Predict, hypothesize and imagine the Futures

From Physics to Futures Studies

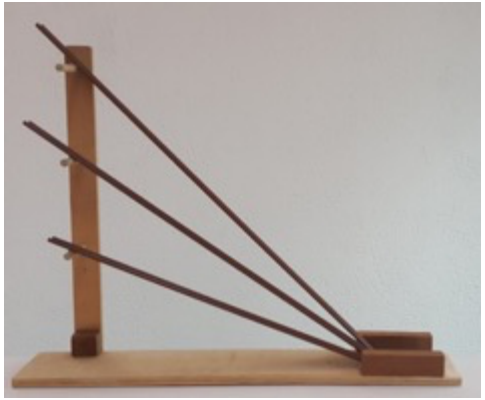
Eleonora Barelli
eleonora.barelli2@unibo.it

The project is co-funded by the Erasmus+ Programme of the European Union. Grant Agreement n° 2016-1-IT02-KA201-024373.

I SEE
It's your time to imagine the futures

Physics and futures

- Physics has been developed (also) to predict the future and to manage its uncertainty in a rational way
- A change in perspective: from classical Newtonian Physics, realm of determinism, to modern science, realm of uncertainty and of the un-predictable
- The **science of complex systems**



It's your time to imagine the futures

Concepts and Activities

- Which **words** and **concepts** to introduce the science of complex systems to secondary school students?
- Which **tools** to “experience” these concepts? (videos, web pages, applets, …)
- Which **original activities** can be desiged to use these tools in education?

The words of complexity

Complexity forces us to change our approach toward future and offers us a *heritage* of **new words and concepts**

non-linearity

circular causality

deterministic chaos

emergent properties

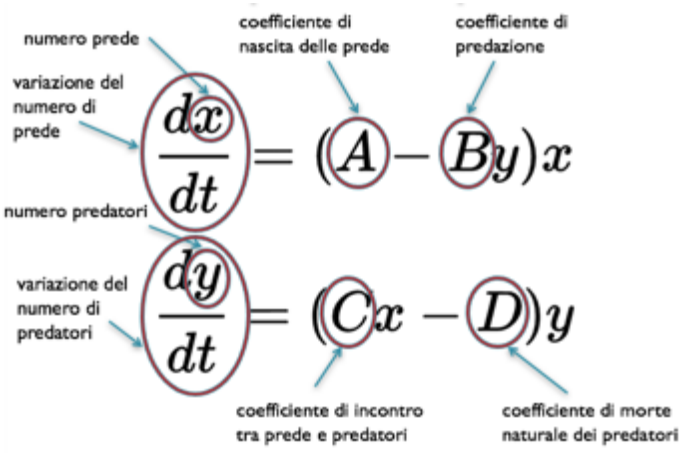
Non-linearity

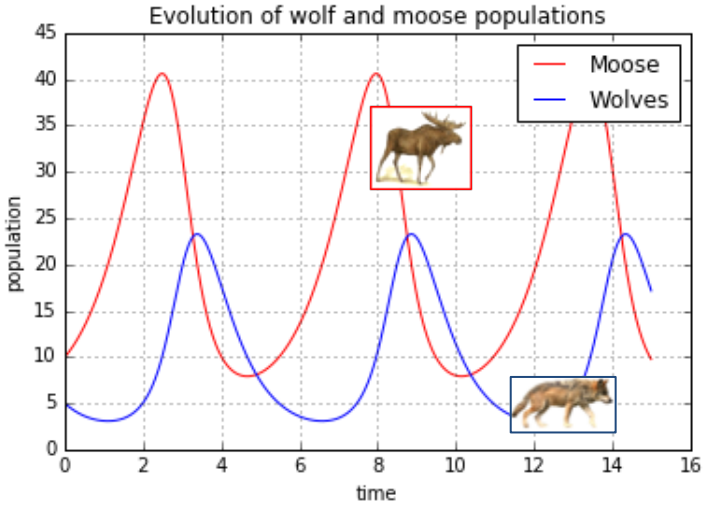
Many models that describe complex systems cannot be written in the form of linear equations.

Renounce to the superposition priciple, to reductionism and to determinism that, more or less explicity, characterize the physical models analysed at school.

ACTIVITY 1

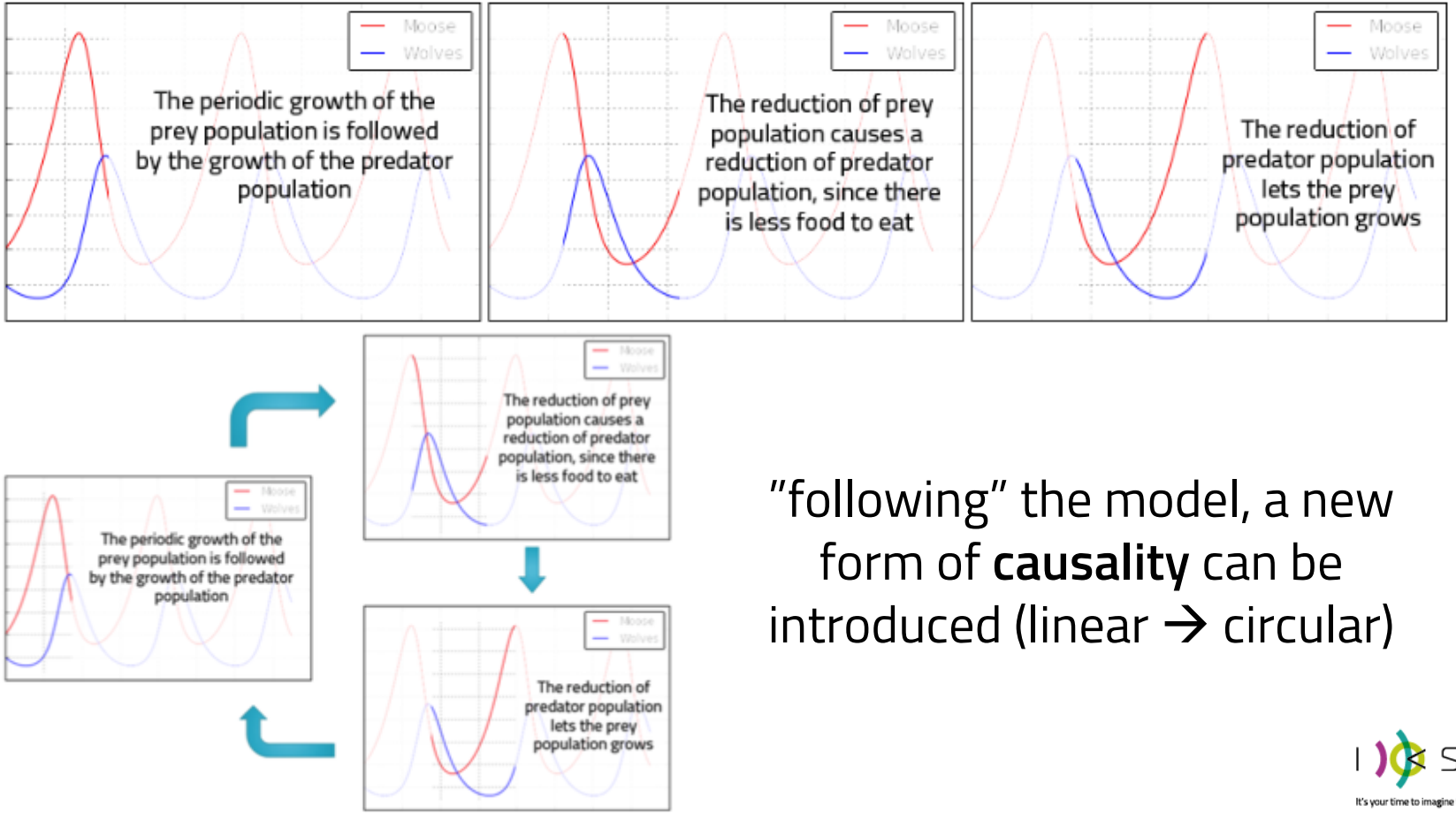
The Volterra-Lotka predator-prey model





http://www.phschool.com/atschool/phbio/active_art/predator_prey_simulation/

SEE
It's your time to imagine the futures



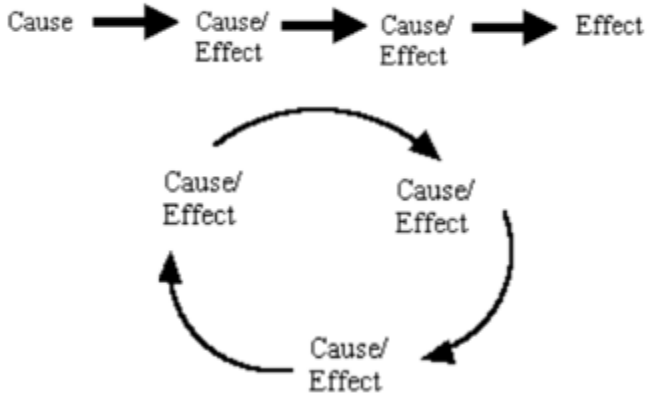
"following" the model, a new form of **causality** can be introduced (linear → circular)

ACTIVITY 1

- **Disciplinary content**: non-linearity between variables in a complex system
- **Context of application**: ecology
- **Form of presentation**: simulation that allows the students to "play" with the parameters of the model. Advanced version: simulazione che permette agli studenti di "giocare" con i parametri del modello. Versione avanzata: tutorial with a commented Pyhton script for the simulation.

Circulat causality and feedback

The last effect of the causal chain modifies (literally "feed-backs") the first cause from which the loop was originated, amplifying (*positive feedback*) or softening it (*negative feedback*)



ACTIVITY 2

A Ted-Ed lesson to introduce the concept of feedback and related examples in many contexts

mutual causal interaction

amplifying vs counteracting

ongoing process

essential force in the build up of ecosystems

feedback loops play together

stable balance

long term equilibrium

resilience

unexpected reactions

stabilizing effects

complex but harmonious

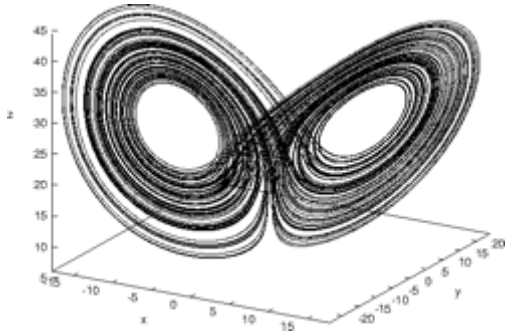
http://ed.ted.com/lessons/

ACTIVITY 2

- **Disciplinary content**: concepts of feedback and circular causality
- **Context of application**: ecology, climatology, economy, computer science
- **Form of presentation**: video-lesson, interactive test to assess the aquired knowledge, collective discussion to share other examples

Deterministic chaos

The sensitive dependence on initial conditions, typical of complex systems, determines a loss of predictability (although the systems are and remain deterministic)



ACTIVITY 3

From Lorenz' model to the Butterfly Effect

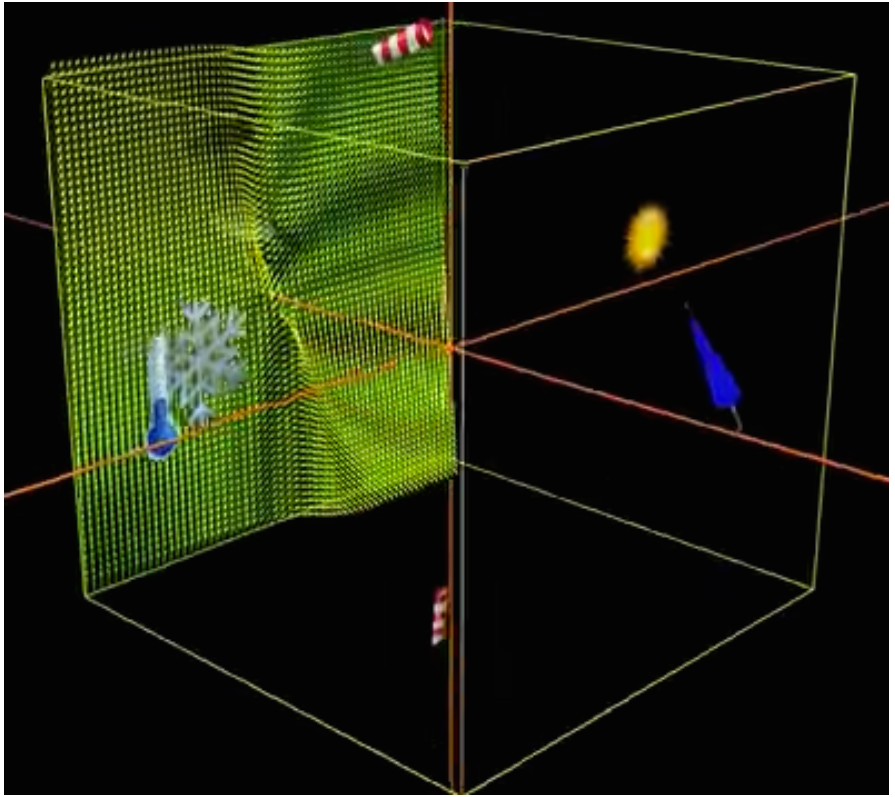
Non-linear equations with three variables (e.g. wind, temperature, rain) to describe the convection in a fluid

$$\Delta x = A\,(y - x)\,\Delta t$$

$$\Delta y = (Bx - xz - y)\,\Delta t$$

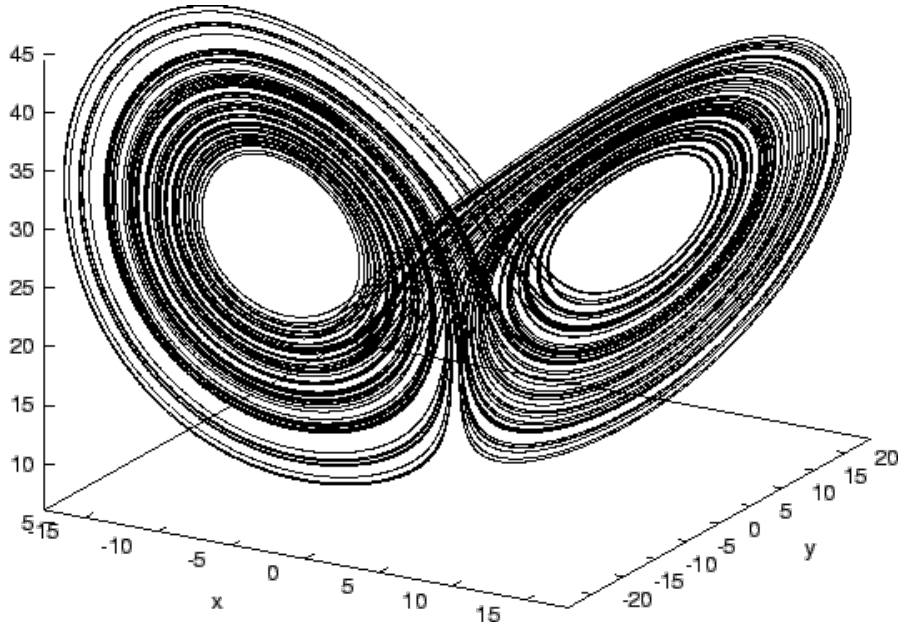
$$\Delta z = (xy - Cz)\,\Delta t$$

- Lorenz wanted to try on a calculator a model for long-term predictions. He introduces in two subsequent runs the same data but, in the first case, with 3 decimal digits, and in the second case with 6 ones
- Two very near states can evolve, after a period of simulated time, into very different states



https://youtu.be/wq9Hhhyqzzs?t=192

- The minimum variation of a factor produces a trajectory which is different from any other
- But these trajectiories are not random-distributed in space
- They are collected into objects with a defined shape: the so-called attractors of the system



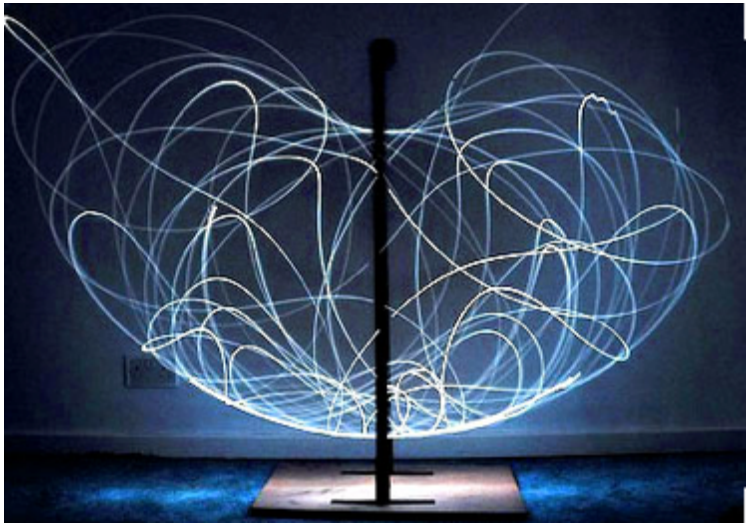
"Can a Butterfly in Brazil Really Cause a Tornado in Texas?"

ACTIVITY 3

- **Disciplinary content**: sensitive dependence of the model on initial conditions
- **Context of application**: meteorology
- **Form of presentation**: video that shows the run of a simulation with two different initial conditions

ACTIVITY 3bis

The double pendulum



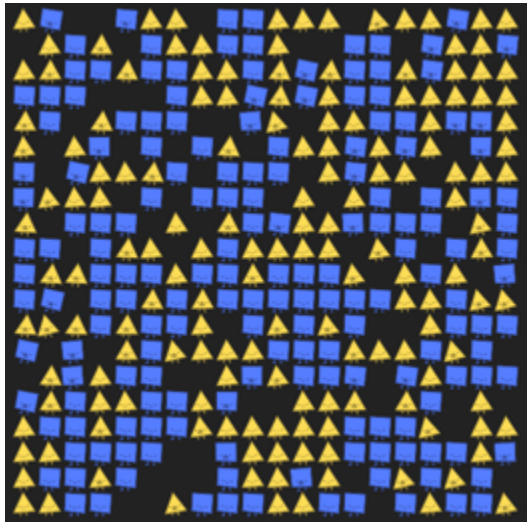
https://www.youtube.com/watch?v=RmF-efwE87s

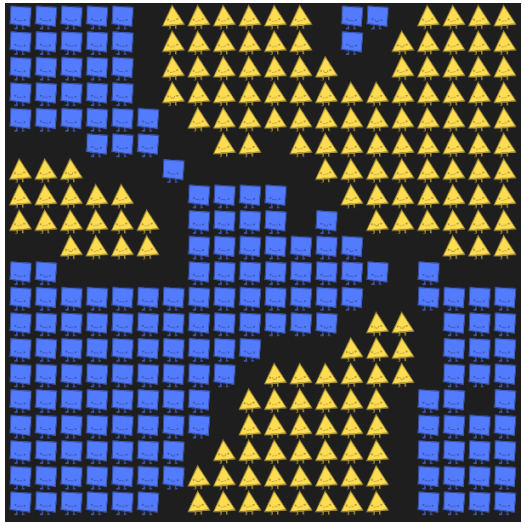
Emergent properties

A lot of complex systems show emergent properties, characterizing only the whole system. They raise from the self-organization of many micro components, each following very simple rules. Although these properties “emerge” from basic rules, they are not linearly ascribable to the components with a classical superposition principle of the effects.

ACTIVITY 4

The Schelling's model of segregation





A 2-dimensional environment is populated by two types of individuals. Simple rules of cohabitation result in scenarios of "segregation"

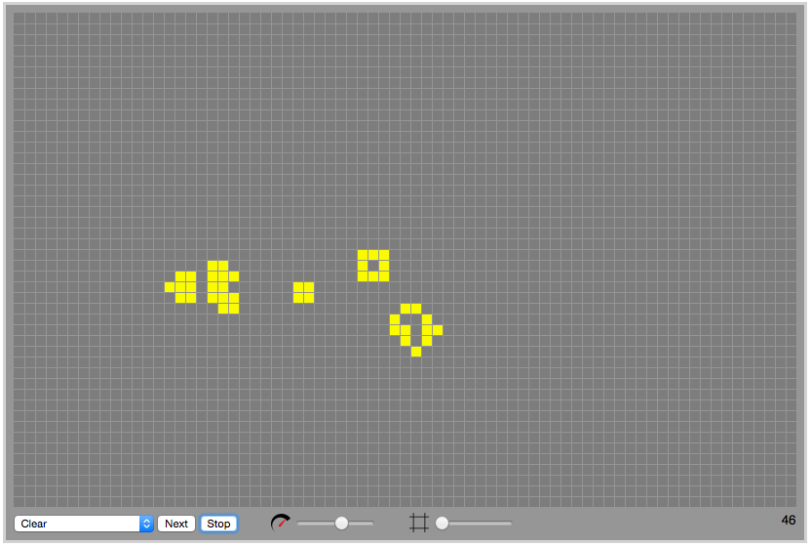
http://ncase.me/polygons/

ACTIVITY 4

- **Disciplinary content**: concept of self-organization of a complex system
- **Context of application**: social sciences
- **Form of presentation**: simulation integrated within a “playable post”

ACTIVITY 4bis

The “Game of Life”



The rules of micro-components in this model reproduce, in a simplified way, the behaviour of cells.

https://bitstorm.org/gameoflife/

- In these properties that characterize complex systems reside **new ways for talking about time** and for thinking about the future
- Uncertainty, probability, space of possibility become crucial concepts for the scientific disciplines
- Concepts that, from science, in-form other disciplines…

The future from science to social sciences

Futures Studies

A branch of social sciences that studies differents types of futures and the ways to

predict them → forecast

foresight ← hypothesize them

anticipate them → anticipation

Forecast → Foresight
Prediction → Projection

- **Univocal result** of the application of a model
- The “weather forecasts” in meteorology (even if, because of non-linearity, the predictions are reliable just on a limited period of time)

- **Fan of possibilities** as wide as many and various are the future scenarios and assets
- The different projections depend on the different hypotheses that are considered (e.g.: future socio-economical developments that could or could not be achieved)

SEE
It's your time to imagine the futures

The futures cone

"The Future is many, not one."

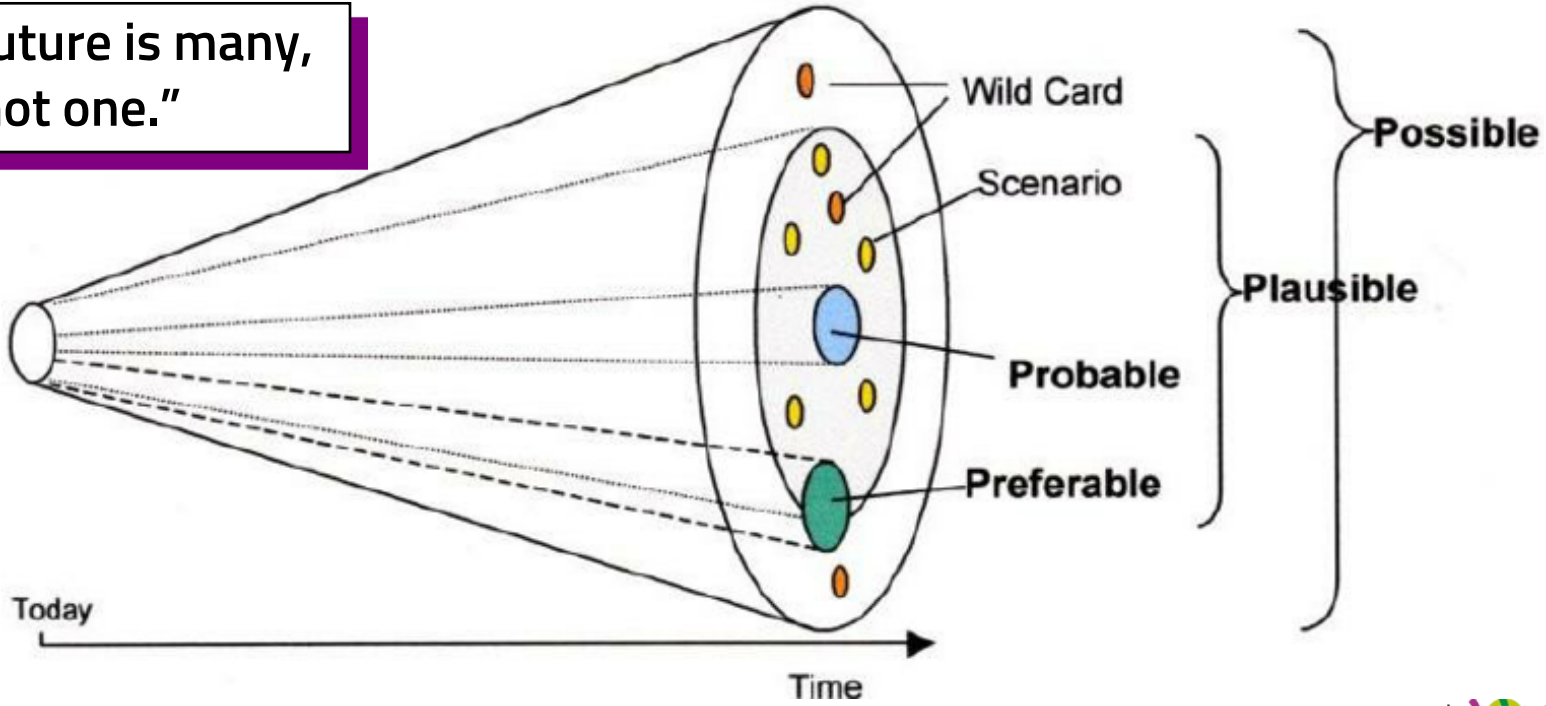
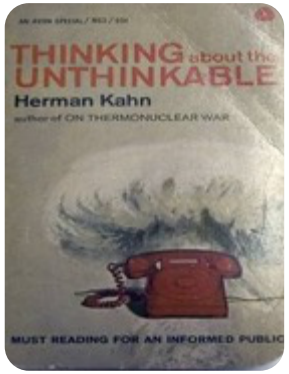


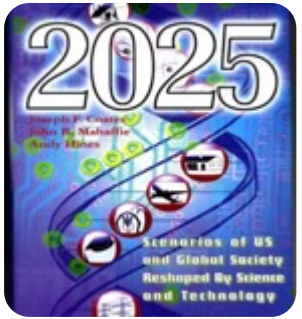
Image retrived by http://www.nesta.org.uk/blog/accuracy-and-ambition-why-do-we-try-predict-future
[Image credit: Ironing drone by Max Cougar Oswald & Nihir on the Noun Project via Creative Commons]

I SEE
It's your time to imagine the futures

Possible scenarios

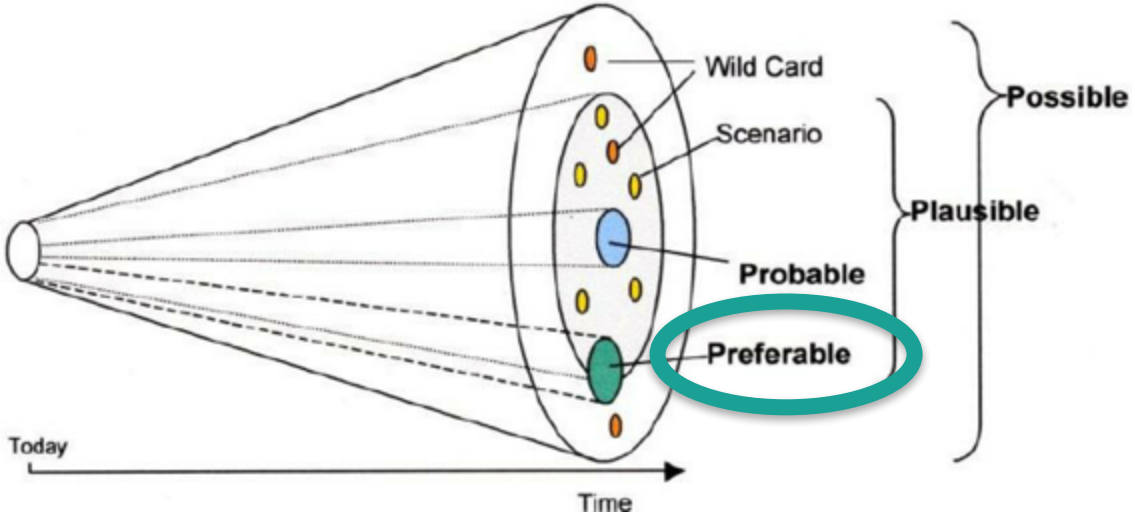
- A scenario can be defined as a **description of a possible future situation**, with the path of development (trends and **events**) that realizes that specific situation
- The scenarios do not want to give a complete description of the future, but to highlight the central elements of a possible future, focusing of the **key factors** that will probably orient the future developments
- The goal of sceanarios is **NOT** to **predict** the future!





It's your time to imagine the futures

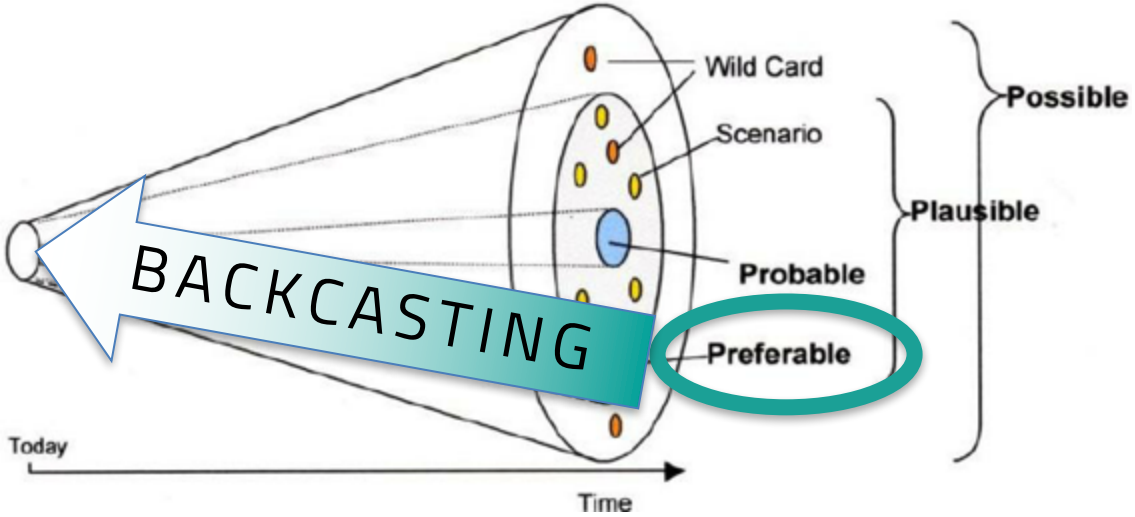
Foresight → Anticipation



Not only probable, plausible and possible futures…

the desirable futures

Foresight → Anticipation

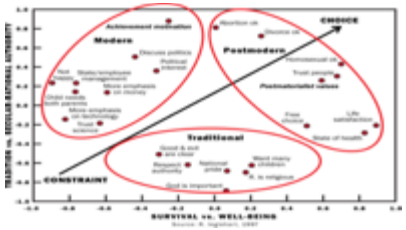


Once defined the desirable future, one goes back to identify policies, programs, actions that bring from that future to the present

Drivers and Values

Empowered Individuals

Scaling Up Green



Post-Materialist Models

Enoughness

Localization

Sharing

Living within Limits

Integration of Virtual & Real

New Metrics for Success

Appropriateness

Authenticity

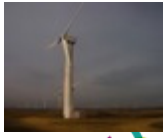
Community

Experiences

Smartness

Spirituality

Simplicity



Sustainability

It's your time to imagine the futures

ACTIVITIES THAT FOLLOW

Thinking about **cities** (present and ideal ones) as a way to analyse the present, to think the future, to imagine it, to desire and to act creatively

Thank you for your attention!

The project is co-funded by the Erasmus+ Programme of the European Union. Grant Agreement n° 2016-1-IT02-KA201-024373.

It's your time to imagine the futures