

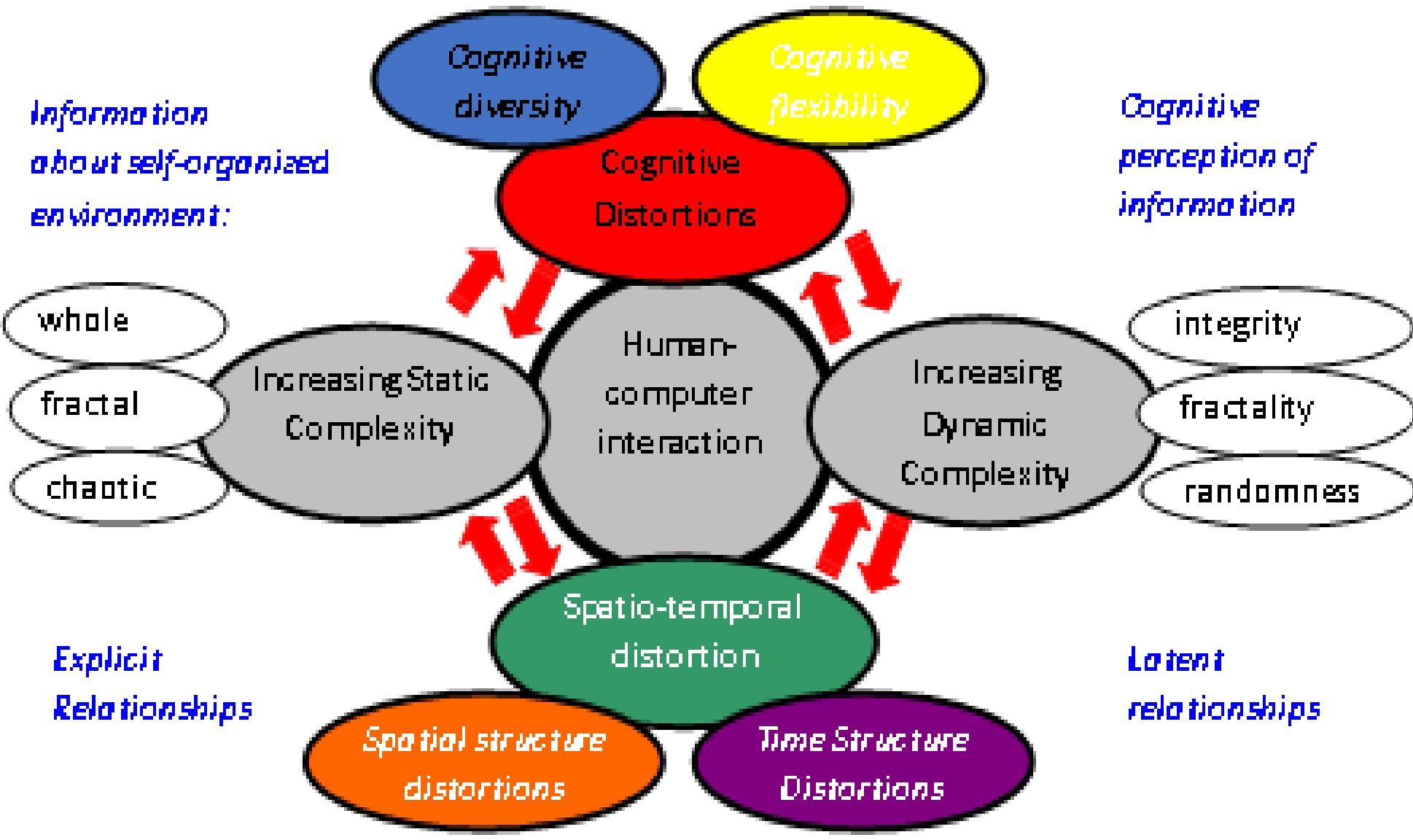
CONVERGENT APPROACH TO DYNAMIC SYSTEMS SAFETY – COGNITIVE ASPECTS

O. Illiashenko (1), V. Mygal (2), G. Mygal (3), O. Protasenko

(1-3) National Aerospace University “Kharkiv Aviation Institute”, 61074, Kharkiv, Ukraine

(2) Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine

DYNAMIC AND STATISTICAL COMPLEXITY



The complexity of model synthesis increases structural complexity, which slows down:

- selection of relevant sources of information
- identification and classification of states,
- decision making in real time.

Complexity is a universal concept for the safety of dynamic systems

DUALITY OF DESTABILIZING FACTORS

- variety of local signal distortions,
- dynamic and statistical complexity,
- a harbinger of irreversible states, instabilities, etc.

Destabilizing factors

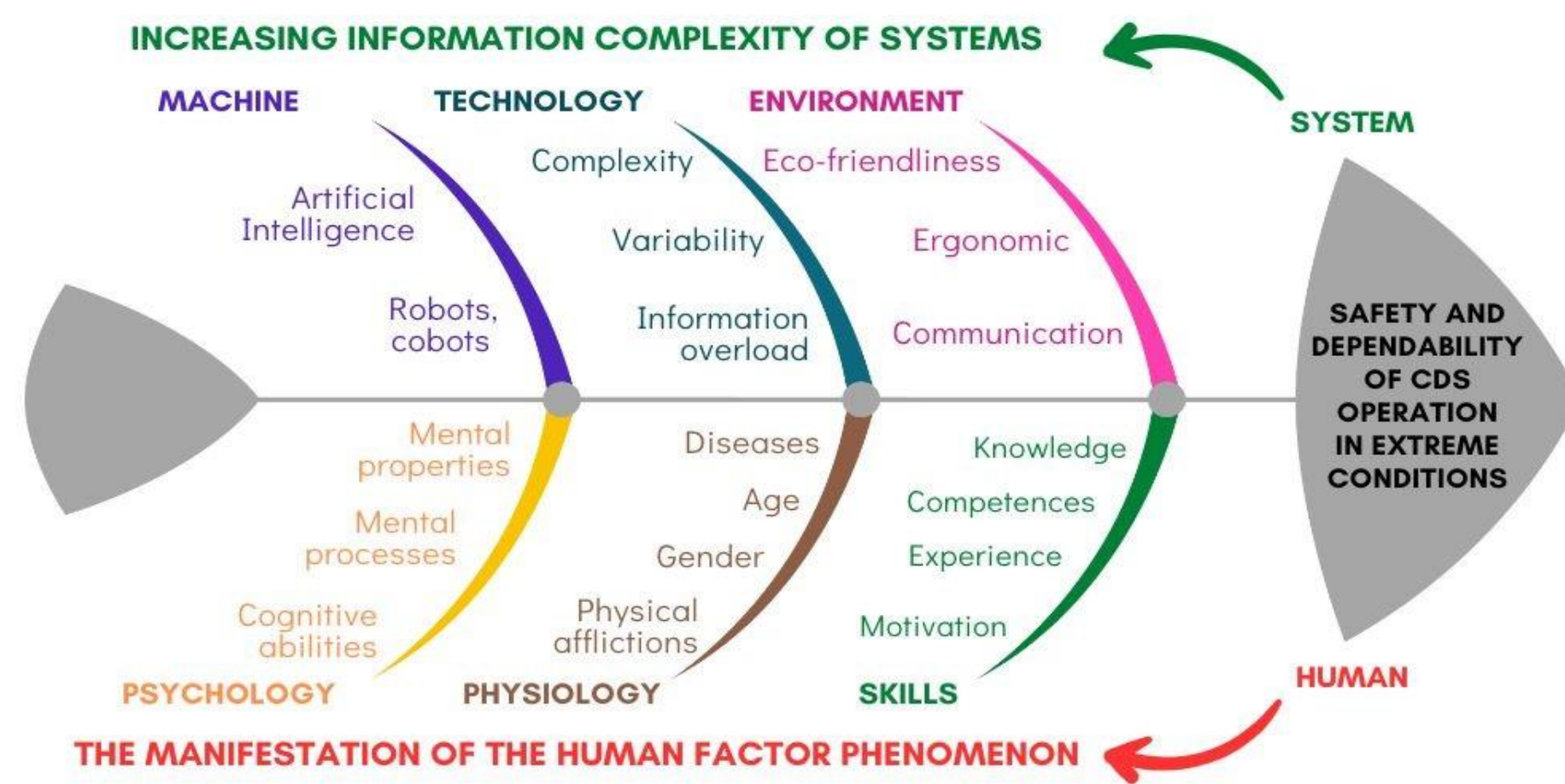
On the one hand, they limit the possibilities:

- modeling,
- forecasting,
- quick decisions
- identification
- classification of transition states.

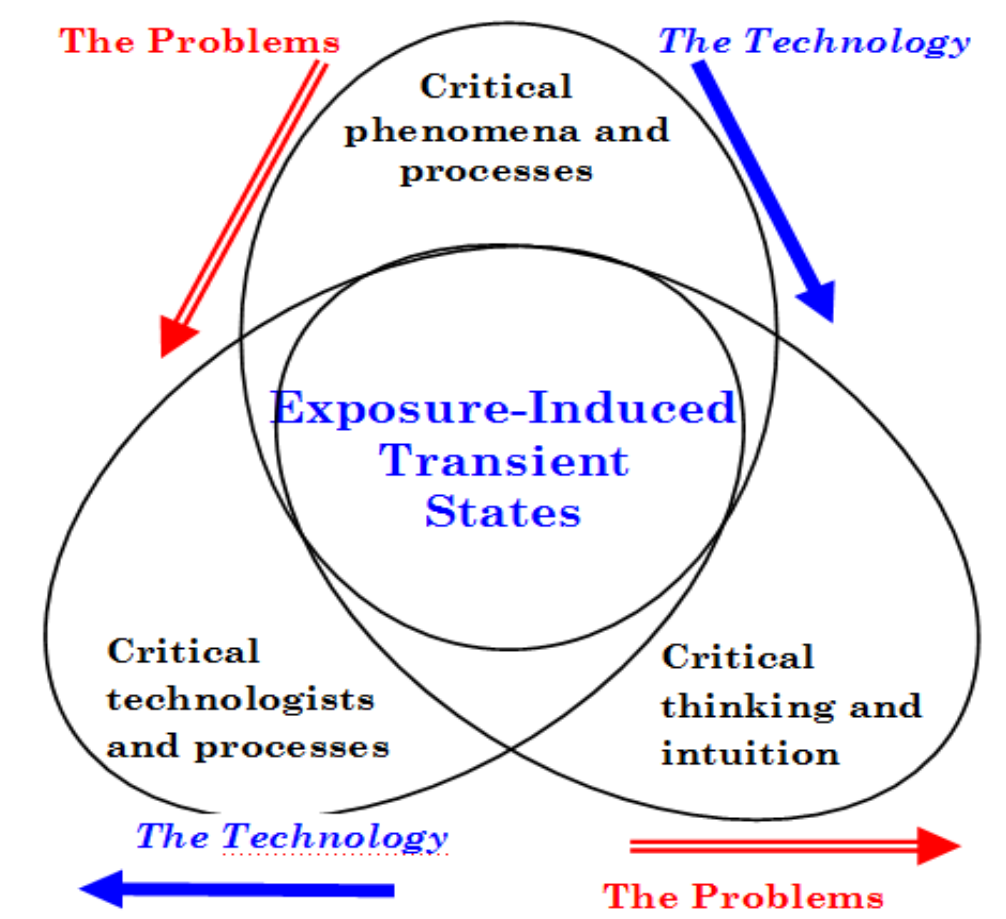
On the other side,

- they induce a rearrangement of signature configurations that defines individuality.
- It displays the change in dynamic parameter relationships.

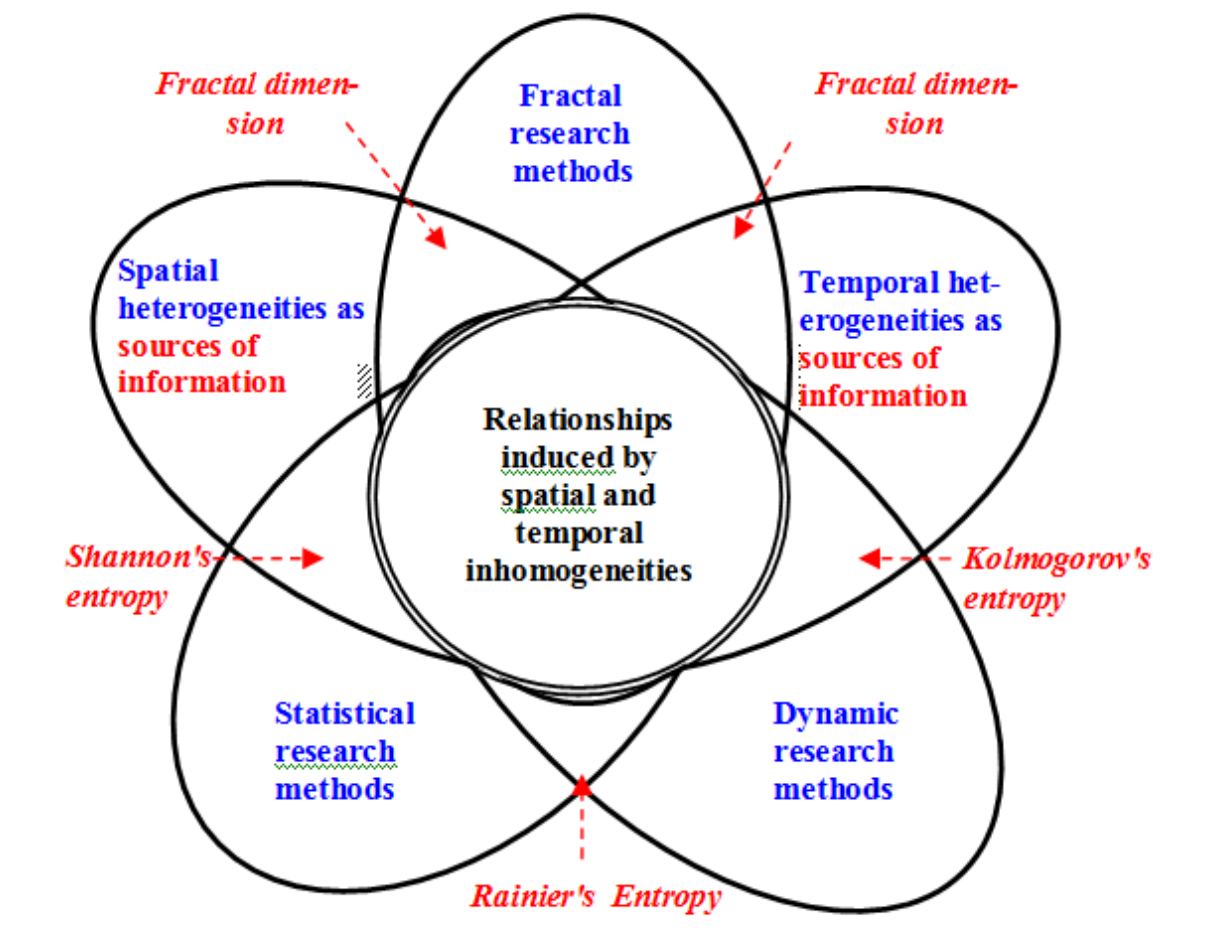
The goal is a convergent approach to visualizing the functioning of dynamic systems using topological 3D models



SELF-ORGANIZED CRITICALITY NEW TECHNOLOGIES AND CHALLENGES:



Statistical complexity induced by spatial and temporal inhomogeneities



Local distortions - universal sources of information

DYNAMIC EVENT SPACE

- Unification follows from:
- theory of dimensions and dynamic similarity,
 - variational principles of dynamics,
 - methodology of dynamic balance (equilibrium)

- Unique opportunities due to:
- the relationship of dynamic parameters,
 - geometric and energy interpretation of the formulations of the principle of least action,
 - natural decomposition into conjugate components of the dynamic system structure.

The complementarity of signatures simplifies the analysis and synthesis of models, and the phase portrait is a simplified model of the 1st order signature

Phase portrait

COMMON

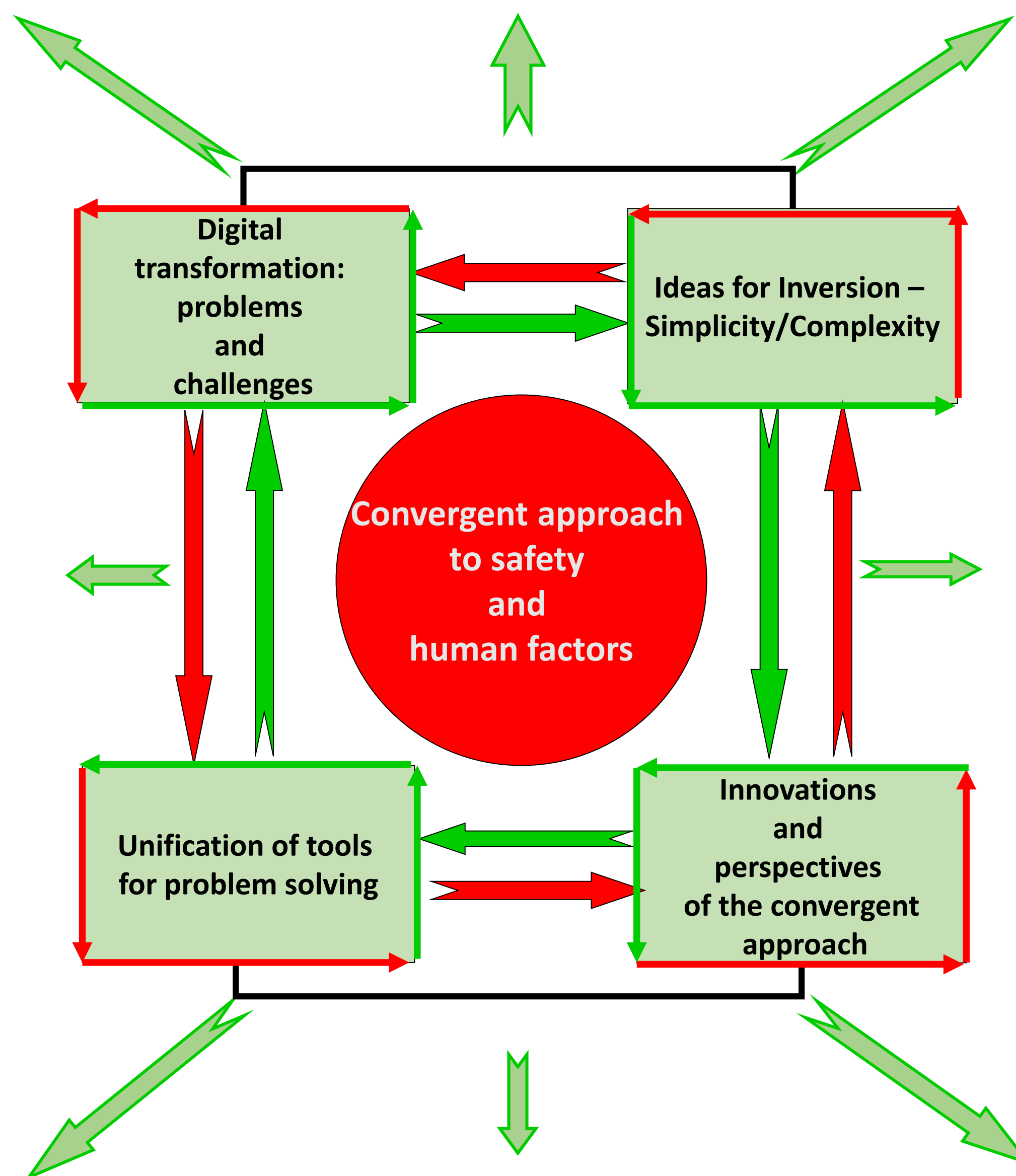
3D model and 3 patterns

Visualization of statics, dynamics, symmetry

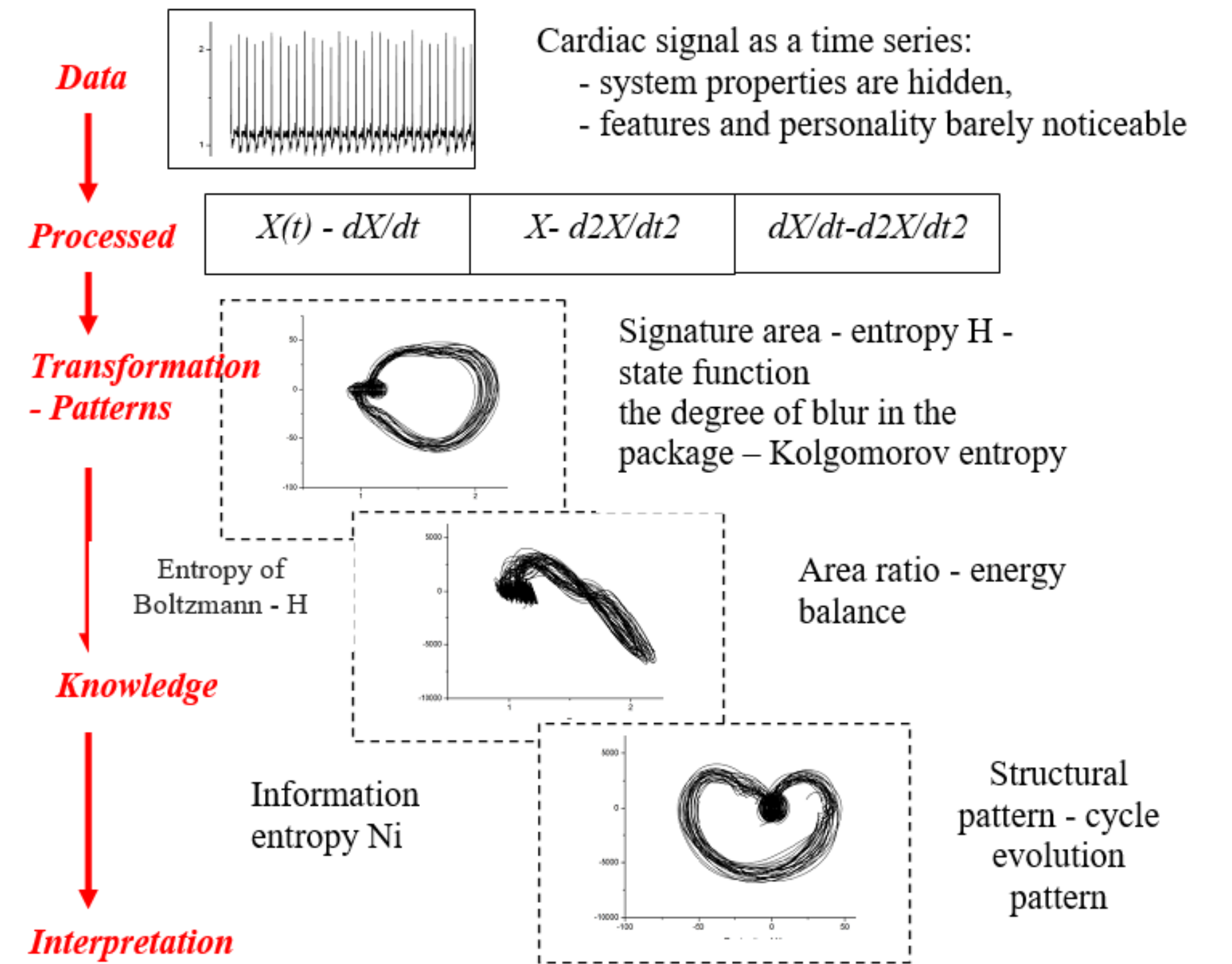
DIFFERENT

A topological 3D model and three cardiocycle patterns. Patterns display the relationship of the components of the cycle and the power of the subsets of microstates

3D - visualization of the dynamic structure at the heart of the convergent approach



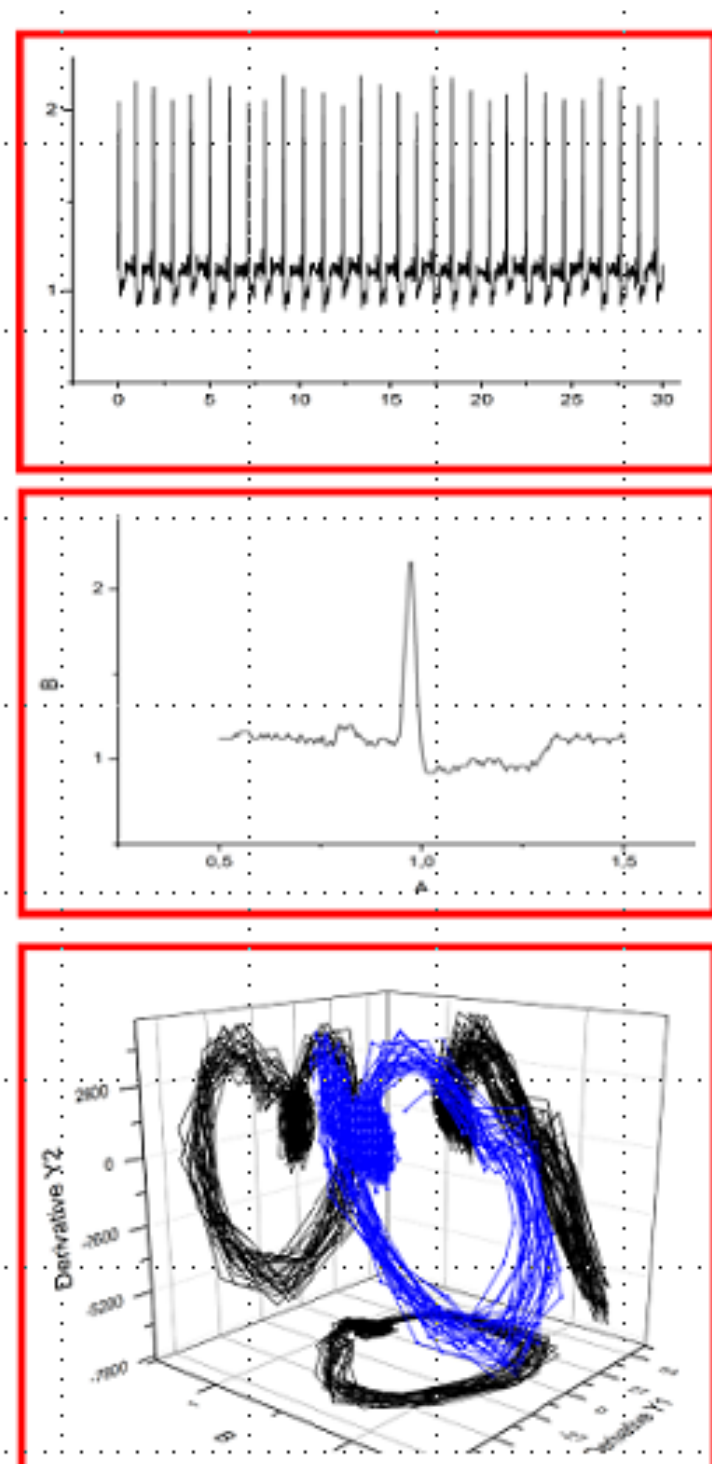
STRUCTURE RESTRUCTURING VISUALIZATION ALGORITHM



The nature of local changes in a quasi-periodic cardiosignal reflects the packet representation of its spatiotemporal signatures.

A measure of the complexity of a dynamic system is the topological entropy, which reflects the nature of the restructuring of the signature configuration in the package.

CARDIAC SIGNAL, PHASE PORTRAIT AND TOPOLOGICAL 3D MODEL OF FUNCTIONING



300 cardiocycles V (t) for analysis heart rate variability

Cardiocycle V (t) - analysis of parameters

3D - model and structural and entropy analysis of three signature packages

In the cognitive space, the phase portrait as a sequence of dynamic states is a simplified model of the 1st order signature.

The 2nd order signature configurations reflect the interconnections of the conjugate components of the functioning cycle and the power of their subsets.

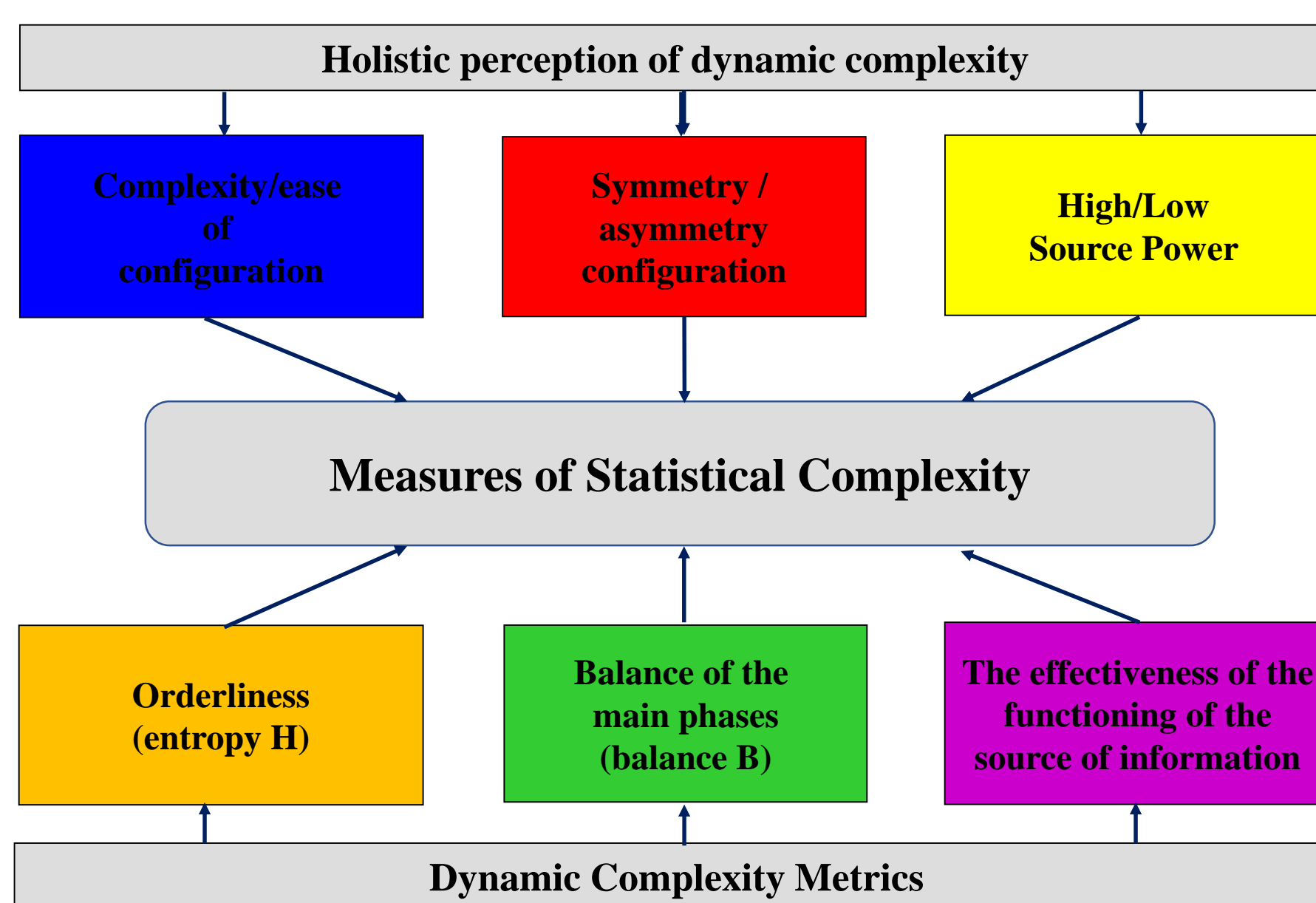
The basis of the convergent approach to safety is the visualization of processes of different nature and scale in the cognitive space

SIMPLICITY OF COMPLEXITY OF DYNAMIC STRUCTURE: UNIVERSAL, MULTIFACETED AND HEURISTIC

- Heuristic is due to:
- morphologically different dynamic systems are functionally subject to the same principles of physics and biomimicry,
 - different dynamic systems operate according to the same laws and obey the principle of detailed balance,
 - the reconstruction of the time series into a 3D model is accompanied by a natural decomposition into conjugate components.

Universal markers of a topological 3D model of a time series of various nature are:

- dynamic symmetry/asymmetry,
- trajectory density:
- homogeneous / heterogeneous,
- big/small
- discrete / continuous,
- source power change.



INDUCED SOURCES OF INFORMATION

Perspectives

External and internal stress factors create local distortions in information flows of different nature, which are induced sources of information. They create systemic security problems, for which we develop:

- cognitive modeling based on a transdisciplinary approach,
- unified tools for processing information flows of different nature,
- visualization of the dynamic structure of the time series and integrative markers.

Modeling is based on the visualization of the spatio-temporal structure of information sources of various nature in the cognitive space. The transformation of a fractal signal into a topological 3D model of functioning and its spatiotemporal signatures allows:

- evaluate complexity by the degree of order,
- degree of energy balance using probabilistic research methods.
- predict using deterministic research methods,

The application of the convergent approach and means for its implementation to sources of information of different nature (EMR sensors, radiation and acoustic radiation), as well as the characteristics of the PFS of the human body (EEG, EOG, etc.) demonstrate the advantages and new opportunities for revealing hidden spatio-temporal relationships, which determine the safety of the functioning of dynamic systems in difficult conditions. An atlas of such models will simplify the intelligent choice of an effective solution

The innovative potential of the approach, tools and atlas of models includes:

- cognitive visualization and meta,
- new opportunities for human-computer interaction in teaching,
- design and testing of new DS.

This will increase the safety of the functioning of complex dynamic systems, including the functioning of the human body.