

Directed Evolution (DE) as a Thinking Method for an Informational Civilization

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Alvin Toffler's Waves

- Agricultural - began about 10,000 years ago
- Industrial - began about 300 years ago
- Informational - began in the mid-20th century



Alvin Toffler's Waves.

The Main Features

- Type of production (individual, mass, etc.)
- Type of resources utilized (natural, renewable, non-renewable, etc.)
- Type of information accumulation and transfer
- Type of education (individual, mass, degree of children participation in adults' life, etc.)
- Main conflicts
- Type of provision (self-provision, based on division of labor, etc.)
- Population density and life arrangement (small communities, large cities, etc.)
- Type of mentality (based on traditions, laws, etc.)
- Relationships with the natural environment
- System of ruling people (countries)



The Main Features of the Third Wave

- Combination of mass and individual production
- Emergence of “smart” equipment
- Enormous diversification of products, services to meet requirements of smaller groups of consumers
- Non-renewable resources saving technologies
- Quest for harmony with nature
- Increased scale of danger of wrongful actions of humans
- Enormous amount of information and new technologies for information and knowledge management
- Systemic approach
- Weakening of nuclear family
- De-urbanization
- Combination of individual and standard approaches to education, legal, political and other aspects of life



Transition: Future Shock

- Alvin Toffler warned us that the current transition to the Third Wave might be as painful (or even worse) as the transition from the First Wave to the Second one (Future Shock).
- TRIZ and its application Directed Evolution™ can help make this transition smooth and controllable

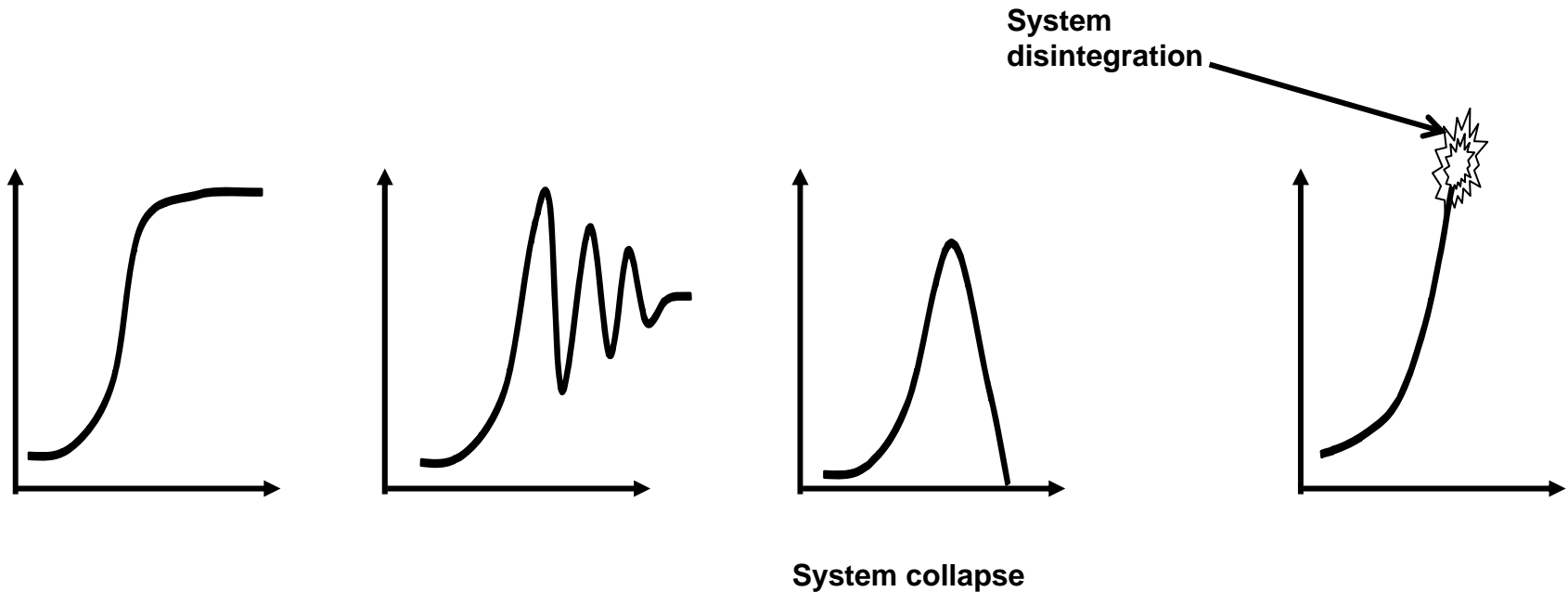


Controlling the Future

- Control of the future means control of:
 - personal life
 - business
 - society



Possible scenarios of evolution



Evolution of Humanity - a Series of Informational revolutions

- The first revolution - invention of language
- The second revolution - invention of written language
- The third revolution - invention of printing
- The fourth revolution - mass production of books, magazines; telecommunication
- The fifth, upcoming revolution - implementation of informational technologies



The Fifth Informational Revolution - What to Expect?

- Changes in the way we live, work, and do business (eCommerce)
- Possible emergence and spreading of dangerous social theories, religions and/or superstitions
- Perfusion of dangerous knowledge
- Possibility of socially dangerous associations (such as terrorist organizations)
- Disruption of privacy
- Damage to countries lacking effective access to information
- Degradation of languages (other than English)



Assumptions

- Whatever a genius (or a group of people) can do as the result of talent, luck, intuition, etc., an average human (group) can do even better with effective, convenient tools.
- *It is time to make evolution manageable*, rather than continue with the uncontrollable (i.e., haphazard) evolution of humanity driven by numerous random historical events and the actions of outstanding leaders.
- The ability to control our own lives, businesses, and the survival of humanity *depends on on the development of appropriate tools*.



Managing the Future and Creativity

- The essence of management is the making of numerous decisions
- Complex situations are always ill-defined situations requiring the analysis of possible variants, the adaptation of these variants, or the invention of new ones
- Management of the Future is inseparable from management of Creativity



Methods of Managing the Future and Creativity

Model of the Wave	Method of managing the future	Creativity methods
1 – “cycle”	No management	Trial-and-Error Method (TEM)
2 – “railroad”	Strategic planning	TEM plus methods of psychological activation
3 – “car race”	Directed Evolution™	TRIZ plus methods of psychological activation



Assumption

- Creativity is the most important component in any human activity during the Third Wave era.
- It becomes necessary for a country, corporation or individual to plan and control its own destiny and ultimate survival.
- The deficit of creativity will become the main obstacle to progress, and therefore *enhanced creative methods should be the main tools for managing evolution.*



TRIZ - a Knowledge-based Approach to Creativity

- The emergence and implementation of innovation is not random or haphazard, but rather are dictated by certain general evolutionary patterns governing the creation of artificial systems
- These patterns can be revealed through study of the history of innovation in various areas, including technology, the arts, social life, etc. and applied to predict possible evolutionary “paths”
- TRIZ-based creativity can be taught to any individual, allowing solving complex creative problems quickly and confidently



DE Roots: The Forecasting of Technology

- Technological Forecasting (1950's)
 - Utilizes probabilistic modeling of future characteristics of various systems
- TRIZ Forecasting (1970's)
 - Utilizes selected TRIZ-based tools to generate an idea(s) helpful for the next product or process generation
- Directed Evolution™(1990's)
 - Utilizes extended set of Patterns/Lines of Evolution to generate an exhaustive set of potential scenarios of system evolution



What Questions Do They Answer?

- Traditional Technological Forecasting
 - What is going to happen with my product or process parameters?
- TRIZ (technological) Forecasting
 - What change(s) should be made to move my product or process to the next position on a specific pre-determined Line of Evolution?
- Directed Evolution™
 - Which scenario of evolution should be selected from an identified comprehensive set of scenarios to make it a winner?



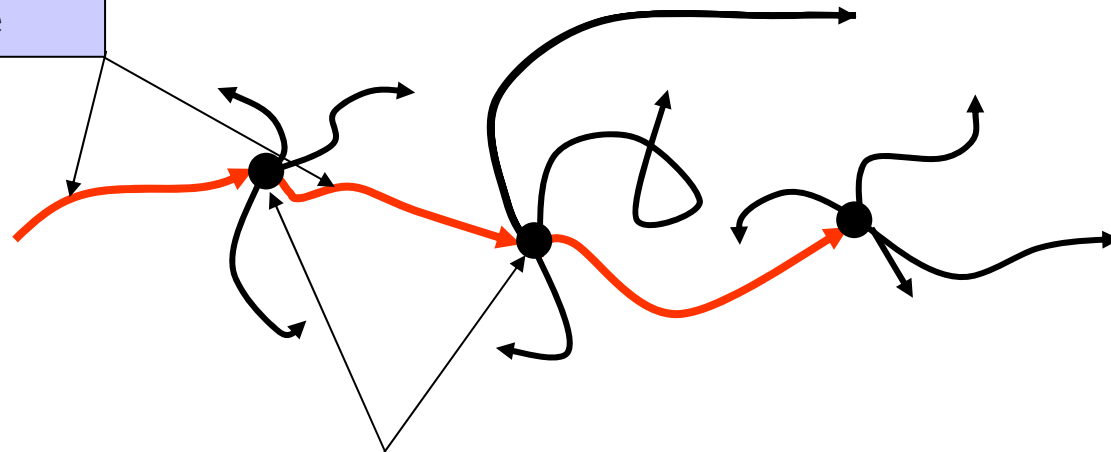
Directed Evolution™

- An application of the Ideation/TRIZ Methodology
- Systematic process to predict the future generation of a system by inventing it
- A systematic approach targeting the identification of a comprehensive set of potential scenarios of evolution of:
 - Products/Services/Processes
 - Technology
 - Organization
 - Industry
 - Market



Evolution, Prediction and Control

Realized trajectory:
Easy to predict
Difficult to influence



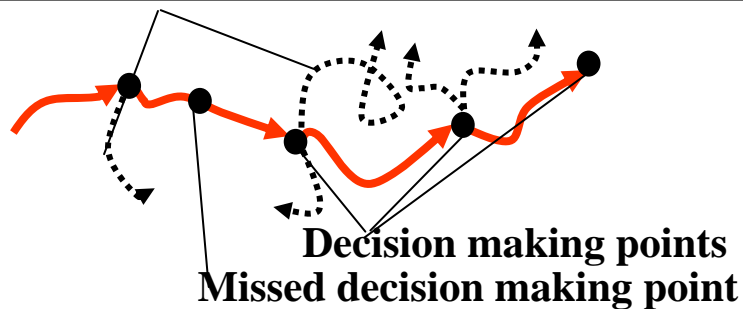
Bifurcation (branching) point
Easy to influence
Difficult to predict

The Essence of Directed Evolution

- It is possible to control evolution through influencing the system at crisis points.
- For this objective, it is very important to identify all possible crisis points and all possible alternative directions at every point

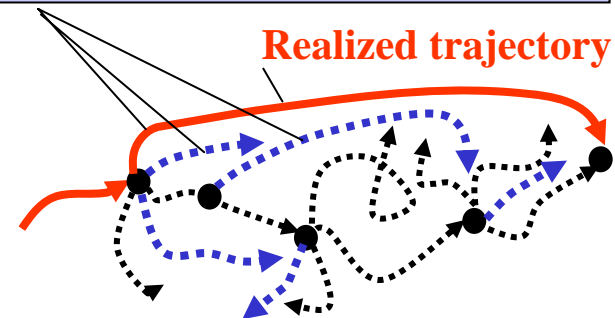
Usual process of decision making

Obvious alternatives for decision



DE based process of decision making

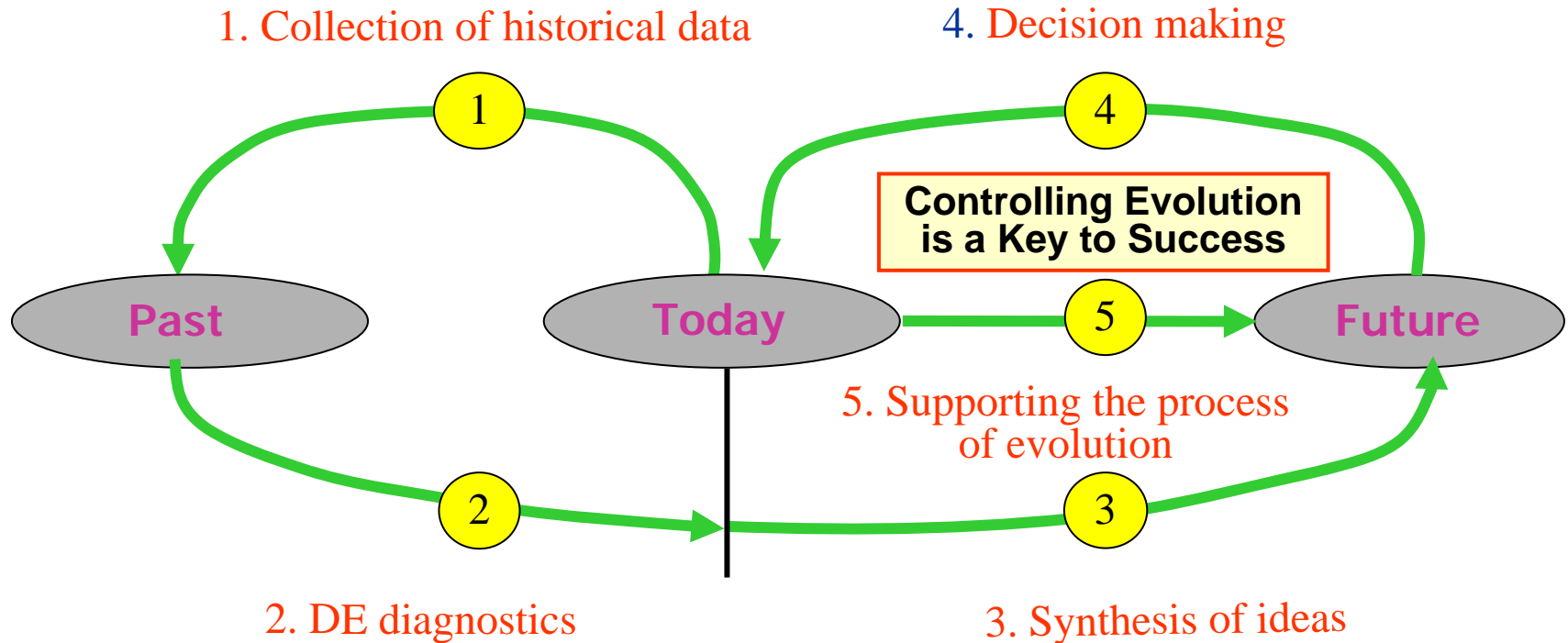
Creative Alternatives for decision



General Schema of Directed Evolution

Today is a Key to Understanding the Past (History)

Understanding the Future is a Key to Controlling Evolution



The Past is a Key to Understanding the Future



DE Process

- DE process includes 5 basic steps with multiple sub-steps and can vary depending on the following factors/conditions:
 - Project size
 - Area
 - Age and nature of the DE object
 - Marketing and/or technological position and objectives
 - Availability and accessibility of information
 - Current marketing situation
 - Situation with intellectual property



Stage 1. Collection of Historical Data

- Main objectives:
 - Accumulate data for further work
 - Reveal positive and negative trends in the given system's evolution
- Work completed - learning about:
 - System structure and operation
 - Problems and contradictions related to the system and its production
 - System environment and resources
 - History of ideas
 - Market situation

Stage 2. DE Diagnostics

- Main objectives:
 - Identify possible directions for evolution
 - Formulate all problems that should be addressed for this evolution to be successfully realized
- Work completed:
 - Mapping of historical data and positioning the given system on the patterns/lines of evolution
 - Identifying missing and future steps on evolutionary lines
 - Extrapolating lines of evolution for the given system into the future



Stage 3. Synthesis of Ideas

- Main objectives:
 - Generating ideas that will move the system to the next evolutionary step
- Work completed:
 - Analysis of all ideas obtained on previous stages
 - Problem solving



Stage 4. Decision Making

- Main objectives:
 - Prepare all necessary materials for making decisions regarding the direction(s) of evolution of the given system
- Work completed:
 - Concept development
 - Building potential evolutionary scenarios
 - Introducing necessary corrections required to avoid potential problems (Failure prediction)

Stage 5. Supporting the Process of Evolution

- Main objectives:
 - Ensure continuous evolutionary process
 - Predict and monitor various changes in the system environment that could cause deviations from the planned scenario
 - Solve new problems and make necessary corrections of scenario(s)

DE Tools and Techniques

- DE Questionnaire
- Problem Formulation
- Analysis of evolutionary resources
- Analysis of basic trends and needs
- S-curve analysis
- Patterns/Lines of evolution
- DE Failure analysis
- DE Failure Prediction
- Ideation Process for Inventive Problem solving (IPS)
- Ideation Brainstorming



DE Questionnaire

- The DE Questionnaire is based on TRIZ System Approach and is designed for the following purpose:
 - Collect and document information about the given system and its environment
 - Identify and fill the gaps in our knowledge about the system and its environment
 - Initiate the thinking process from the perspective of the patterns of evolution
 - Reduce psychological inertia

Problem Formulation

- An analytical technique/tool based on System Approach
- Helps transform complex and net-like information into a well-organized cause-effect knowledge map (net)
- Allows transformation of the map into an exhaustive set of specific directions for innovation
- Can be completed manually or with the Problem Formulator™ software tool



Analysis of Evolutionary Resources

- Helps to unveil various resources (often hidden) that can be utilized for inventing new generations of the system
- Involves work with various check lists of resources including:
 - Technical resources (substances, energy, functional, informational, time, space, etc.)
 - Human resources including people that are going to support the DE process from the top down and from the bottom up
 - Available financial resources
 - Other business assets



Analysis of Basic Trends and Needs

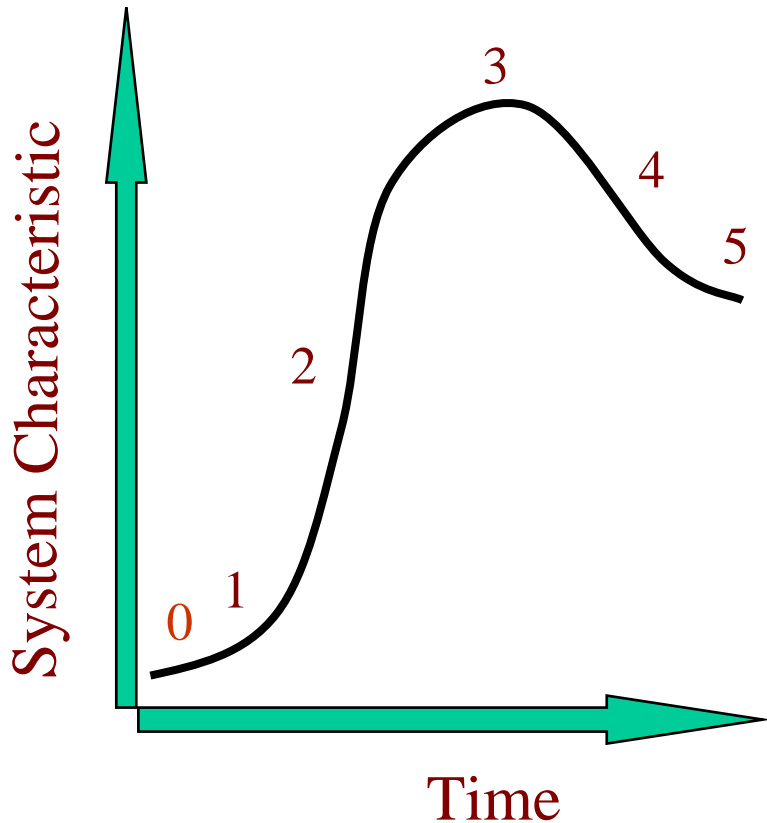
- Helps identify impeding and driving forces of the given system evolution including:
 - Technical, economical, psychological, environmental, safety, etc. limitations
 - Various demands and challenges including marketing, super-systems, innovation, etc.



S-curve Analysis

- Based on the extended (i.e., composed of six main stages) S-curve
- Targets the identification of the system's evolutionary position
- Allows develop a strategy for evolution depending on the system's position identified

Stages of System Evolution



Stage 0 - a system does not yet exist but important conditions for its emergence are developing

Stage 1 - a new system appears due to a high-level invention and begins developing slowly

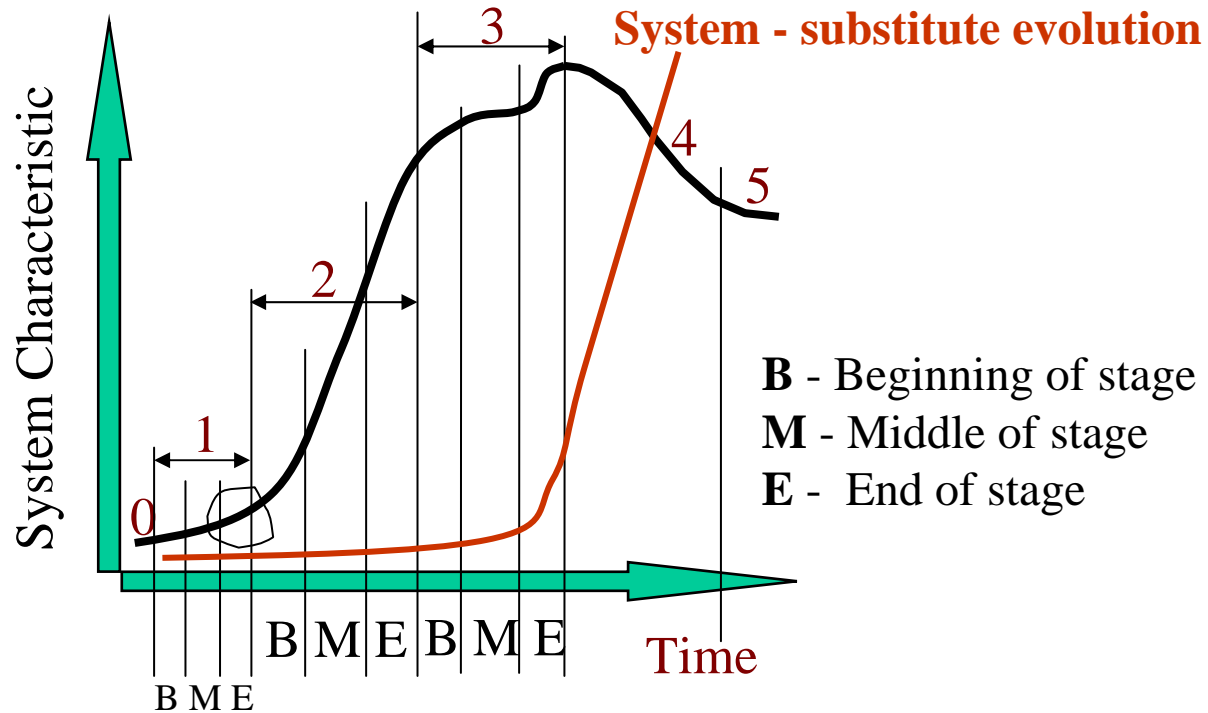
Stage 2 - begins when society recognizes the value of the new system

Stage 3 - begins when the resources on which the original system is based are mostly exhausted

Stage 4 - begins when a new system (or the next generation of the current system) emerges to replace the existing one

Stage 5 - begins if the new system does not completely replaced the existing system, which still has limited application

S-curve analysis



Organization feature matrix (fragment)

Feature of an Enterprise	Stage 1: Start-Up	Stage 2: Growth	Stage 3: Maturity / Stagnation	Stage 4: Contrived Dynamic Prosperity
Goals of the organization	Develop the business; create a market	Develop the business; increase and develop the market and the organization itself	Survive as an organization. Bureaucratic or monopolistic organizations: continue to develop the organization	Continue to develop the business; increase and develop the market
Factors stimulating business development	Personal motivations of those involved in the business	Personal motivations of organization personnel; public demand	Public demand	Personal motivations of organization personnel; public demand
Factors impeding business development	Lack of resources; no market in place	Unable to quickly utilize resources, much time spent searching for new ideas using Trial-and-Error method	Resources of the business are exhausted. The organization is interested in stability rather than change	Inherent resources in product/service under development and/or market demand are exhausted
Organization size	Fewer than fifty people	50 - 1000 and growing	Practically unlimited	Practically unlimited

S-curve Analysis. Main Sub-steps

- Building S-curves for the main system parameters
- Building S-curves for influential sub-systems
- Evaluating the system position based on number of patents, citations, organizational features, lines of evolution of the applicable market
- Checking for the main mistakes typical for the given stage of evolution
- Identifying correct directions for development
- Revealing “bottlenecks” - i.e. sub-systems that force the system into the maturity

Patterns/Lines of Evolution

- Stages of evolution
- Evolution towards increased Ideality
- Evolution towards increased involvement of resources
- Non-uniform development of system elements
- Evolution towards increased dynamism and controllability
- Evolution towards increased complexity followed by simplification (reduction)
- Evolution with matching and mismatching elements
- Evolution towards micro-levels
- Evolution towards increased use of fields
- Evolution towards decreased human involvement

Stages of Evolution

- Identify the stage (or sub-stage) in which your system resides
- Get familiar with typical business objectives for the current stage (or sub-stage)
- Learn about mistakes (traps) typical for the current stage (or sub-stage)
- Formulate strategic objectives for the system's development



Evolution toward Increased Ideality

- Increase the number of useful functions
- Improve the quality (and other parameters) of the useful functions
- Reduce the number of harmful functions
- Reduce the magnitude of harmful parameters
- Combine the above



Evolution toward Increased Involvement of Resources

- Look for resources readily available in the system or/and its environment, including:
 - Substances, fields, functions, information, space, time, changes
- Consider the following ways to modify existing resources for better utilization:
 - Accumulation of resources
 - Concentration of resources
 - Combination of resources
 - Physical or/and chemical transformation of resources



Non-uniform Development of System Elements

- Different System elements (sub-systems) evolve at their own pace resulting in contradictions
- Formulate contradiction for your system using recommended templates
- Consider resolving formulated contradictions by applying Separation Principles (in time, in space, etc.)



Evolution toward Increased Dynamism

- Decrease the degree of stability
- Convert stationary condition into a mobile one
- Divide a system into mobile parts
- Introduce a mobile object
- Apply various physical and chemical effects

Evolution toward Increased Controllability

- Introduce a control field
- Introduce a controllable additive
- Introduce a controllable anti-process
- Provide self-control of the system
- Introduce negative or positive feedback



Evolution toward Increased Complexity followed by Simplification

- Build a bi- or poly-system:
 - From homogeneous elements
 - From “compensating” elements
 - From systems with shifted characteristics
 - From competing systems
 - From antagonistic systems
 - By combining competing systems that are in different evolutionary stages (“towing”)
 - Utilizing the binary principle
 - Creating a dynamic bi-system



Evolution toward Increased Complexity followed by Simplification

- Simplify resulting bi- or poly-system using the following recommendations:
 - Apply disposable objects
 - Apply a model or copy
 - Make an object dismountable
 - Change the principle of operation
 - Apply specialization
 - Use more highly integrated subsystems
 - Exclude auxiliary functions
 - Exclude duplicate elements
 - Utilize self-service
 - Consolidate discrete subsystems



Evolution with Matching and Mismatching Elements

The following parameters should be matched or mismatched:

- System structure
- Materials
- Physical state
- Chemical properties
- Temperature
- Dimensions
- Weight
- Strength
- Reliability
- Rhythms of operation
- Electric or other resistance
- Magnetic properties
- Colors
- Other



Evolution with Matching and Mismatching Elements

- Consider matching various system parameters for the purpose of improving functionality. Make the parameters equal, proportional or mutually dependable
- Consider the intentional mismatching of various parameters for the purpose of:
 - Eliminating harmful effects
 - Making the system parameters controllable (changeable depending on condition)

Evolution toward Micro-levels

- Consider utilizing deeper structural levels or combinations of these levels, using:
 - System made of elements with specific shapes
 - Poly-system made of elements with simple shapes
 - Poly-system of small elements (powder, micro-spheres, granules, drops, etc.)
 - Effects associated with substance structure (super-molecular or crystal level)
 - Molecular phenomena
 - Atomic phenomena
 - Field actions instead of substances

Evolution toward Micro-levels

- Consider utilizing different aggregate states or combinations of states, using:
 - System made of elements with specific shapes
 - Solid-state substances
 - Plastic and elastic materials
 - Gels
 - Liquids
 - Liquids in critical or supercritical phases
 - Gases
 - Plasma
 - Voids (areas with low density, vacuum, etc.)
 - Various combinations of solid, liquid, gas and plasma states (foam, liquids saturated with gas, suspensions, sprays, dust, ionized gas, etc.)
 - Aggregate state transformations (melting, evaporation, condensation, solidification, etc.)



Evolution toward Increased Use of Fields

Basic field	Specific fields	Special corresponding substance(s)
Mechanical	Gravity	
	Pressure	
	Shocks, vibration	
	Explosion	Explosives
	Acoustic waves	
Thermal	Heating-cooling	
	Aggregate state transformation	Water-ice-vapor Bi-metals Shape memory materials
Chemical		Catalysts, inhibitors
Electrical	Electrical charges	Dielectric materials
	Electrical current	Conductive materials
Magnetic field	Electrical current	Conductive materials
	Permanent magnetic field	Magnets, ferromagnetic particles



Evolution toward Increased Use of Fields

- Consider transforming an existing but unusable field into another, more useful one
- Consider changing fields parameters from one to another of the following:
 - Permanent, one-dimensional field
 - Permanent, multi-dimensional field
 - Gradient and/or asymmetrical field
 - Alternating field, rotating field, traveling field, etc.
 - Alternating resonance field
 - Non-sine field (rectangular, trapezoid, etc.)
 - Pulsed field
 - Combination of fields with different parameters



Evolution toward Decreased Human Involvement

- Try to replace a human with a machine, device or other equipment using the following recommendations:
 - Permanent, one-dimensional field
 - Make the operations simple (reduce the level of intelligence required to realize the process)
 - Aid humans in easily-automated operations that require power, accuracy, speed or some other characteristic prone to human error
 - Substitute a human without changing the principle of operation
 - Change the principle of operation to suit a “mechanized” operation (i.e., pay attention to power, accuracy, speed, etc., rather than intelligence)



Evolution toward Decreased Human Involvement

- Consider the following ways of substituting humans in various kind of activities:
 - In operations
 - In control
 - In decision making
- In each kind of activities, consider replacing a human as:
 - Tool/sensor
 - Energy/information transformer
 - Source of energy/information



Basic Rules for Working with Patterns/Lines

- Select a pattern and read the recommendations
- For the given system and its competitors, consider the past evolutionary steps that fall under the selected pattern
- Consider if the recommendation(s) can be applied (or reapplied) to the given system to move it to the next step



Basic Rules for Working with Patterns/Lines

- Summarize all generated ideas and group according to:
 - Ideas that you know how to realize
 - Ideas that you like but do not know how to realize. (Use problem-solving tools to further develop these ideas.)
- Try to foresee problems that might arise during implementation. Use the Failure Prediction module for this purpose
- Formulate secondary problems and utilize problem-solving tools to resolve them.



DE Failure Analysis

- Step 1: Invert the problem.
 - How to produce the undesired phenomenon?
- Step 2: Find a way to produce the phenomenon
 - Look for a method utilized when the required phenomenon has to be intentionally produced.
- Step 3: Verify the hypotheses
 - Look for the system's resources are necessary for the required phenomenon occurrence



DE Failure Prediction

- Describe each stage of the Concept implementation
- Consider possible failures during each stage using the list of typical potential negative effects
- List all obvious ways to accomplish each failure
- Consider the following:
 - potentially dangerous moments/periods of time during implementation
 - weak and dangerous zones as resources for potential failures
 - possible harmful impacts on each stage of implementation
 - possible failures of devices, objects, etc.
- Consider measures for preventing the failures you have revealed.



Abbreviated Ideation Problem Solving Process

- Describe the problem
- Describe the Ideal Solution
- Identify and utilize resources
- Work with Drawbacks
- Identify and resolve contradictions
- Synthesize a new system
- Work with secondary drawbacks

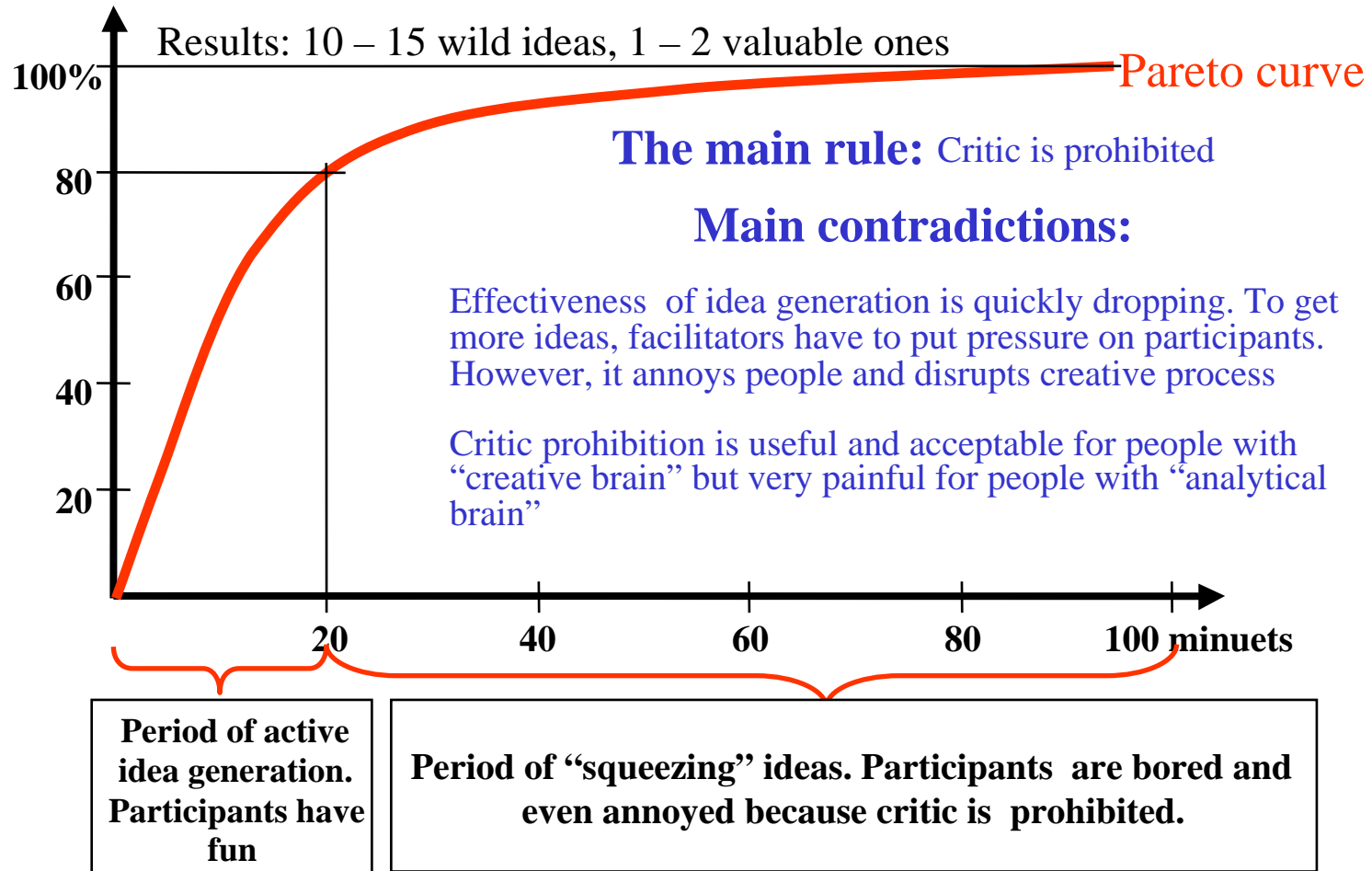


Ideation Brainstorming

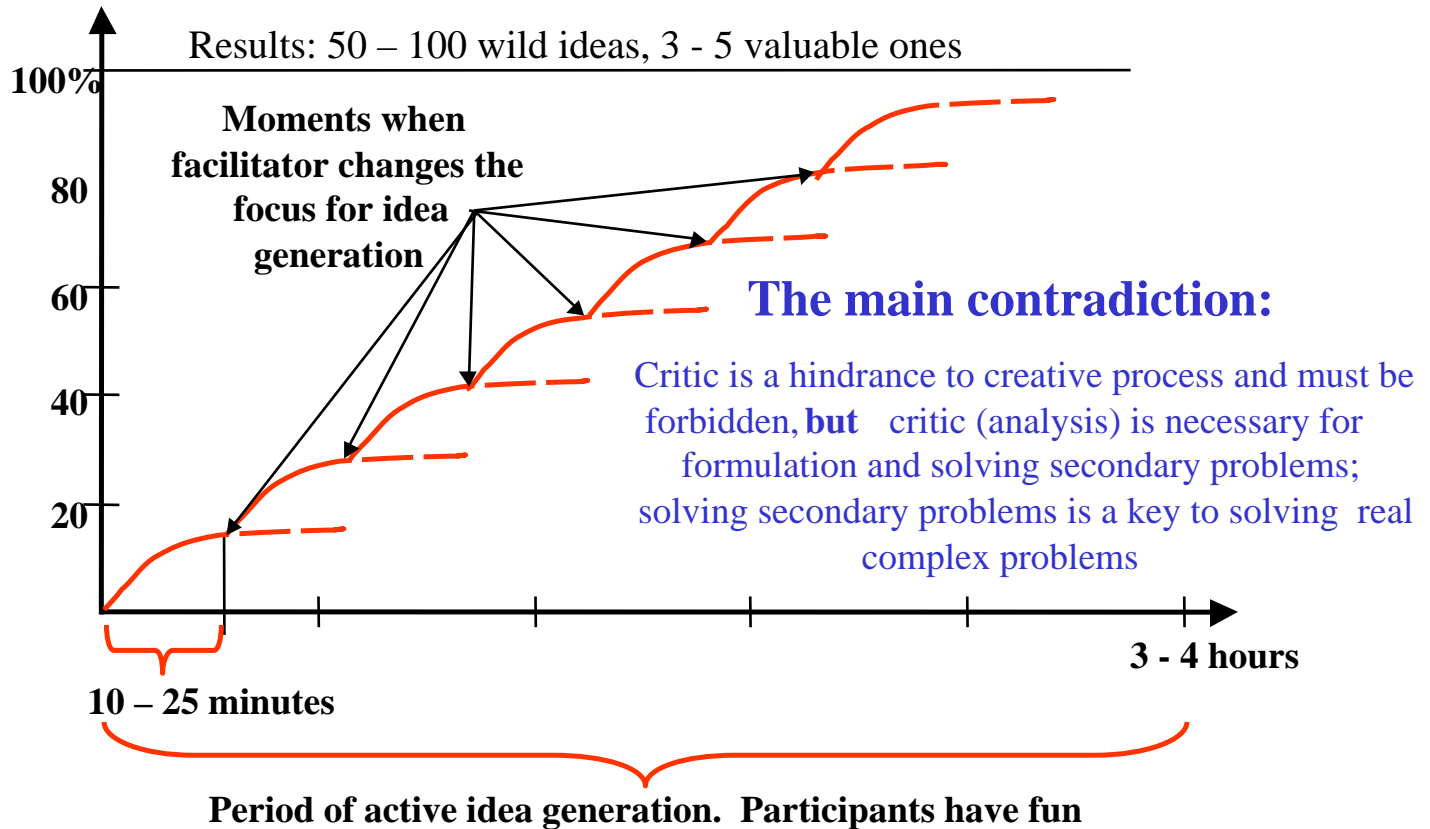
- Preparation for the teamwork session, including:
 - Knowledge-mapping the problem
 - Formulation of problem statements and selection of those to be addressed in the teamwork session
- Idea generation stage around selected problem statement
- Evaluation stage
- Repeating the Idea generation and Evaluation stages for each selected problem statement



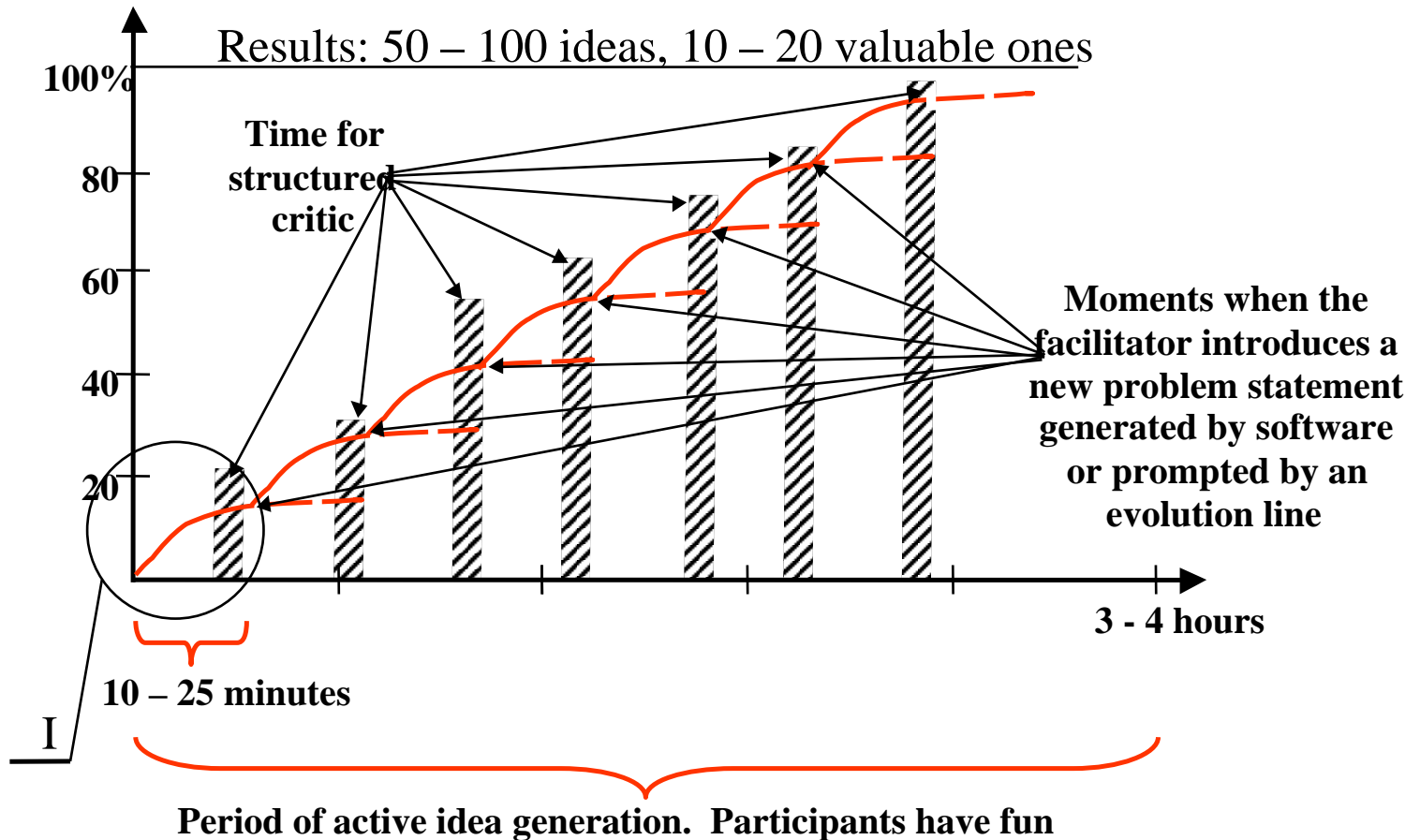
Traditional Brainstorming with an Average Facilitator



Traditional Brainstorming with the Best Facilitator



Ideation Brainstorming



Conclusion

- The essence of the Third Wave is: “Everything is flowing, everything is changing” - and in an unpredictable fashion, as well
- The transition to active management of life and destiny becoming absolutely necessary
- Science fiction writer Isaac Azimov invented psychohistory - a science that allows the prediction and control of the evolution of the human civilization expanded over the entire galaxy
- Directed Evolution is the first step available today for an individual, organizations, and humanity as a whole

