Tel:02.23.23.56.00
renaud.delannay@univ-rennes1.fr


comienzo octubre 2010 abierto plazo de preinscripción
Máster Universitario Física de Sistemas Complejos
Caos clásico y cuántico
Autómatas celulares
Redes complejas
Crecimiento fractal
Universidad Politécnica de Madrid (UPM)
POLITÉCNICA
GSC

New Masters and PhDs



UNIVERSIDAD DEL ROSARIO

Teaching about complex systems in engineers schools? An open discussion

- How far concepts and tools from the complex systems scientific community are already taught in engineers schools or in mainstream education?
- To which extend a general overview of a broad range of mathematical or computer modelling approaches has to be taught in a given field of application?

Teaching about complex systems in engineers schools? An open discussion

- Do we have to encourage autonomous distant learning through the Internet and videoconferences or to build specific curricula?
- Which are so far the main type of applications in engineering?
- E. Morin (Seven Complex Lessons in Education for the Future, 2002) points out that learning means how to face uncertainty , given that ***«knowledge supposes navigating in an ocean of uncertainties through archipelagos of certainties”***.

Universidad del Rosario

What´s next?

- Recognize the need for strategic decision making, from the perspective of complexity.
- Introduce tools and general methods of the theory of complex systems within a general theoretical framework engineering student can adapt to their own research practice.
- Determine the type of emergent phenomena that require complexity theory for proper modeling, simulation and understanding, from the perspective of organizational management.

Universidad del Rosario

What´s next?

- Know the basic mathematical foundations of fractal geometry and fractal analysis of stochastic processes, and associate them with the research topics of interest to engineering education.
- Understand the basic tools for analyzing nonlinear dynamic systems and understand the phenomenon of chaos that such systems can reach display, and identify their applicability in the areas of education and research in engineering.
- Introduce some theoretical proposals to contextualize complex systems engineering.

Universidad del Rosario

Universidad del Rosario

Muchas gracias

leonardo.pineda@urosario.edu.co