Technology Foresight

Co-funded by the Erasmus+ Programme of the European Union

TECHNOLOGY FORESIGHT

Dr. Karlheinz Steinmüller

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Occupation

Since 2001	Sci. Director of Z_punkt
1997	Co-Founder of Z_punkt
1991 - 2001	Researcher / project manager at SFZ – Sekretariat f. Zukunftsforschung Gelsenkirchen
1982 – 1991	free-lance writer
1977 – 1982	Scientist at ZKI – Zentralinst. f. Kybernetik und Informationsprozesse Berlin

Education

1969 – 1971	Physics (TU Chemnitz)
1971 – 1973	Physics (Humboldt-Uni Berlin)
1973	Diploma in theoretical physics
1973 – 1976	Post-grad. Philosophy (Humboldt-Uni Berlin)
1977	Dr. phil.

Interests

- Futures studies, public & corporate foresight
- Emerging technologies
- Scenarios and wild cards
- History and methodology of futures studies
- Science fiction

Books (all with Angela St., in German lang.)

2015	Standards and Quality Criteria of Futures Studies (co-editor)
2014	The Wormhole Odyssey (story cycle)
2010	Computer Twilight (stories)
2008	Darwin's World (biography)
2008	Pulaster. Novel of a Planet
2006	The Future of Technologies
2005	The Dream Master (novel)
2004	Wild Cards. If the Improbable Happens
2004	Andymon. A Space Utopia
2003	Hothouse Age (stories)
2000	Futures Studies in Europe (co-editor)
1999	Visions. 1900 – 2000 – 2100. A Chronicle of the Future

Z_punkt. The Foresight Company

- Founded in 1996
- Staff of ca. 15
- Focus on Corporate Foresight
  - Scenarios & Strategies
  - Innovation & Creativity
  - "Futurizing" the Company

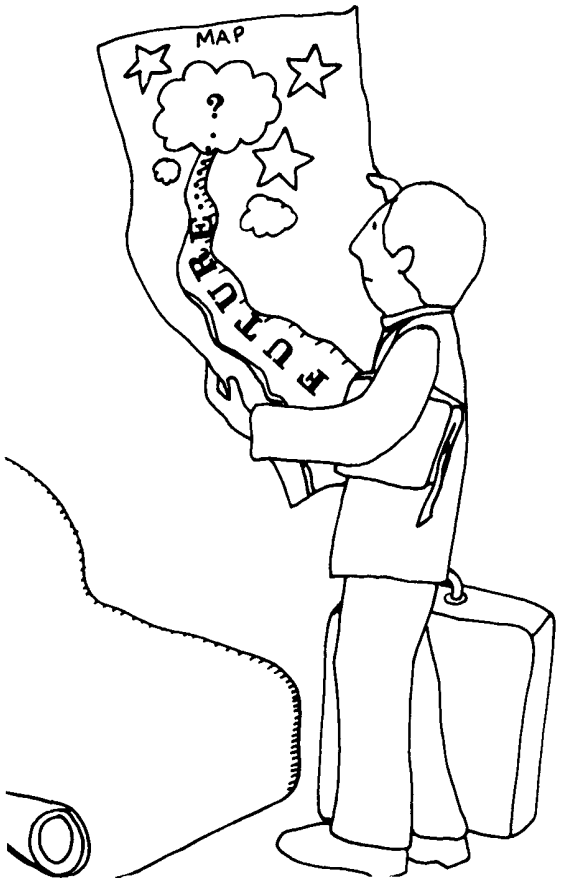
Agenda

Time	
09:00	Introduction
09:15	Presentation on methods and tools Q & A
11:00	Break
11:15	Introduction to Exercise Exercise
12:30	Reflection on Exercise Results Wrap-Up
13:00	Lunch Break

PART 1
METHODS & TOOLS

Overview

- **Looking Back**
- **Technology Foresight**
- **Innovation Processes**
- **Methods, Tools, Resources**
- **Conclusion**



Looking Back: Many Visions

1880 Albert Robida: Telephot

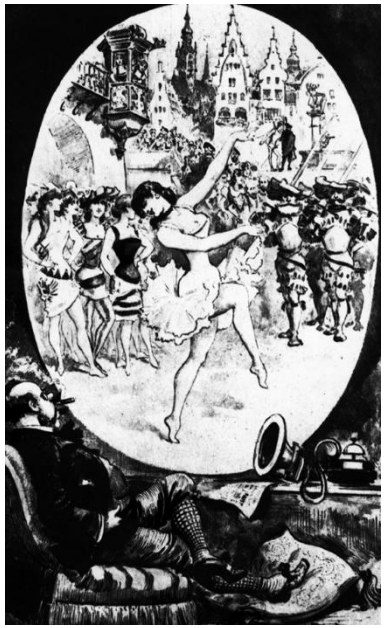
1910 Henry Sloss: Mobile phone

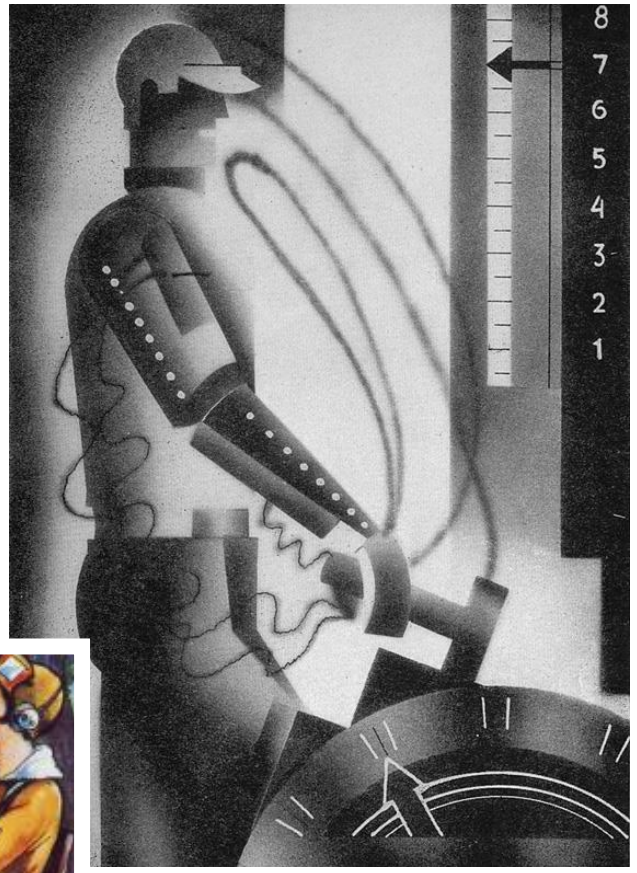
1912 H. G. Wells: Atom bomb

1923 Karel Čapek: Robots

1924 J.B.S. Haldane: Genetic engineering

1930 Birkenhead: Shortening of work hours





Some Did Materialize in a Way…

Hugo Gernsback: Radio for All, 1922

Some Nearly Came True…

Art Radebaugh: Electronic Home Library, 1958

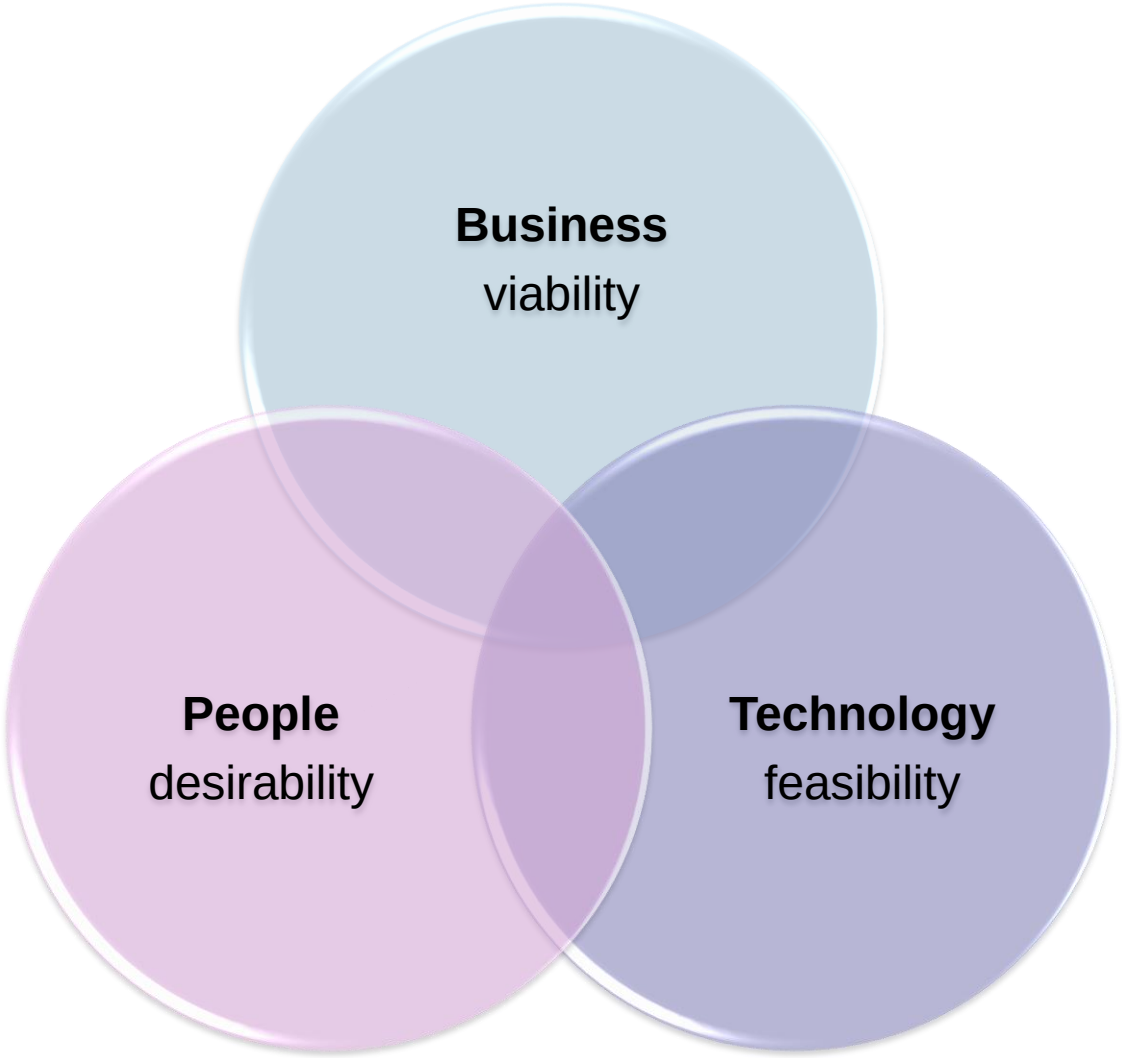
Some Missed the Point.

"Airplanes are interesting toys but of no military value."
Marechal Ferdinand Foch, Professor of Strategy, Ecole Superieure de Guerre

"Everything that can be invented has been invented." - Charles H. Duell, Commissioner, U.S. Office of Patents, 1899

"I think there is a world market for maybe five computers."
Thomas Watson, chairman of IBM, 1943

The Magic Triangle of Innovation



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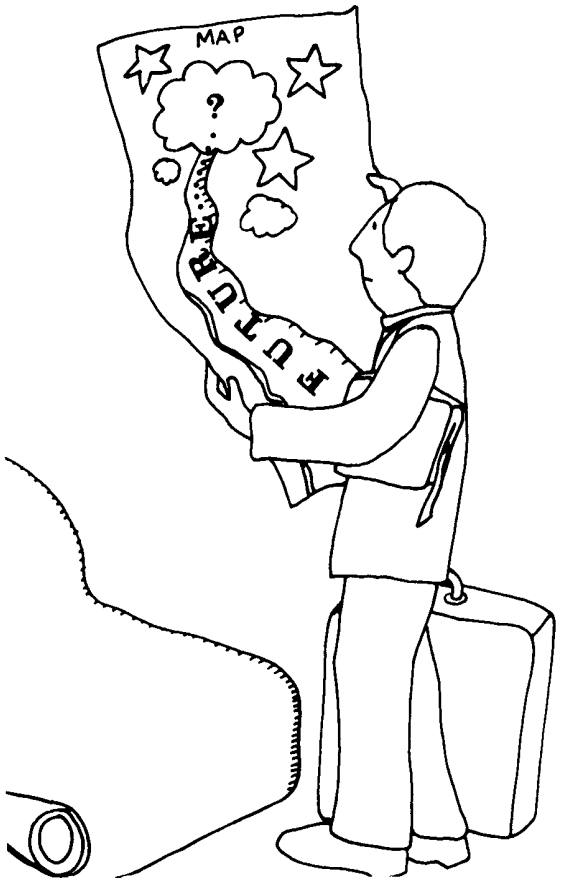
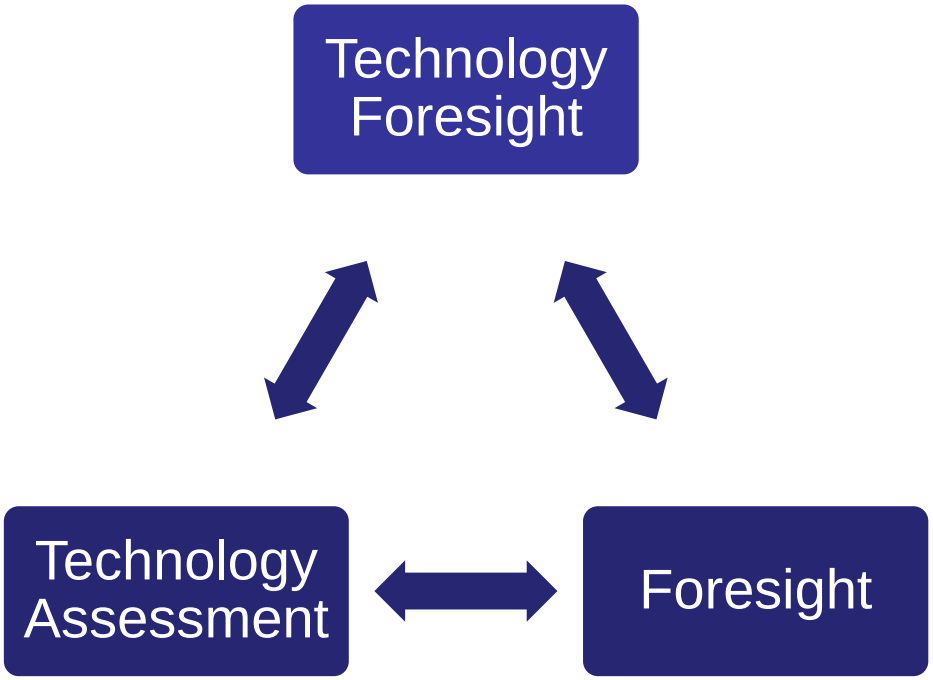


Technology Foresight

"Systematic attempts to observe the long-term future of science, technology, the economy and society, with the aim to identify the emerging technologies that will probably produce the greatest economic and social benefits".

http://future.wikia.com/wiki/Futurology:_Technology_Foresight



Related Fields:

Foresight and Technology Assessment

Foresight
can be defined as a

- systematic,
- participatory,
- future intelligence gathering &
- medium-to-long-term vision-building process

aimed at present-day decisions and mobilising joint actions.

Focus on:
Societal dimension
Mega-trends …

High Level Expert Group: Foresight for Europe, EC / DG Research, 2002

Technology Assessment is a

- scientific,
- interactive, and
- communicative process

that aims to contribute to the formation of public and political opinion on societal aspects of science and technology.

Focus on:

- Public opinion (on risks and opportunities)
- Possible regulatory measures

en.wikipedia.org/wiki/Technology_assessment

Technology Foresight: Tasks

Public domain

- Identification of promising technologies and of potential risks
- Public investments in science & technology
- Best way to support promising technologies by framework conditions (regulation to direct development of technologies)

Corporate domain

- Identification of economically promising technologies
- Analysis of efforts needed
- Analysis of markets and competitors
- Analysis of public policies

Technology Foresight: General Procedure

- Bounding
- Framing

- Horizon Scanning
- & Mapping

- Surveys
- Interviews
- Patent Analysis
- Bibliometrics

- Trend Extrapolation
- Delphi
- Vision Building

- Impact Assessment
- Business Model Development

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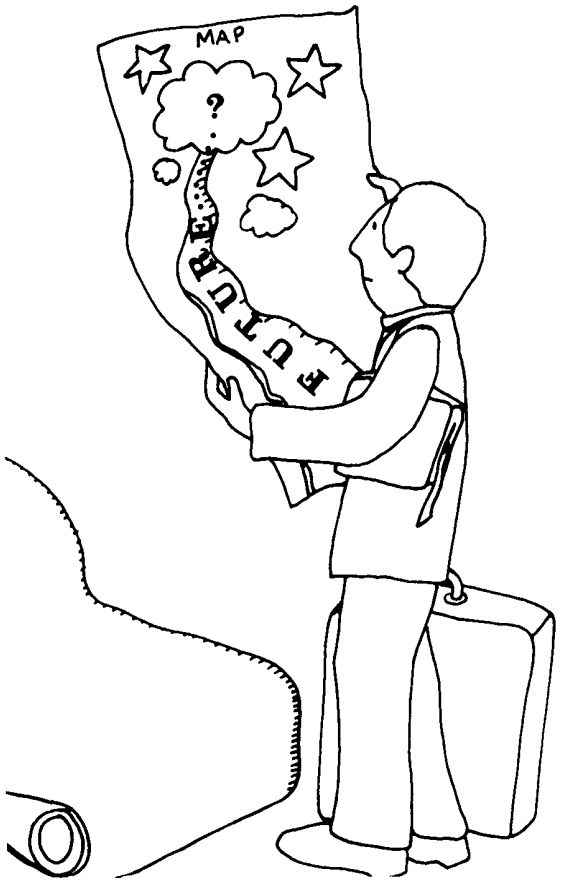
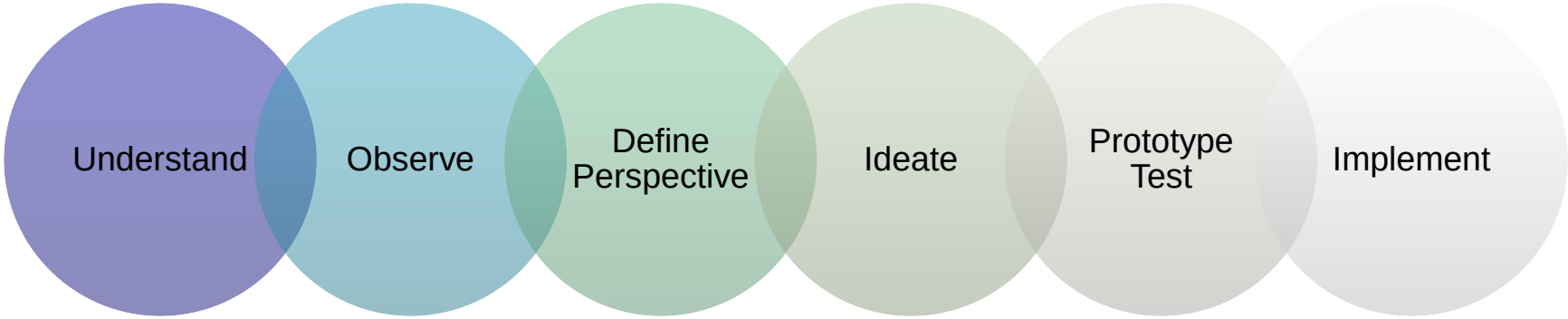
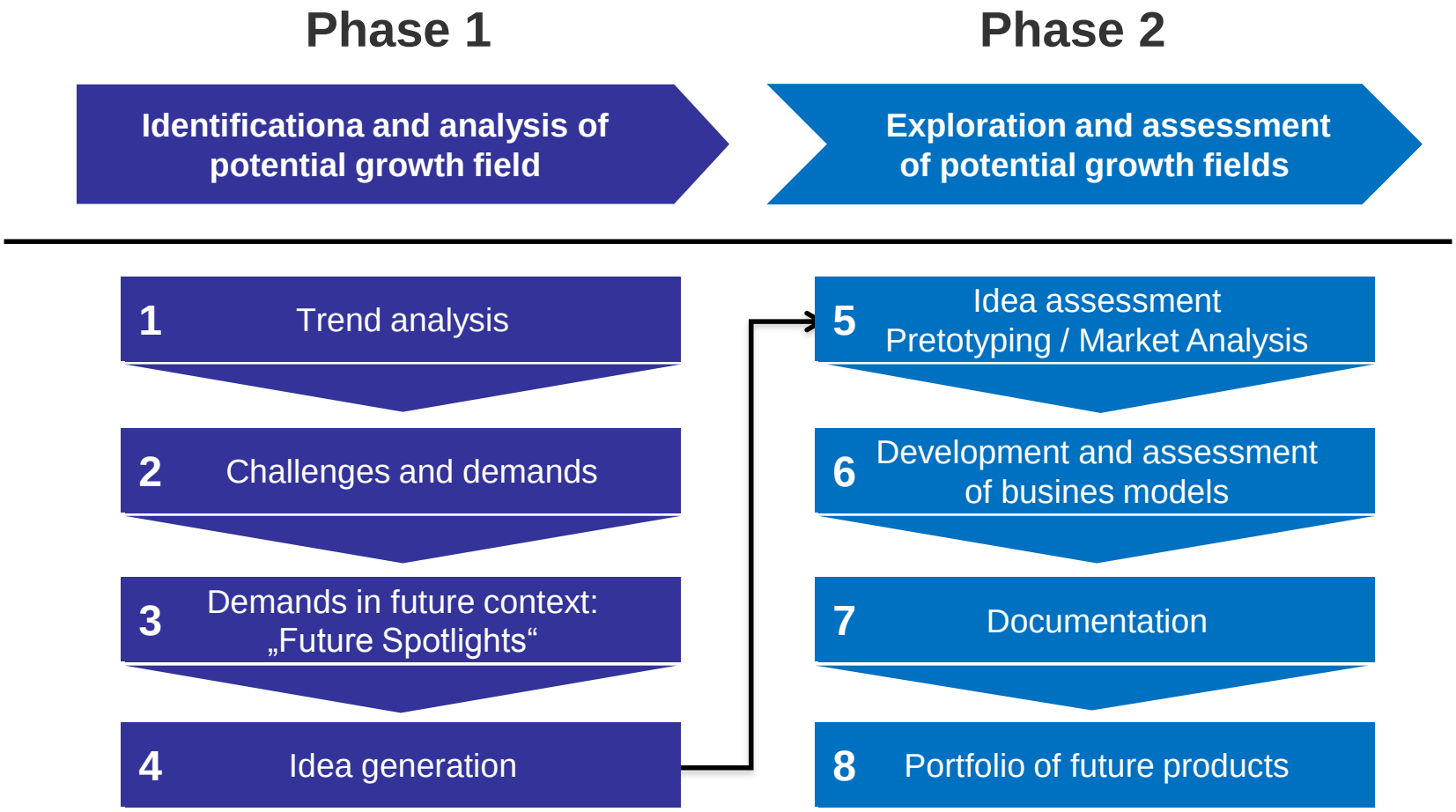


Innovation Process – as seen from Design Thinking



Innovation: Z_punkt Approach



Innovation Workshops: Some Tools

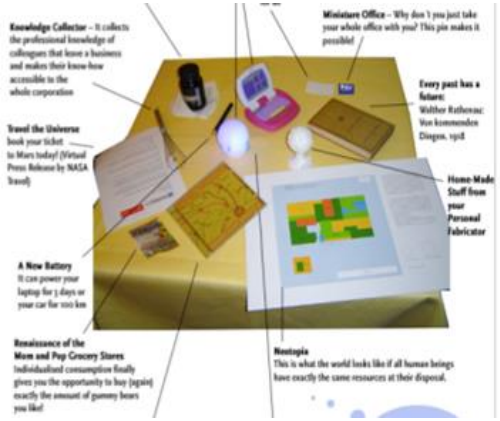
Live Illustrator

Future Wheel

Brainwriting

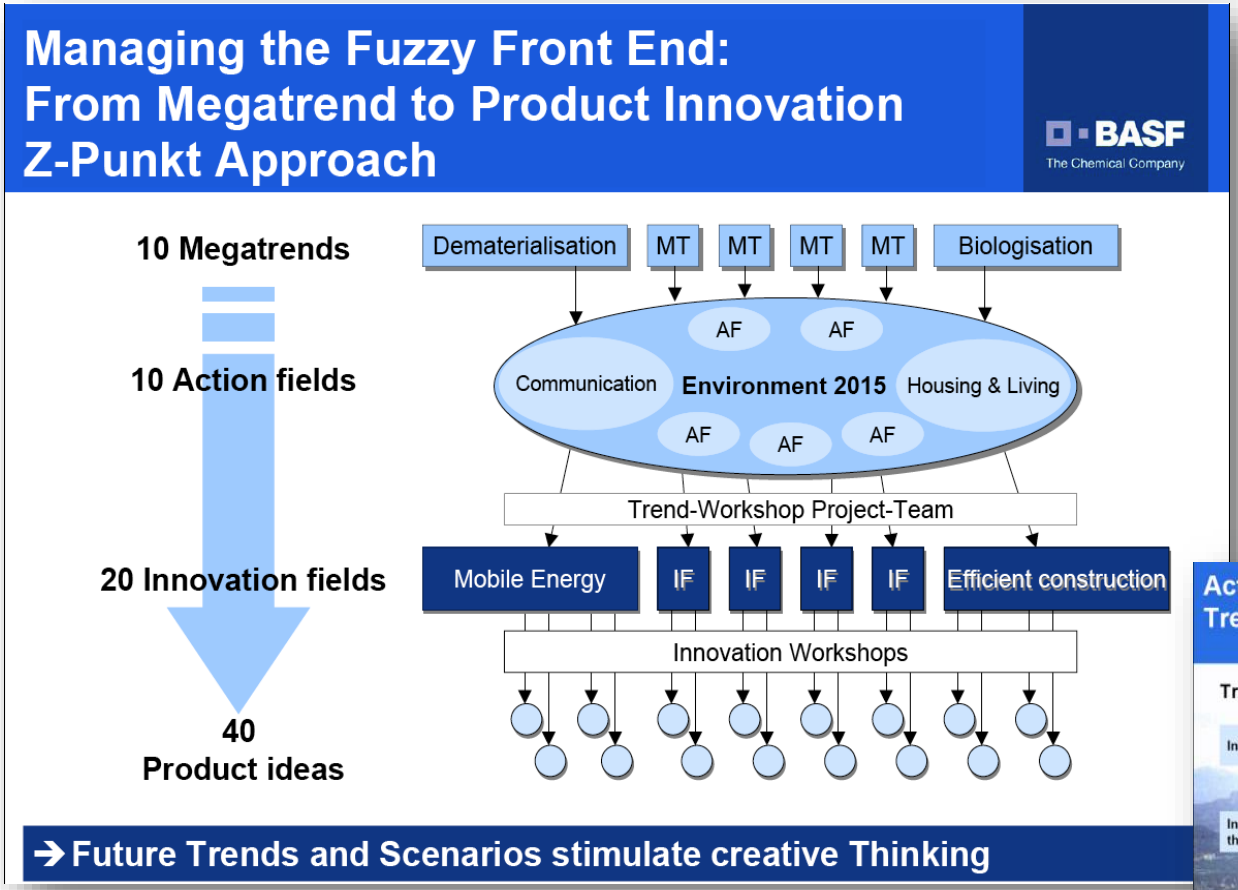
Future Exposition

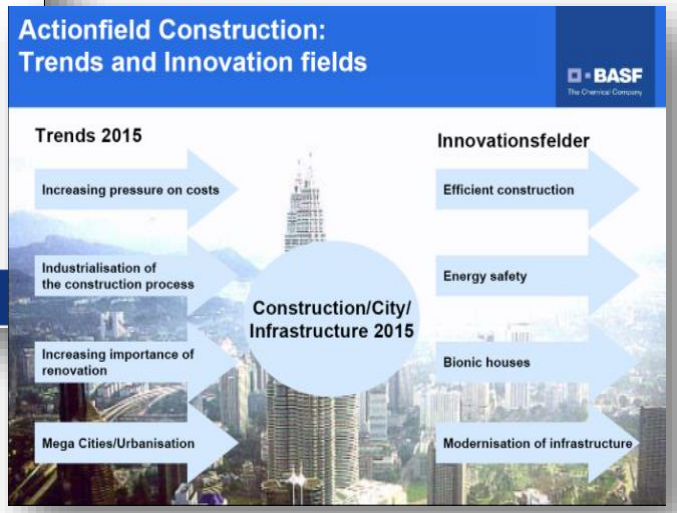
Future Finds



World Cafe

Trend Based Innovation: Example





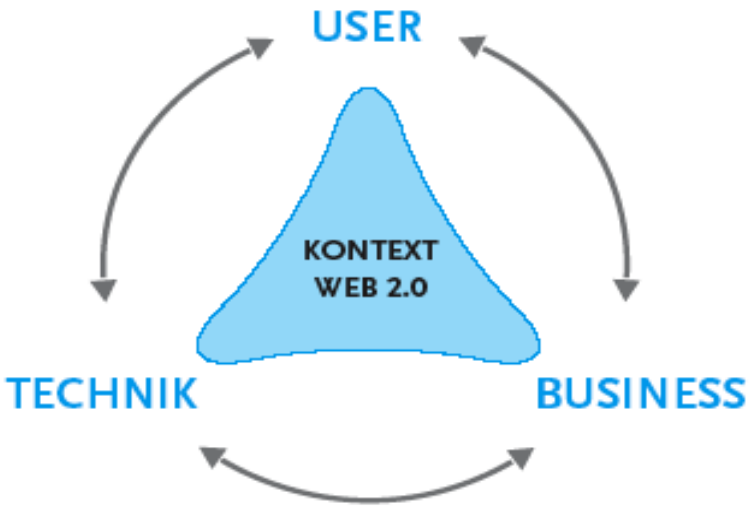
As Best Practice Example released for publication by client BASF

Co-Innovation: Involving Everybody

The User as Co-Innovator

- Usability labs
- Product clinics
- User feedback
- Teaming up with users
- Lead user method
- Open innovation / Crowdsourcing

→ From Consumer to "Prosumer"



OScar
reinvent mobility

Mass Customization & Open Innovation News

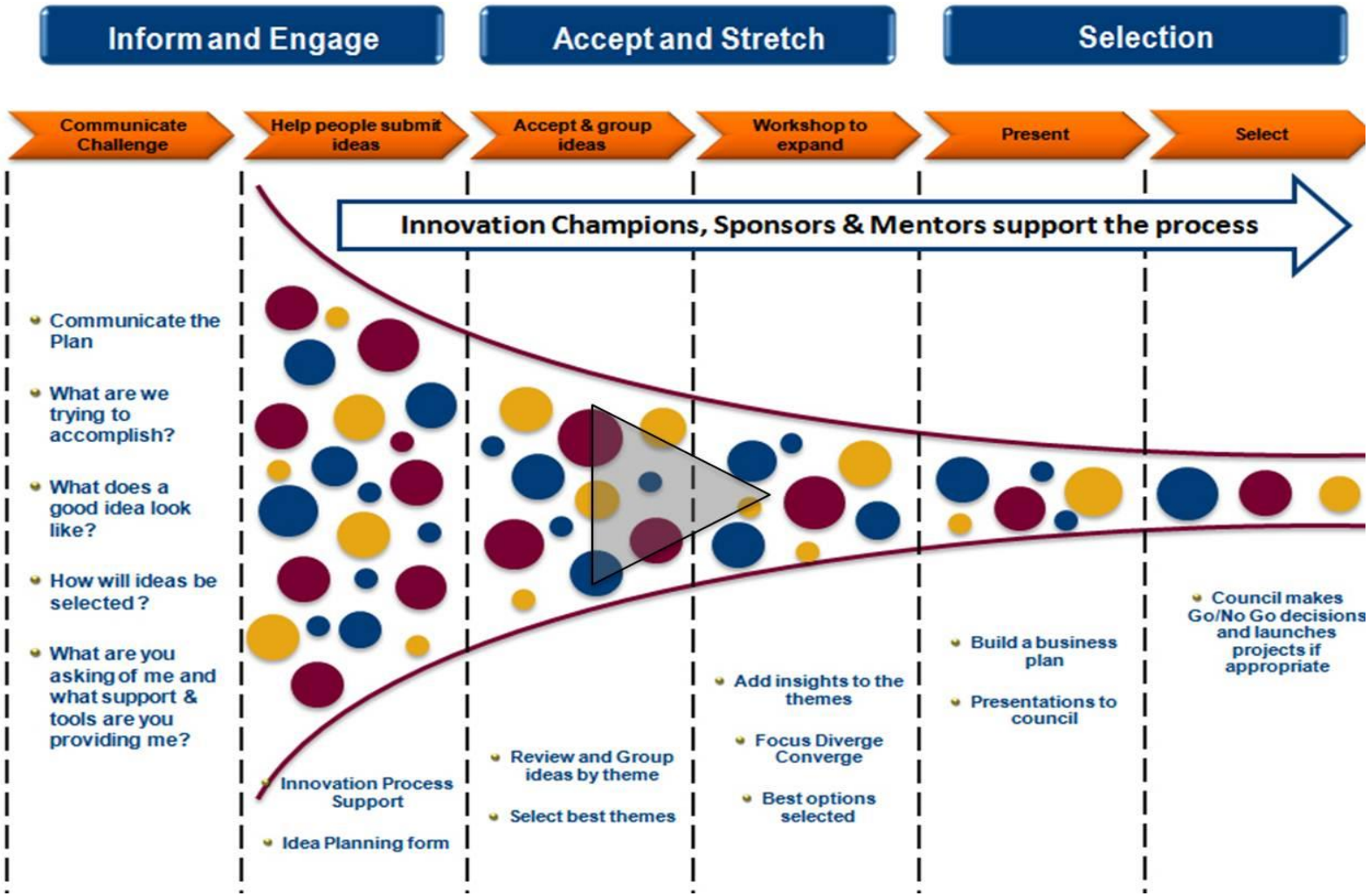
This blog continues a long running newsletter on mass customization, personalization, customer integration, and open innovation -- all strategies building on value co-creation between suppliers and customers. Published and edited since 1997 by Frank Piller, TUM / MIT.

Innovators as Rulebreakers

- Innovations are not made by processes, but by human beings!
- Focus on non-customers!
- Take benefit from disruptive innovations!
- Find rulebreakers from within!
- Make rulebreaking a task for the board!
- Cannibalize yourself!
- Appreciate diversity!
- Do not go for the quick profit!

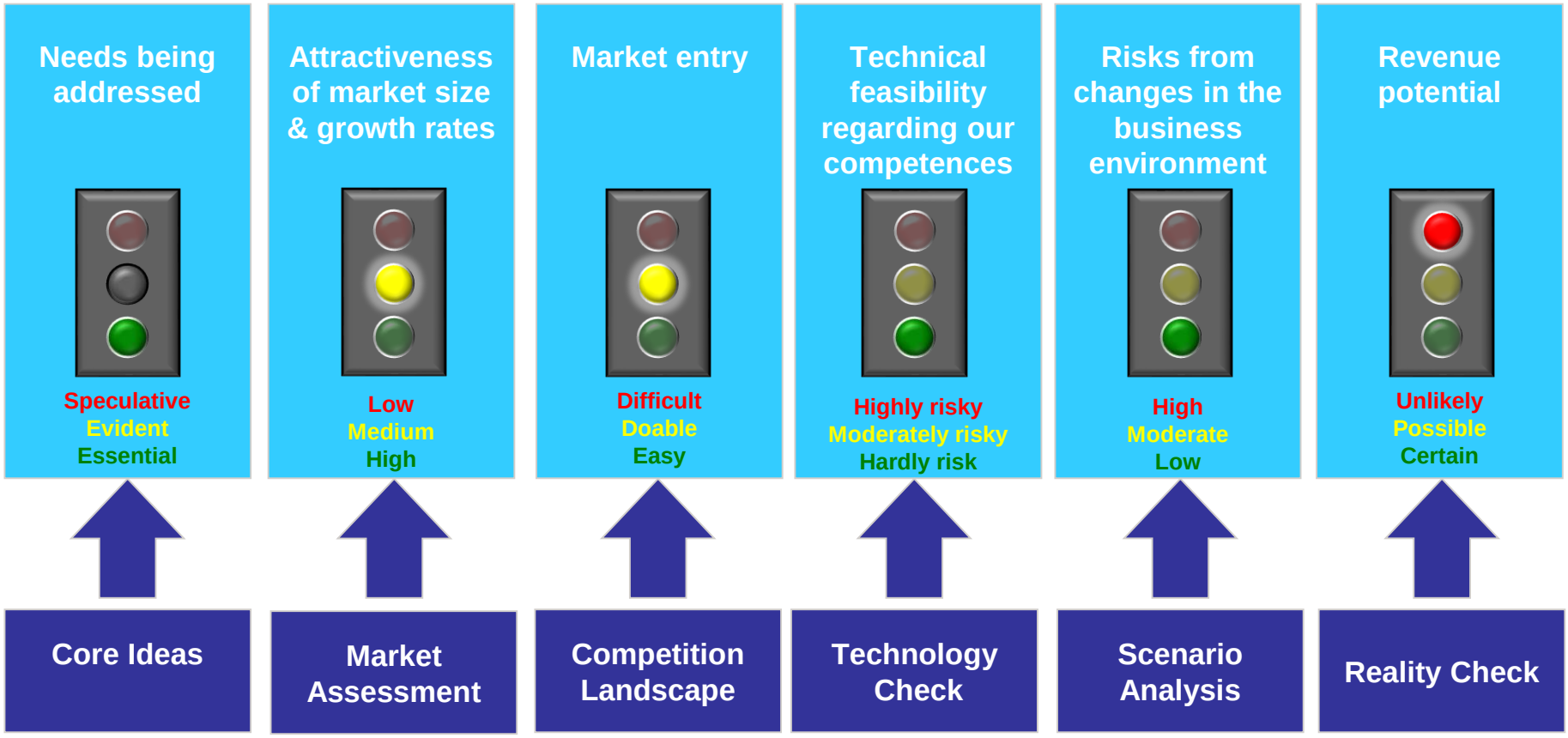
(2010)

Innovation Funnel



http://www.desai.com/our-approach/innovation-funnel/tabid/88355/Default.html

Assessing Ideas: Traffic Lights



Technology foresight supports the assessment of ideas!

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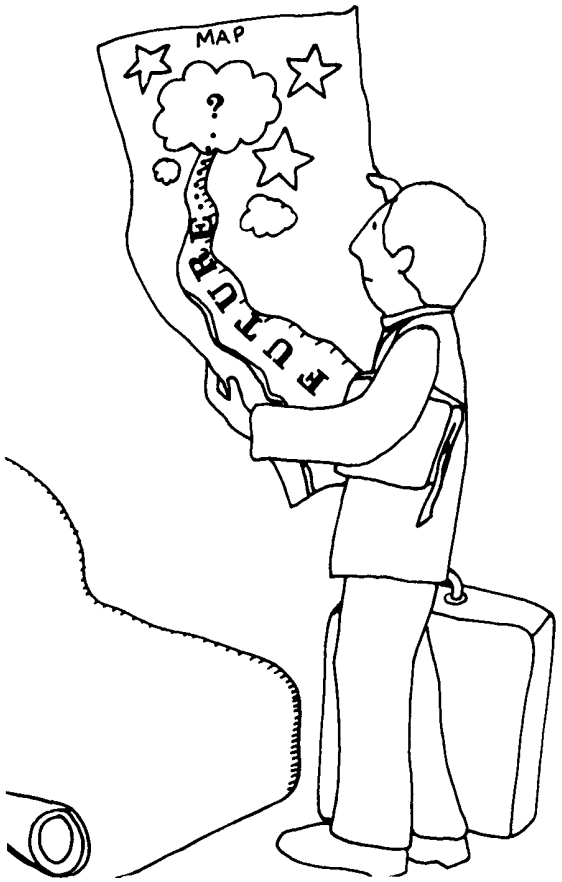
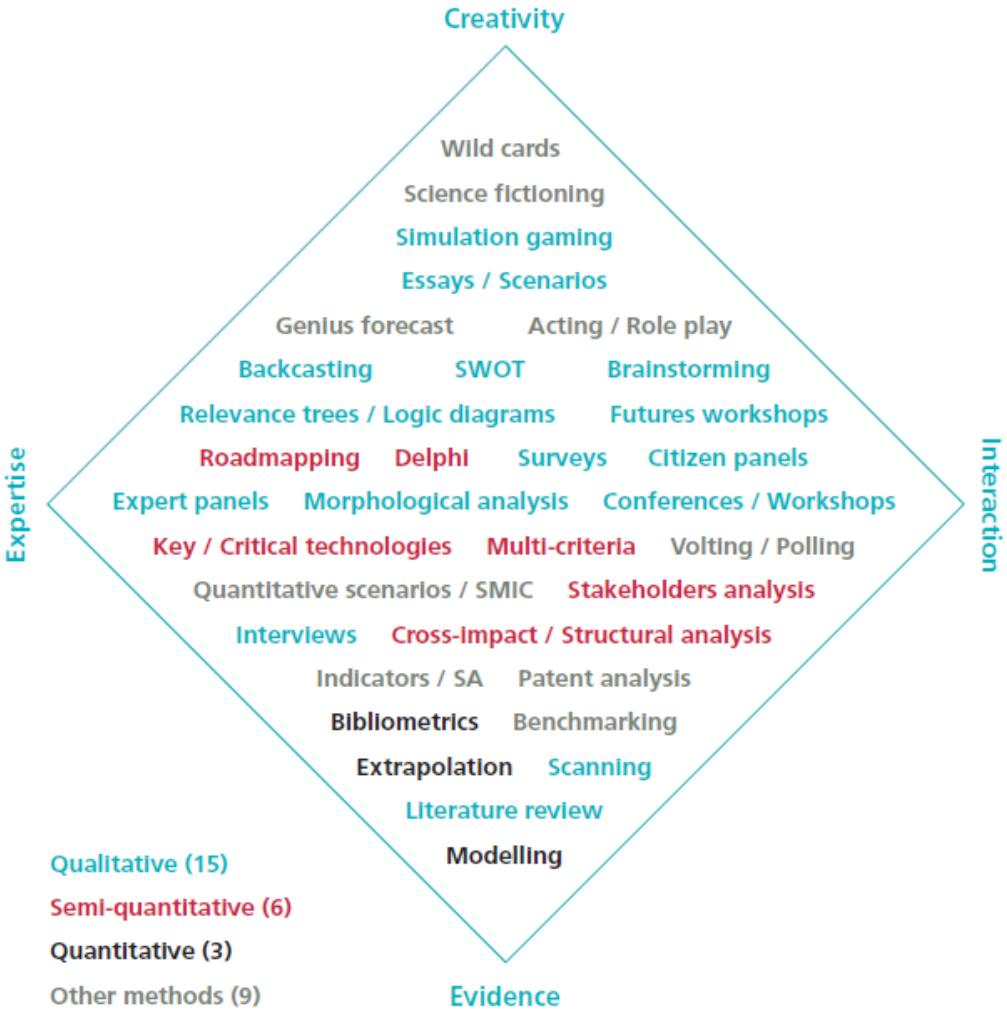
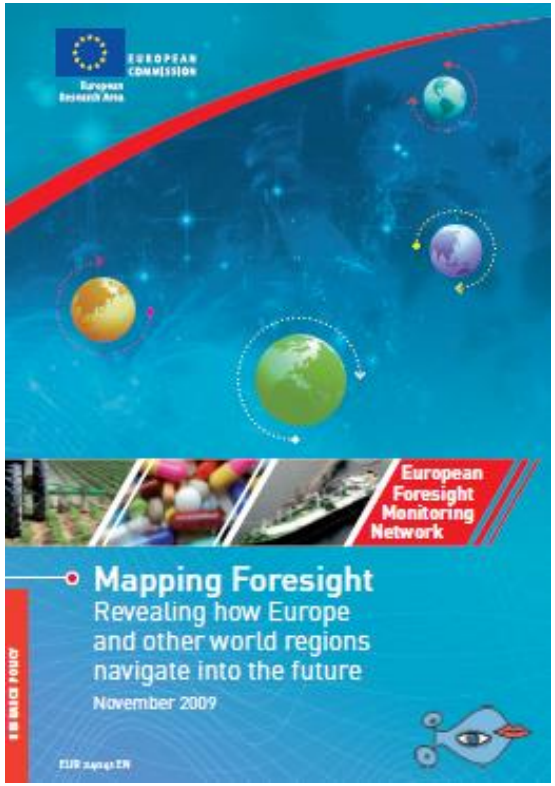


Many Methods: The Foresight Diamond





Popper, R.: Mapping Foresight, 2009

Methods of Specific Relevance for TF

- Environmental Scanning
- Text Mining for Technology Foresight
- The Delphi Method
- Real-Time Delphi
- The Futures Wheel
- The Futures Polygon
- Trend Impact Analysis
- Wild Cards
- Structural Analysis
- The System Perspectives
- Decision Modeling
- Substitution Analysis
- S&T Road Mapping
- Agent Modeling
- Field Anomaly Relaxation
- Prediction Markets
- Genius Forecasting, Intuition and Vision
- Simulation and Games
- Participatory Methods
- Scenarios
- Using Vision in Futures
- Interactive Scenarios
- Robust Decisionmaking
- Relevance Trees
- Morphological Analysis
- Technology Sequence Analysis
- Normative Forecasting
- Statistical Modeling
- Heuristics Modeling
- Casual Layered Analysis
- Personal Futures
- Chaos and Non-Linear Dynamics

Methods used by the national nodes of the Millenium Project
http://www.millennium-project.org/

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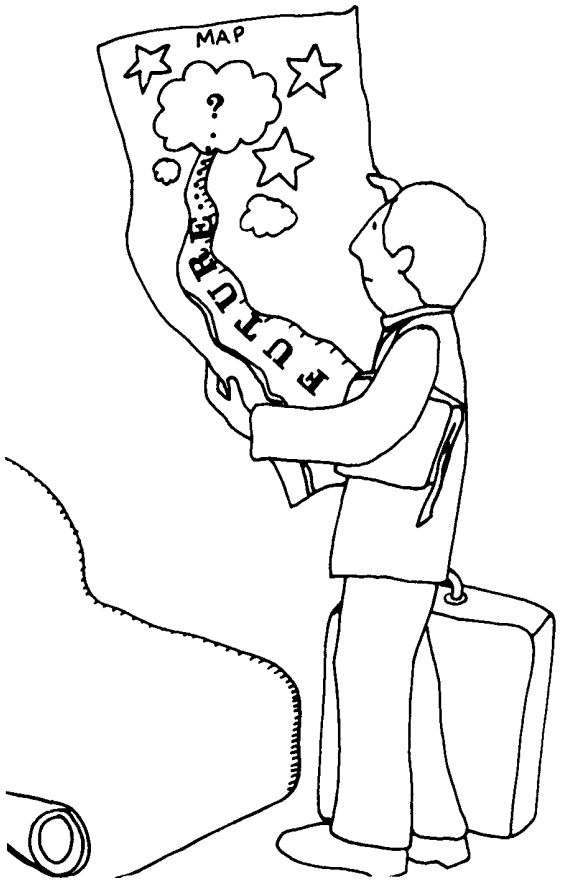
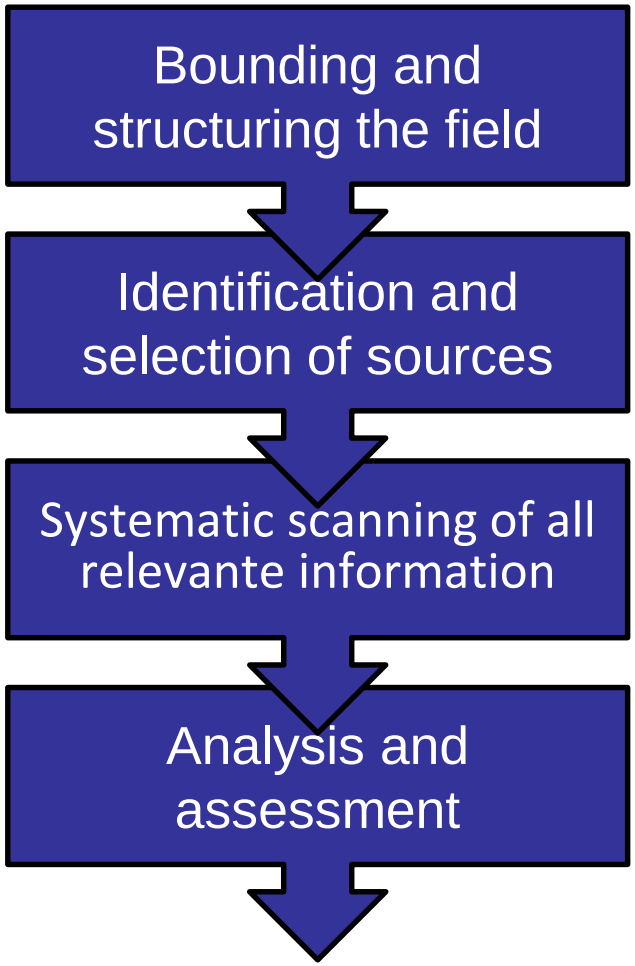


Horizon Scanning
aka Environmental Scanning

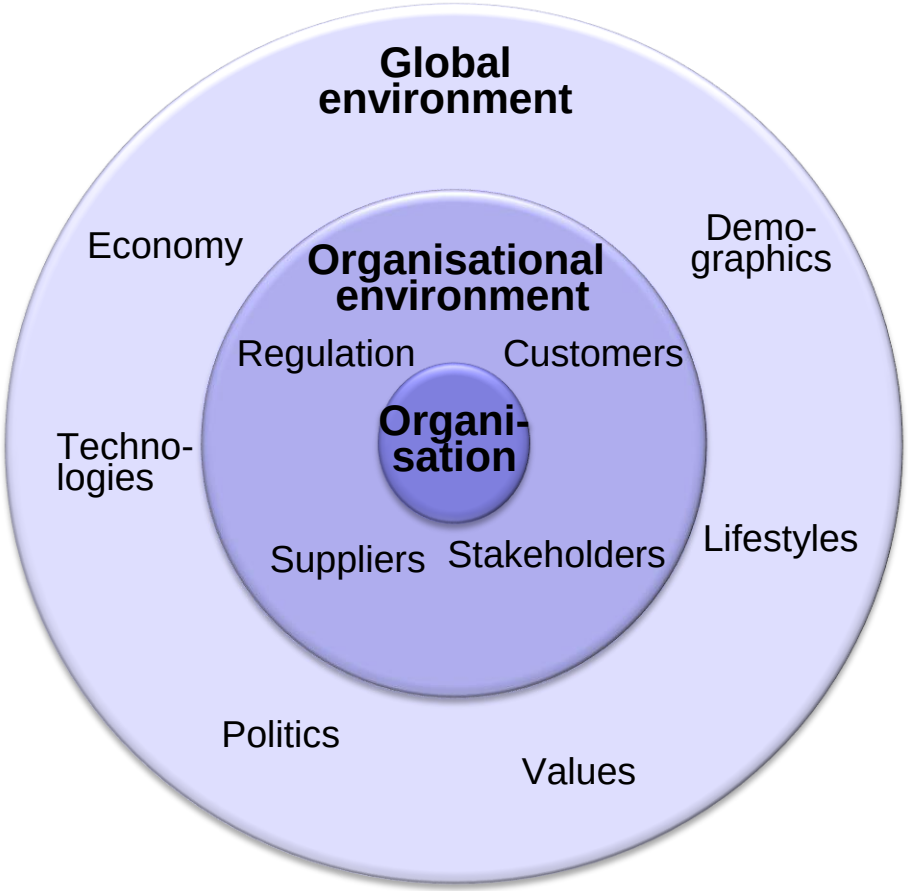


Environmental Scanning

- Primary futures tool for identifying and monitoring emergence, growth, and coalescence of change.
- Related to issues management and competitive intelligence.
- "Environment" refers to the information environment – all media – and "scanning" to the logically structured, iterative monitoring of selected information sources.

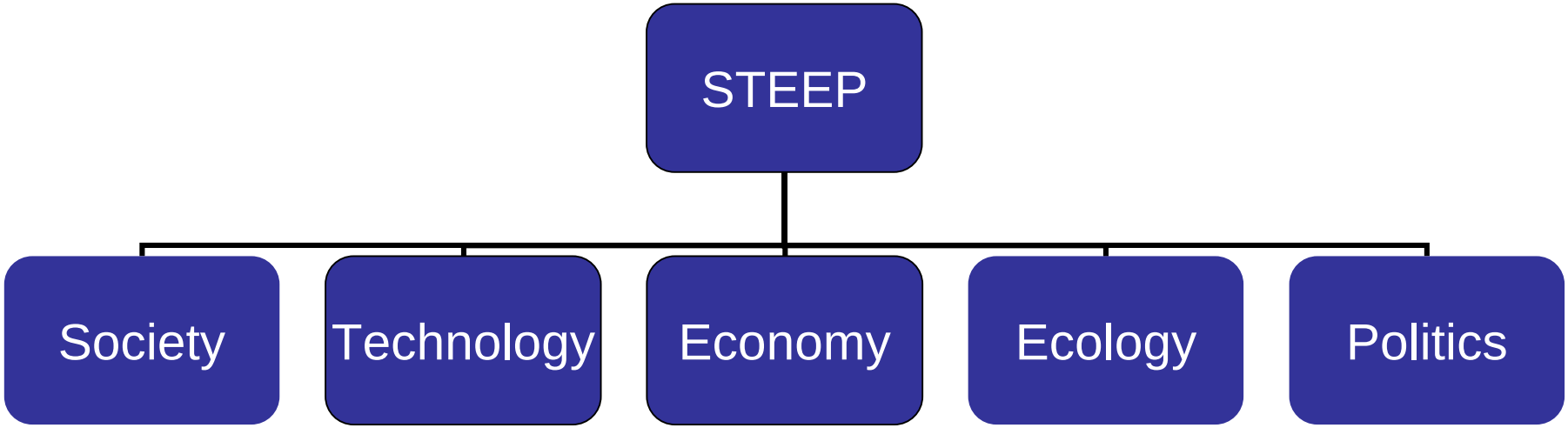
18 September 2004, Wendy L. Schultz, Infinite Futures

Different Ways to Structure the Field:
Zooming into the Business Environment



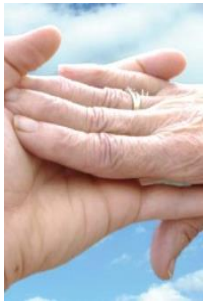
Alternative:
Porter‘s
Diamond

Different Ways to Structure the Field:
STEEP Sectors



360° View – “Everything” has to be scanned …

Mapping Drivers of Change: Mega-Trends



SOCIETY

- Demographic Change
- Women on the Rise
- Cultural Diversity
- New Patterns Of Mobility

CONSUMPTION

- Individualization
- New Consumption Patterns
- Health Thrives

BUSINESS

- Globalisation 2.0
- Knowledge-Based Economy
- Changes in the Work World
- Business Ecosystems

TECHNOLOGY

- Digital Lifestyles
- Biomimicry: Learning From Nature
- Ubiquitous Intelligence
- Technology Convergence

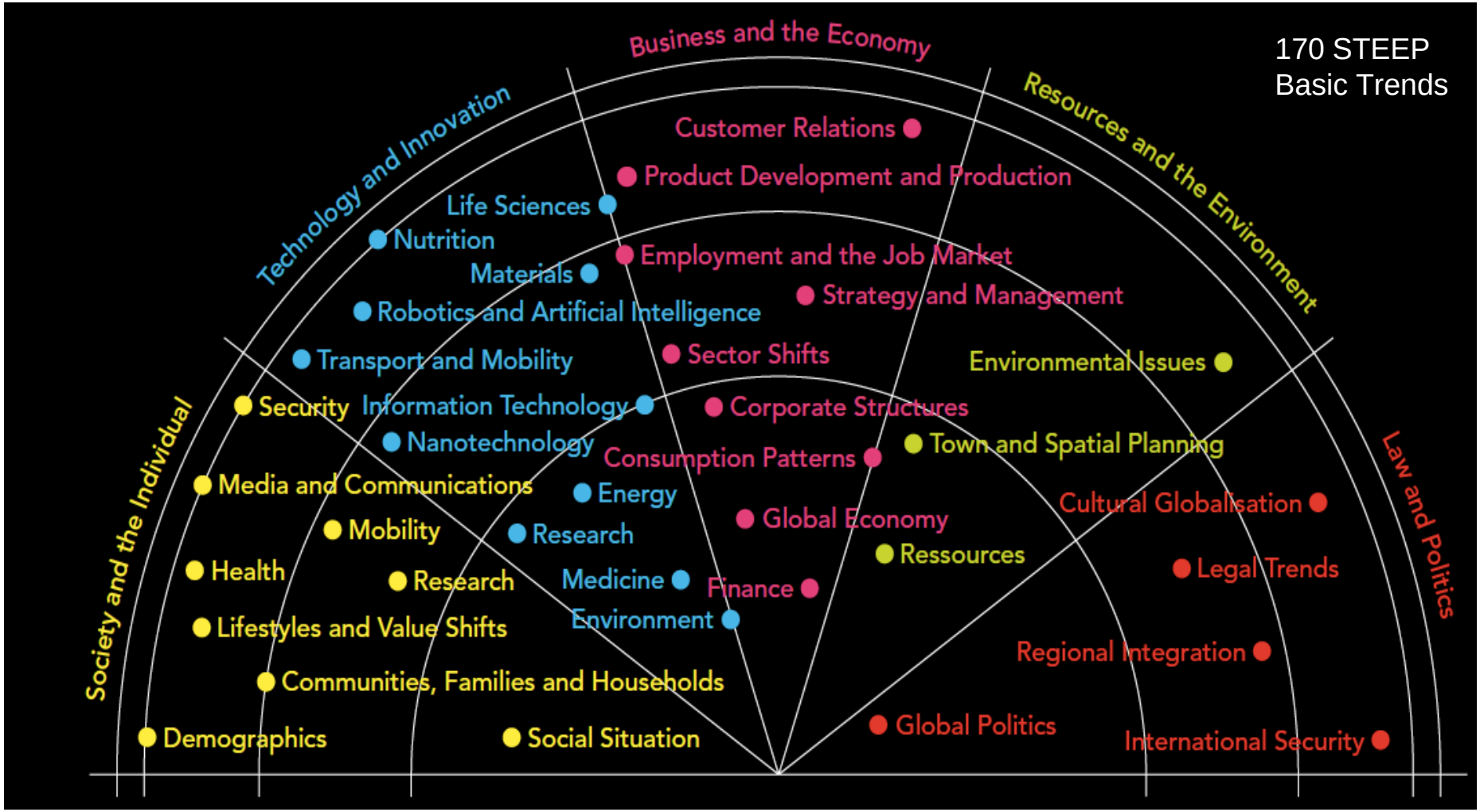
POLITICS

- Urbanization
- New Political World Order
- Growing Security Threats

ECOLOGY

- Reorientation in Energy & Resources
- Climate Change
- Environmental Impacts

Sources & Resources – Example: Z_punkt Trendradar 2020



http://www.trendradar2020.de/

Sources & Resources – Some Examples

General Consultancies

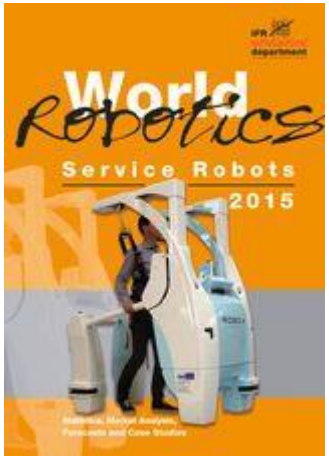
- Gartner (http://www.gartner.com/technology/home.jsp)

Specialised Consultancies

- Materialsgate (https://www.materialsgate.de/en/)
- Wohlers (3D printing) (https://wohlersassociates.com/)

Industry Associations

- International Federation of Robotics (http://www.ifr.org/service-robots/statistics/)



Sources & Resources – Some Examples

International Organisations

- OECD (International Futures Program) (http://www.oecd.org/futures/ifppublicationsandstudies.htm)

Foresight Institutes

- Institute for the Future (http://www.iftf.org/maps/20-combinatorial-forecasts/20-combinatorial-forecasts-map/)
- Shaping Tomorrow (https://www.shapingtomorrow.com/)

National Platforms

- UK Government Office for Science (https://www.gov.uk/government/collections/foresight-projects#horizon-scanning-reports)

Scanning: Different Sources

Sources	Disadvantages
Papers in specialized journals	Often outdated
Conferences	Very heterogeneous
Statistics	Never up to date
Internet search	Unstructured / unreliable
Expert interviews	Expensive
Surveys	Expensive, time consuming

There is always a lack of quality data.

What Does Scanning Deliver?

Information, but

- heterogeneous
- multiple
- unorganized
- contradictory & unreliable
- pertinent and irrelevant

Nevertheless:
the very fundament!

Assess with respect to

- Relevance
- Degree of granularity
- Hidden (or obvious) perspectives (“ideologies”)
- Consensus or productive dissent?
- Scientific accuracy vs. openness for novelties?

Looking For *Weak Signals*

Igor Ansoff 1984:

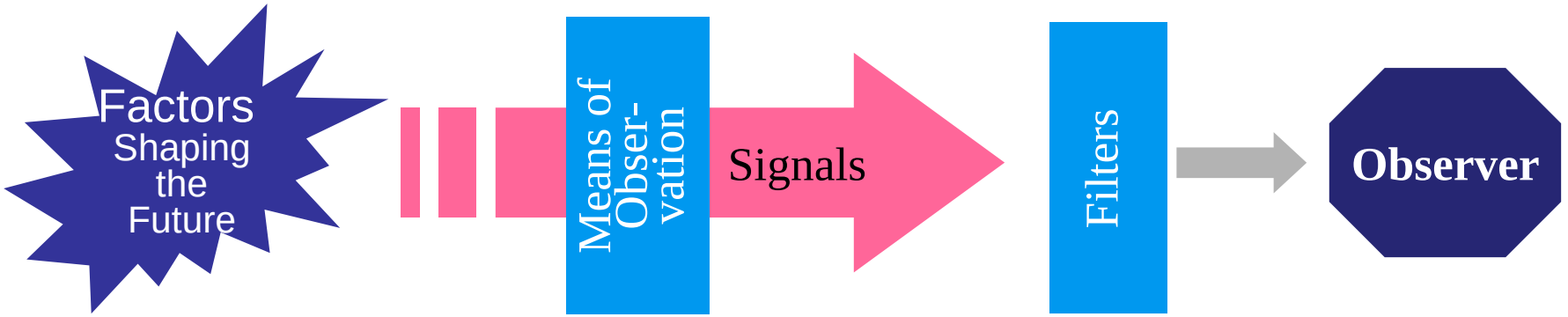
"Other issues will contain weak signals, imprecise early indications about impending impactful events..... all that is known (of them) is that some Threats and Opportunities will undoubtedly arise, but their shape and nature and source are not yet known."

Michel Godet:

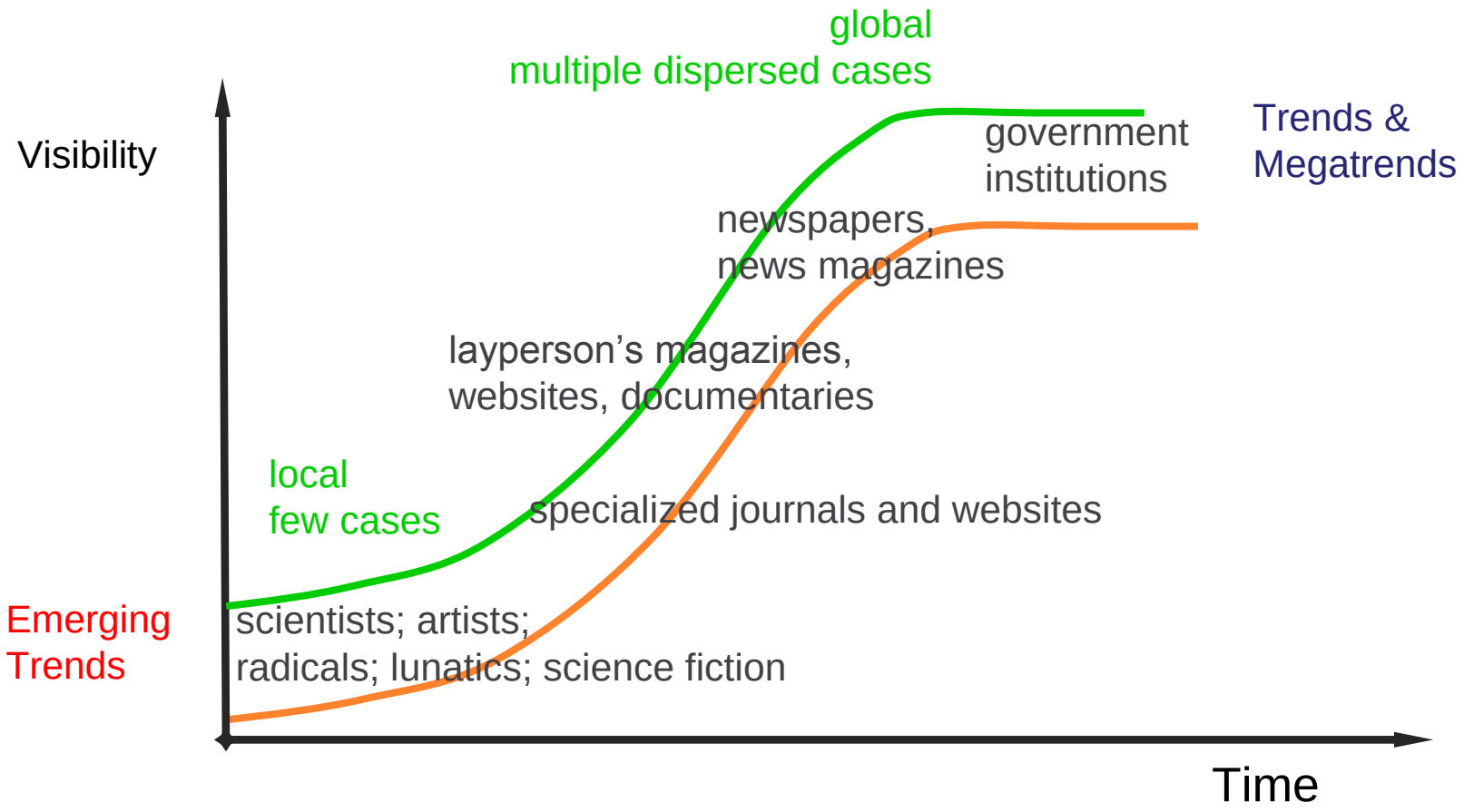
"...a factor of change which is now barely perceptible but will make up tomorrow's heavy or mega-trends."

But also indicators of ruptures, wild cards and other discontinuities

The channel model of weak signals

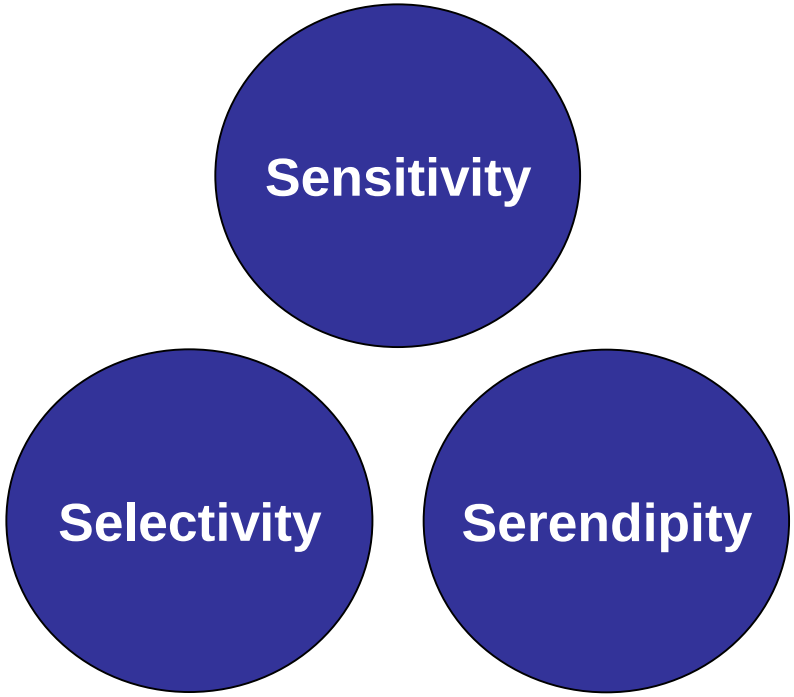


Where to Find Weak Signals?



© adapted from J. Coates, *Issues Management*

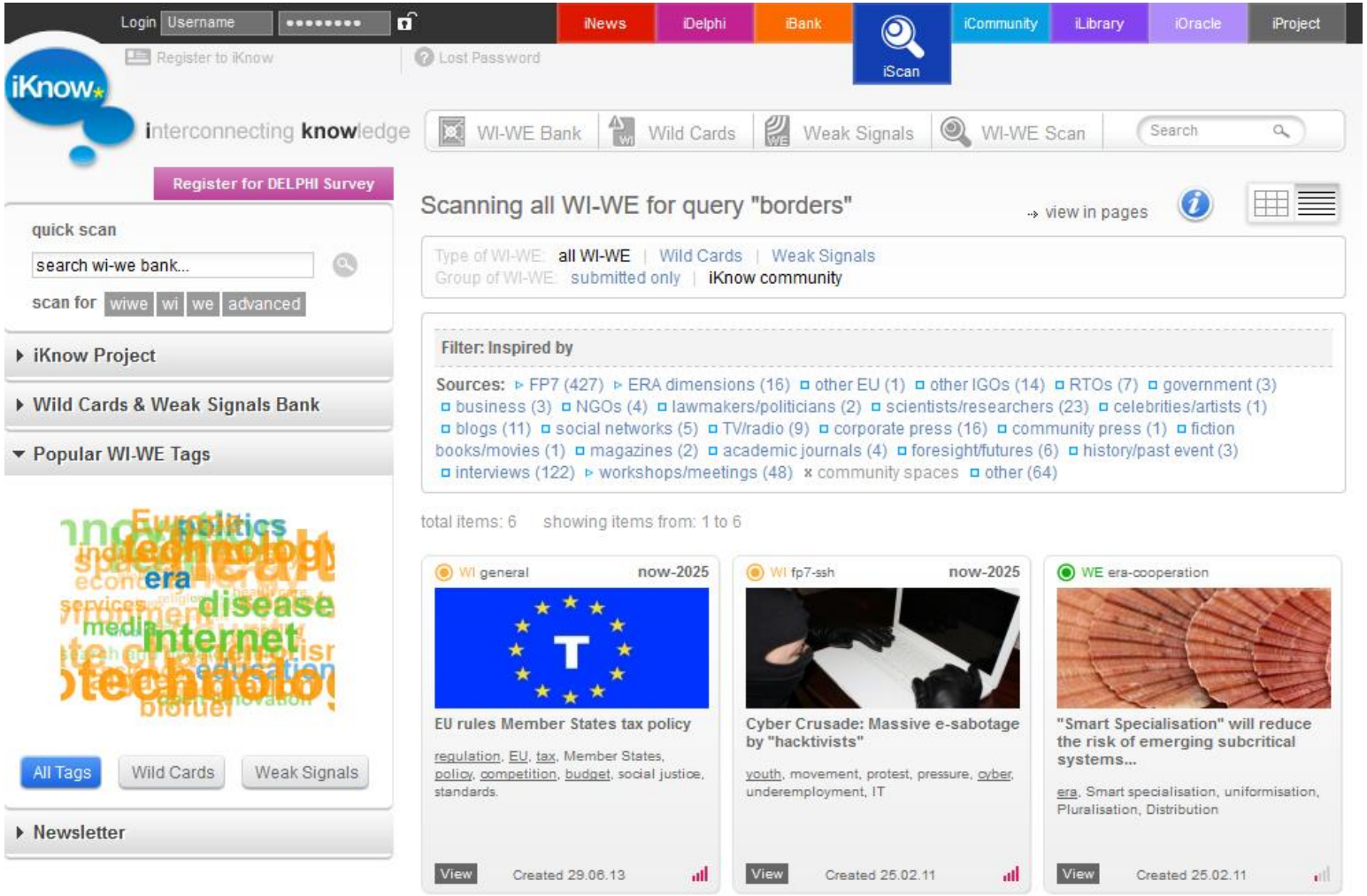
The 3 S of Weak Signal Search



- How to develop sensitivity?
- How to balance sensitivity vs. selectivity?
- How to organize serendipity?

There are too many and never enough weak signals.

Weak signals – Example: *iKnow* WiWe Bank



http://wiwe.iknowfutures.eu/

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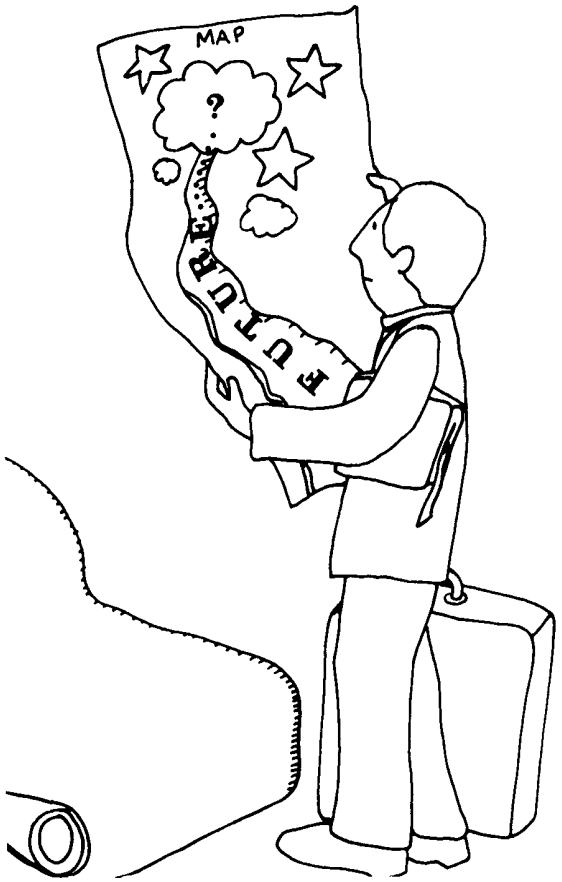


Technology Trend Analysis

Aims

- short and medium term projections, esp. for
  - technometrical parameters
  - technology diffusion
  - market potentials
  - other quantitative figures

As Starting Point for Further Analysis

- Trend Implications
- Delphi Surveys
- Scenario Generation
- Roadmapping
- Strategy Building

Trend

Trend (tendance):

- Measurable or observable change
- with a given direction
- within a given system
- over a defined period of time
- having impact on the future dynamics of the system

Inspired by Philippe Gabilliet, *Savoir anticiper, Les outils pour maîtriser son futur*, 1999, p. 167

Characteristics:

- Phenomenological description
- Relatively stable
- Often no information about underlying forces
- Always within a given system

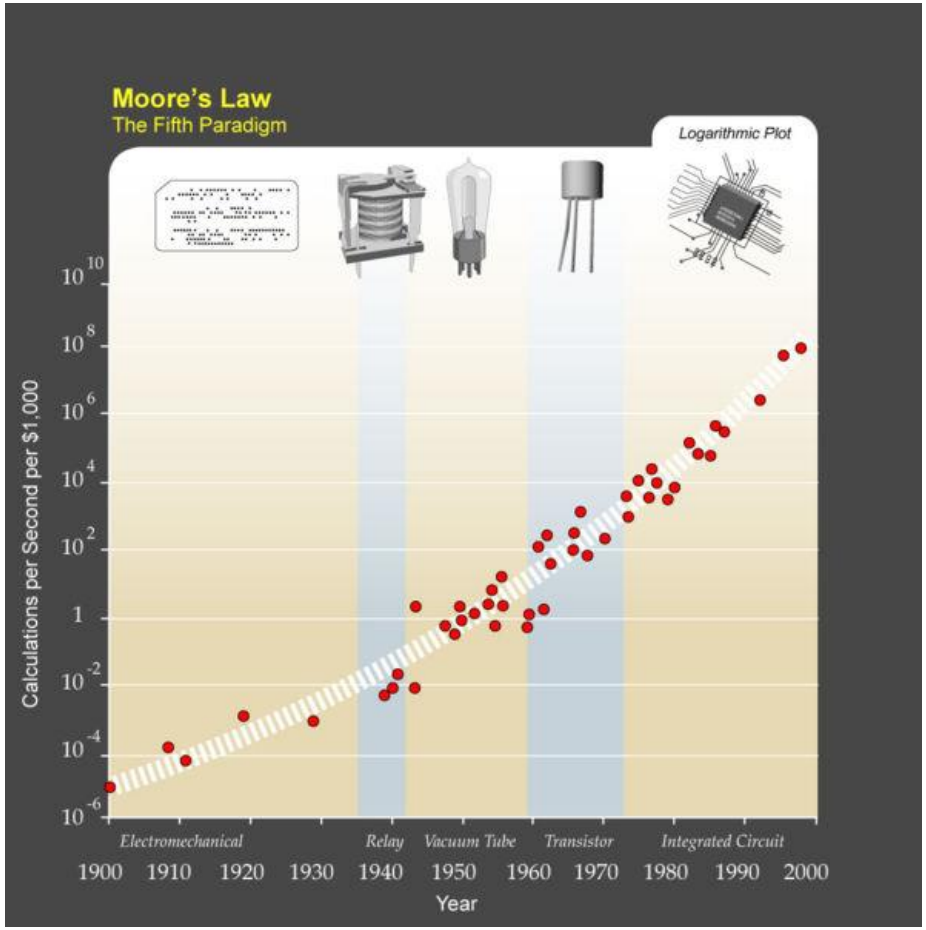
A trend is a trend is a trend.
But the question is, will it bend?
Will it alter its course
Through some unforeseen force
And come to a premature end?

(Sir Alec Caircross, Economic Journal 1969)

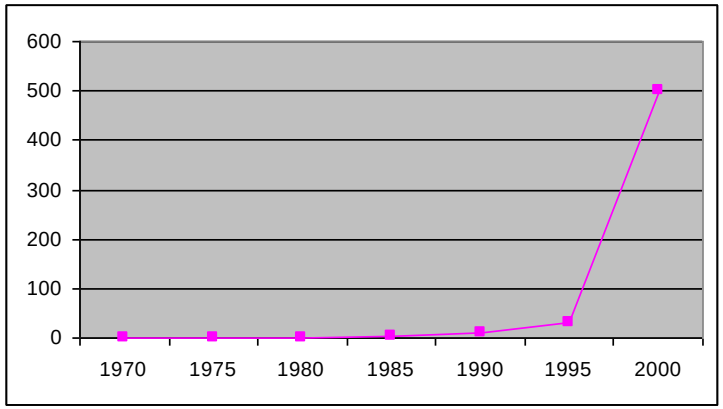
Trend Analysis: Procedure

- What is the empirical evidence for the trend?
- What are conditions, prerequisites for the trend?
- How stable is the trend?
- Which kind of dynamics? Linear? Exponential? …
- How long is the trend expected to continue?

Exponential Growth
Example: Moore's Law



Moore's Law:
twice the performance every 18 months



Logarithmic scale

Normal scale

Exponential Growth
Example: Cost per Genome

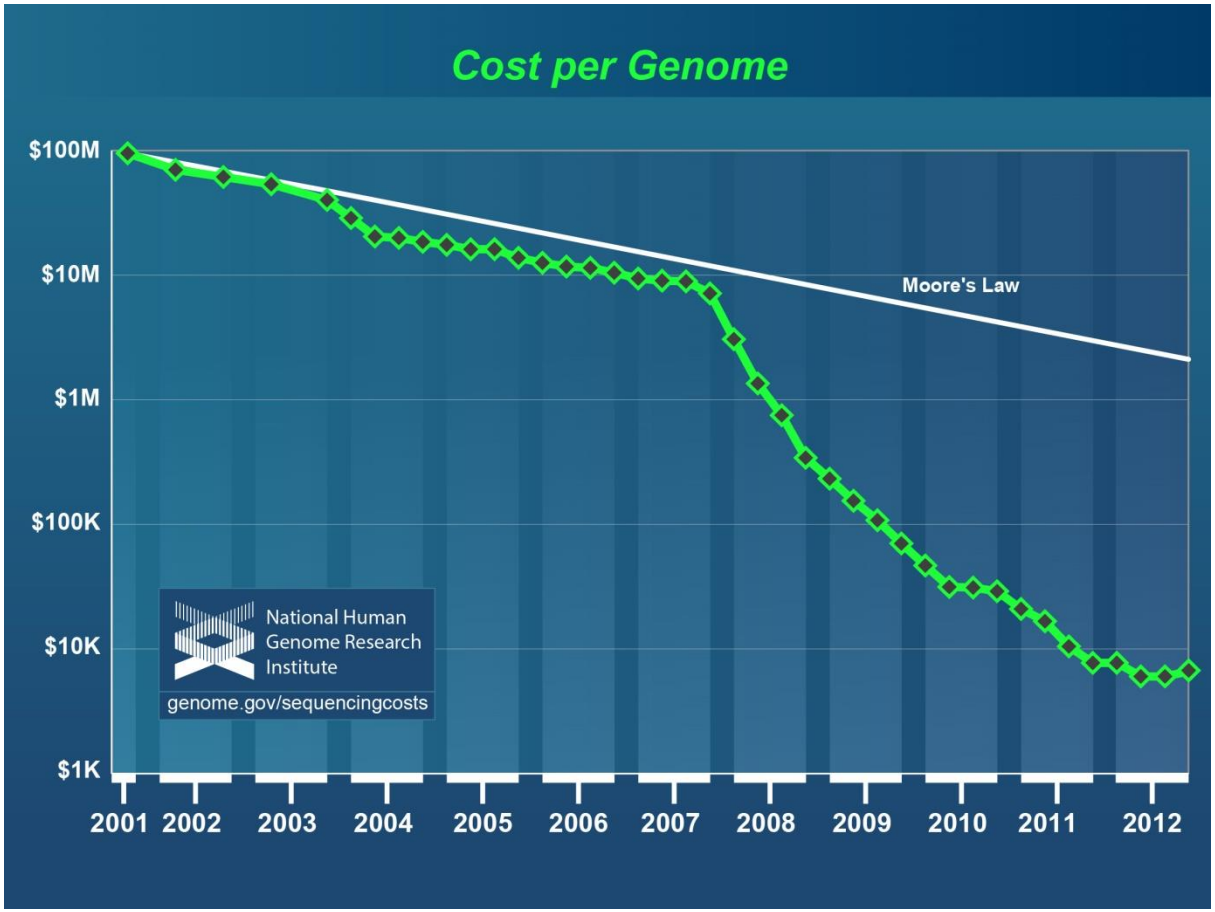
Today

- Genomics, Genetic engineering
- Proteomics, Metabolomics
- System biology

Tomorrow

- Synthetic biology
- Gene hacking
- Tissue Engineering

First mapping of the human genome (2000): USD 3 Bl.



http://www.genome.gov/pfv.cfm?pageID=27541954

Limits of Extrapolation

Subjective

- Bias of researchers
- Interest driven forecasts
- Hypecycles of public perception
- Conflicting interpretations

Objective

- Ruptures of trends
  - e. g. due to new breakthrough technologies
  - Due to qualitative, structural changes in the markets
- Insufficient data
  - Especially for emerging technologies, recent innovation etc. there are no sufficient data to fit the curves.

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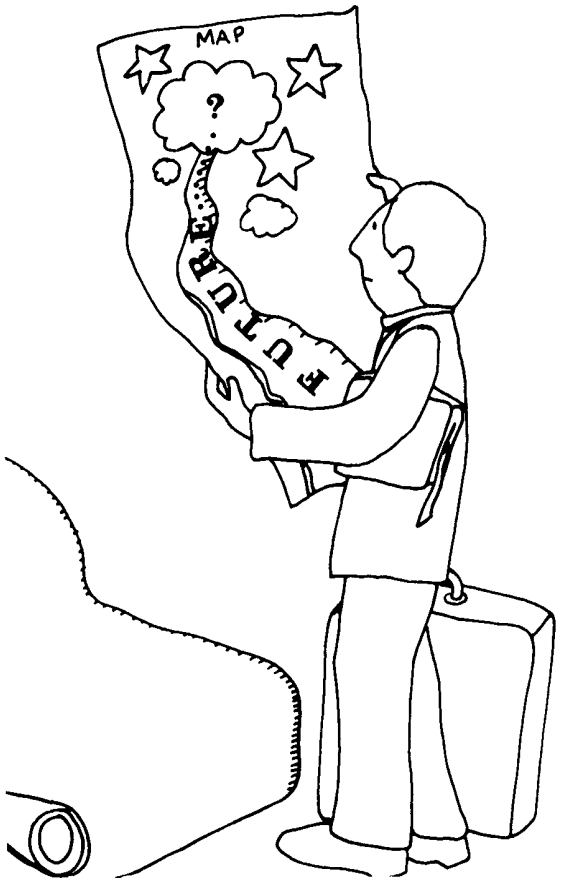
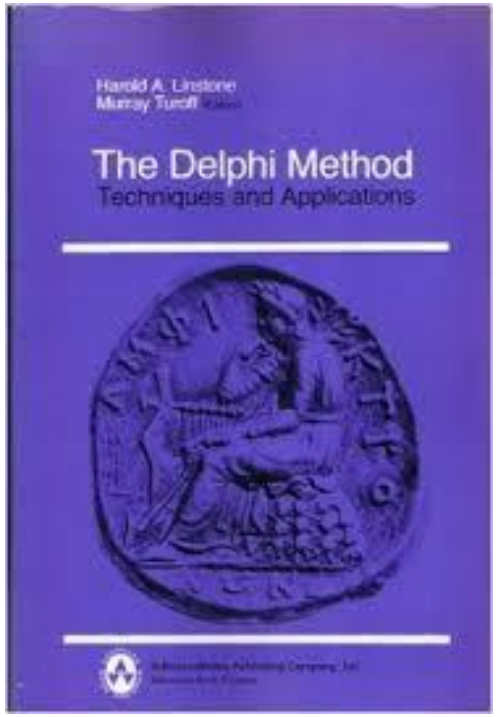


Delphi Studies

Delphi

is a procedure to "obtain the most reliable consensus of opinion of a group of experts... by a series of intensive questionnaires interspersed with controlled opinion feedback“ (Dalkey/Helmer 1963)

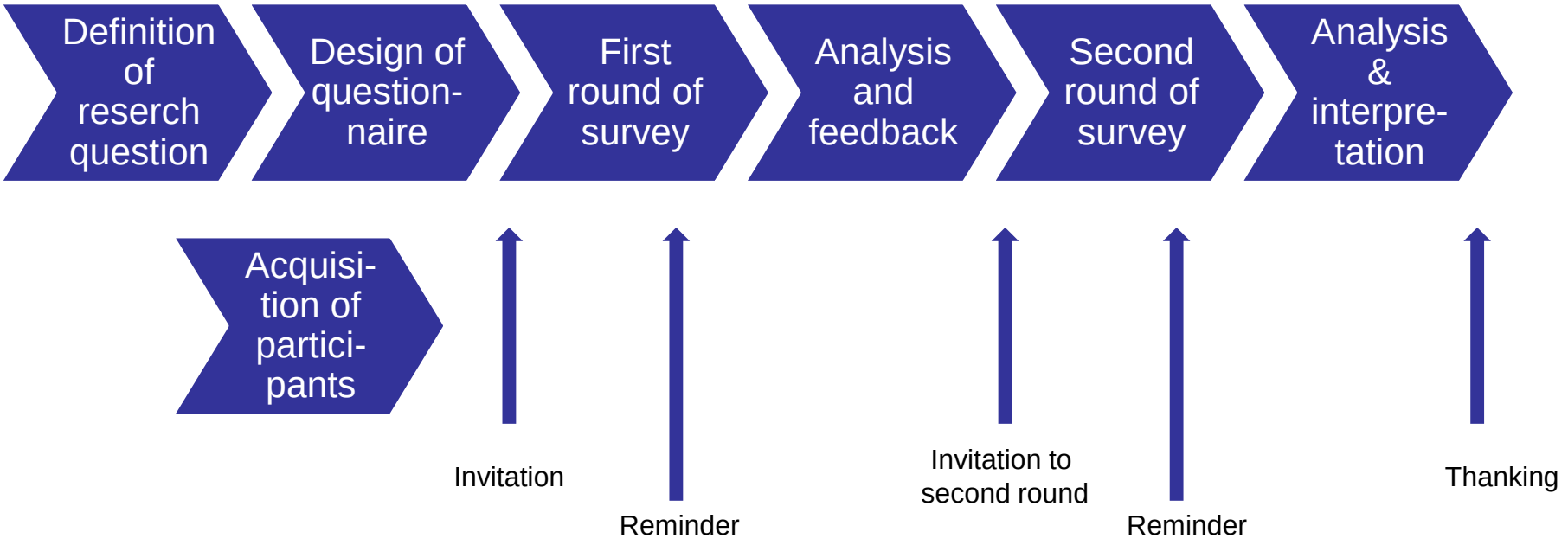


Uses, e.g.:

- estimation of times to technology breakthroughs
- establishment of roadmaps

„method of last resort“

Delphi Studies: Procedure



Real Time Delphi

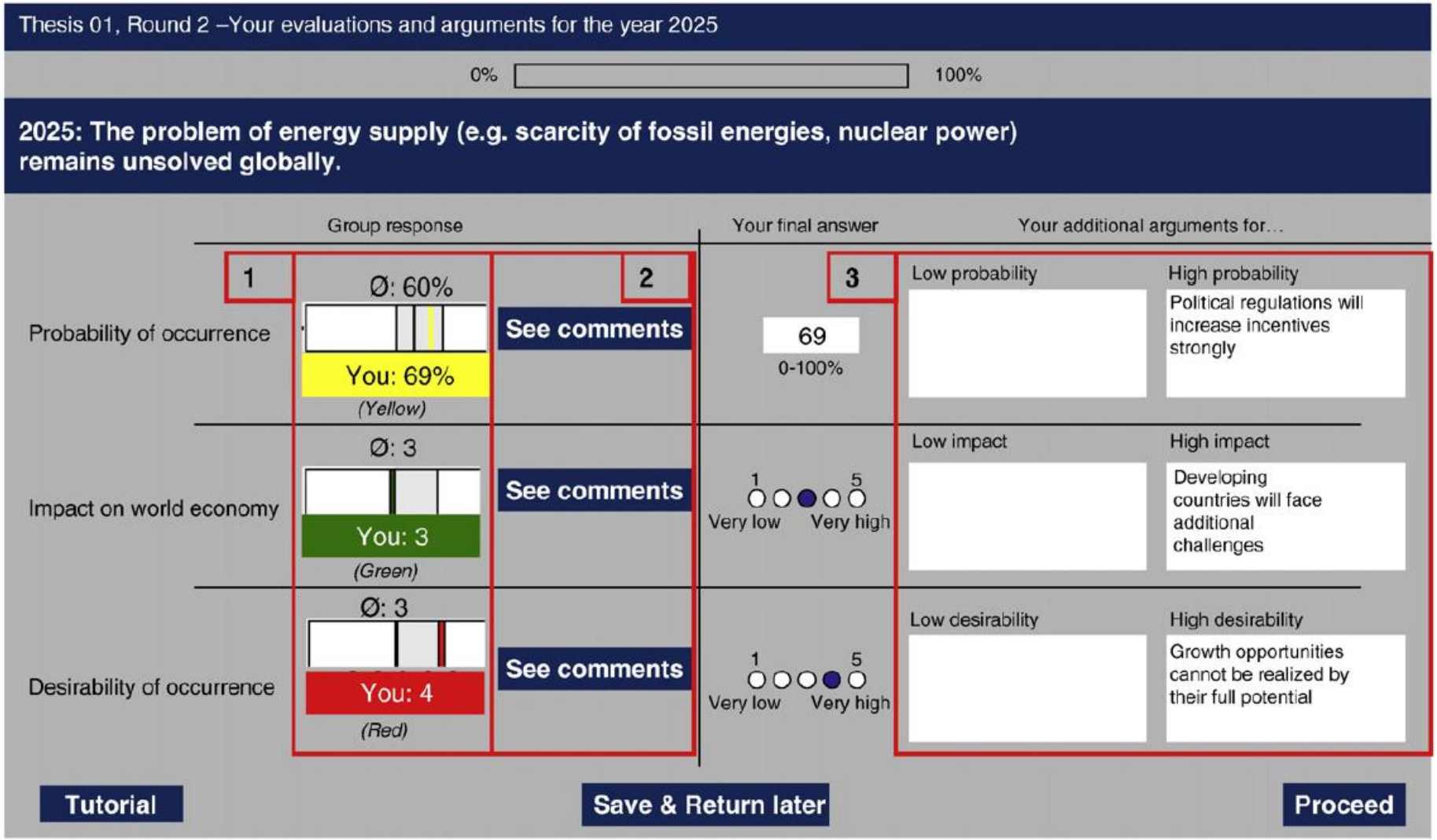
Advantages

- Online!
- Quick & flexible
- No separate rounds: participants may come back to the survey as often as they want

Attention

- Seed population of answers necessary
- Sample has to be large enough to avoid identification of participants

Real Time Delphi
Example: Feedback



Delphi Studies: Advantages and Challenges

Advantages

- Many ways to interpret results
- Pragmatic way to consensus
- Suited for organisations
- High impact, easy to communicate

Challenges

- Often: Lack of real experts
- Bias by popular images of the future
- Non-mainstream ideas filtered out
- Often: pro domo assessments
- No standards for Delphi studies

Delphi is no substitute for in-depth studies.

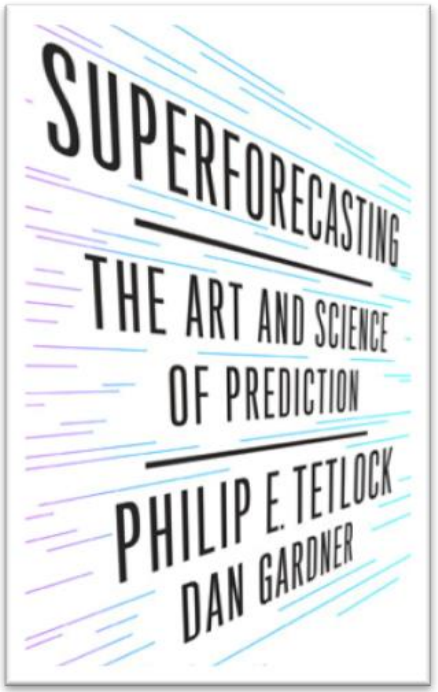
Comparison of Expert Based Methods

	Group Discussion	Expert Interviews	Delphi Surveys
Advantages	Intense & quick	Rapid & affordable	Comprehensive & Reliable
Disadvantage	Getting the group together		Several rounds → time consuming
Feedback	During group discussion	No feedback	Anonymized feedback
Group Dynamics	Opinion leaders and conformity Consensus possible	No consensus possible	Less conformity Consensus possible
Cognitive Processes	During group discussion	None	By means of feedback

The “Crowd” as Expert

Six Lessons about Crowd Prediction

- Forecasting accuracy is a matter of skill, not just luck.
- Forecasting training and teaming improve forecasting performance.
- Tracking top performers, and placing them in flat, non-hierarchical teams improves motivation, engagement and performance.
- Frequent, small belief updates are the marks of an accurate forecaster.
- Dispositional, behavioral and situational factors, as well as past performance, are highly predictive of individual accuracy.
- Probability prediction polls can produce more accurate crowd estimates than prediction markets.



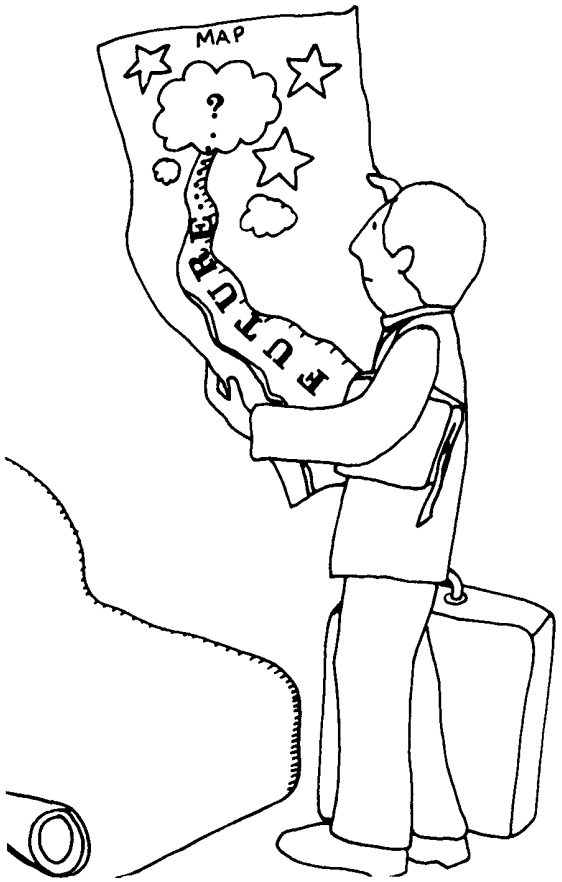
(2015)

The Good Judgment Project

Since 2011: prediction competitions
www.goodjudgment.com/

Overview

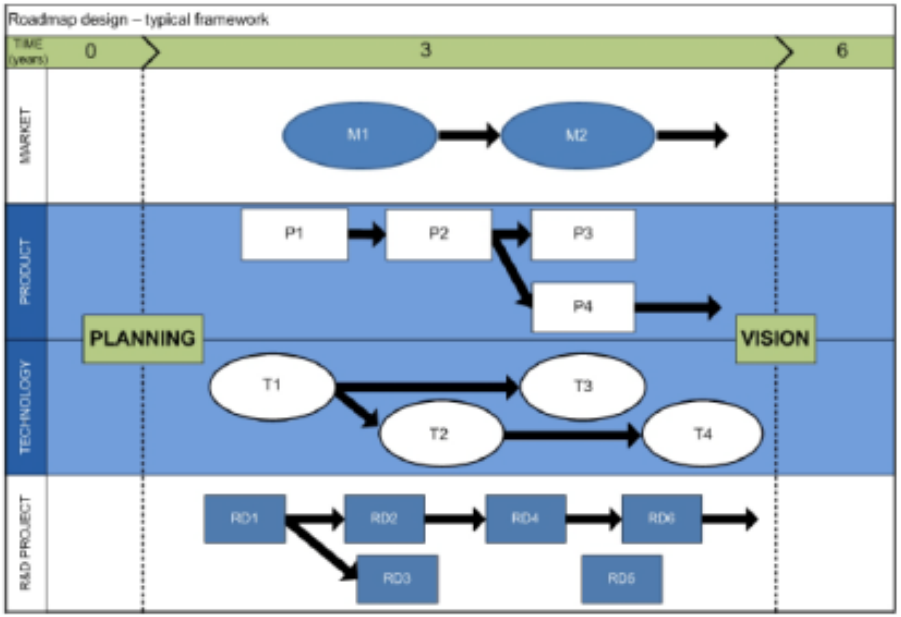
- Looking Back
- Technology Foresight
- Innovation Processes
- **Methods, Tools, Resources**
  - Horizon Scanning
  - Trend Analysis
  - Delphi Studies
  - Roadmapping
- Conclusion



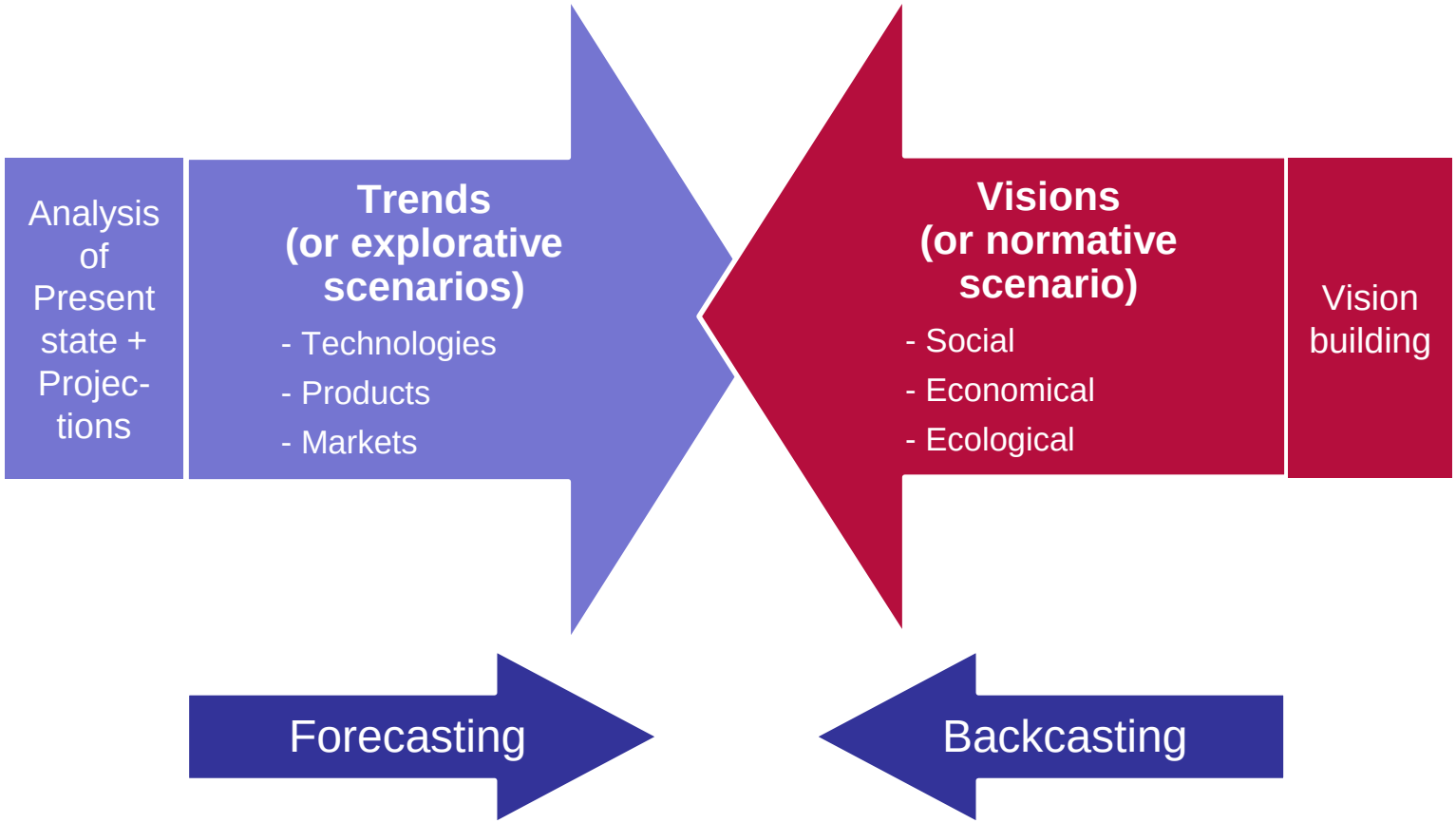
Roadmapping

Roadmap

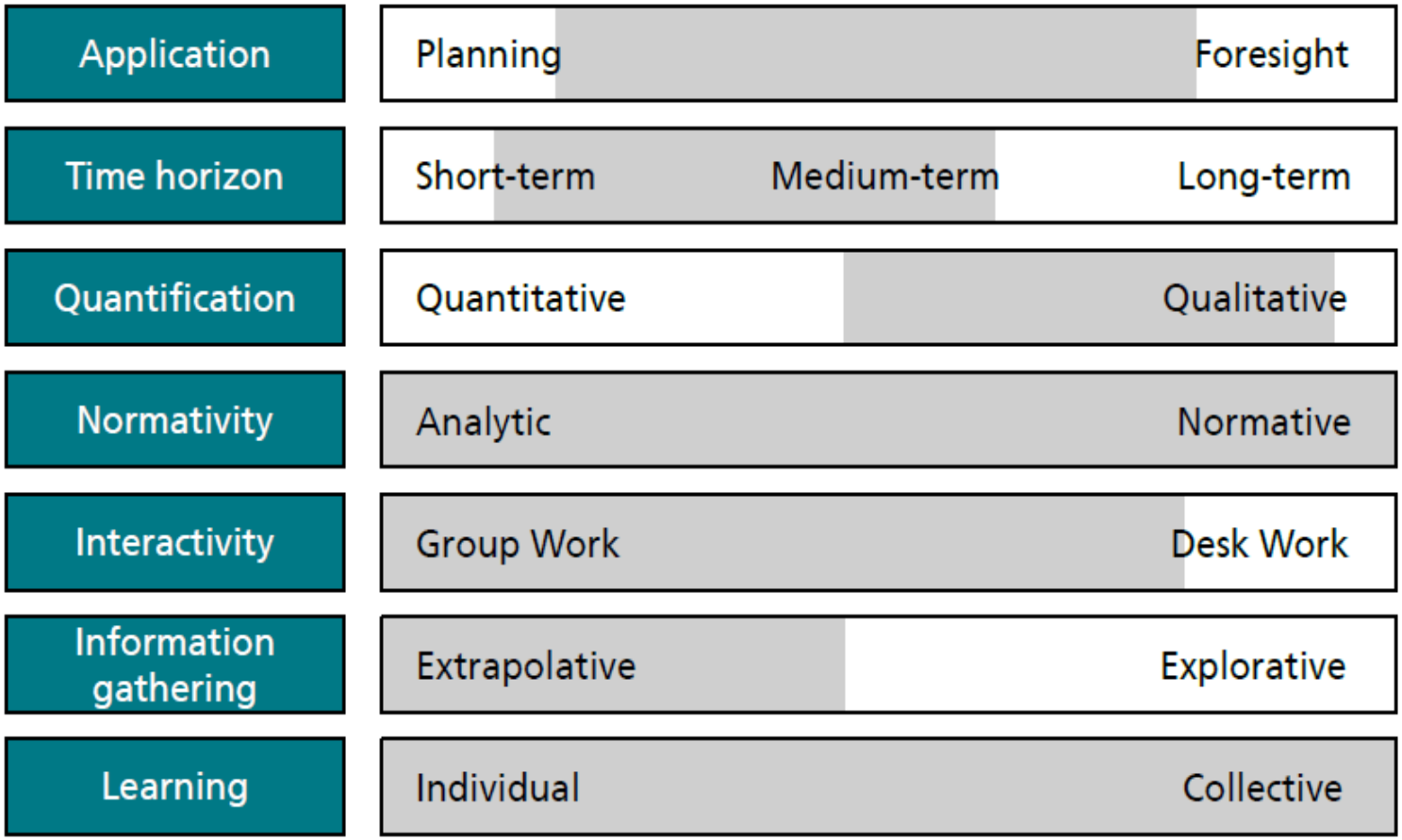
- graphic representation of events, decisions, trends etc. which lead to a fixed future state
  - Used as planning technique
  - Mostly for R&D processes
  - constructed by back-casting: Starting with the fixed future state, you ask first for immediate preconditions or requirements for this state, then for preconditions for these conditions etc. till you can connect to the present state.



Roadmapping: General Idea



Roadmapping: Different Types



Roadmapping: Procedure

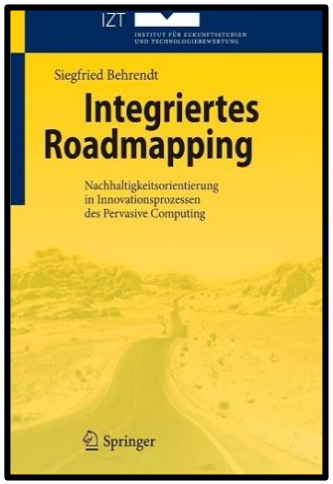
Preparation
- Bounding and framing
- Identification / invitation of experts

Structuring
- Definition of time horizon
- Structuring the search space (Topics and fields of action)

Roadmap Generation
- Identification of starting and final states
- Forecasting / Backcasting
- Identification of milestones

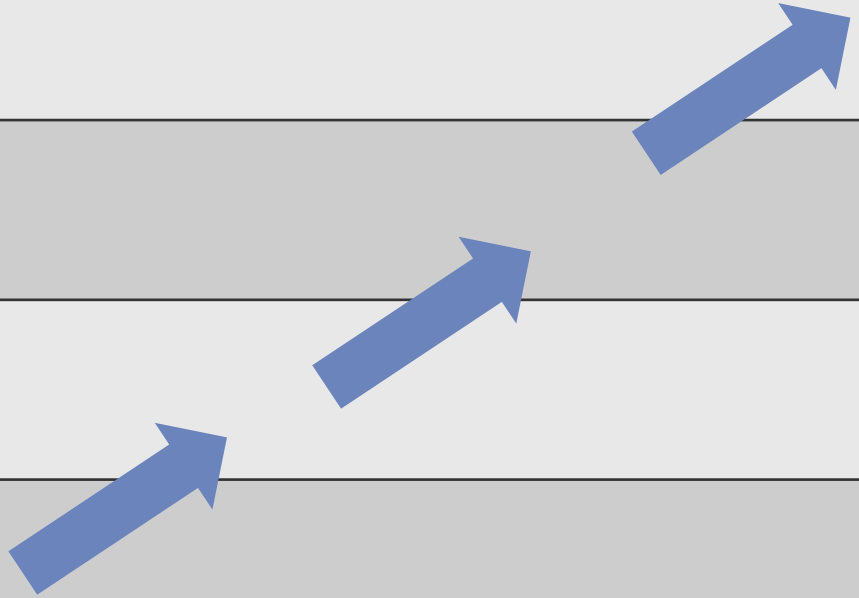
Validation
- Check of comprehensiveness
- Check of consistency

Implemen-tation
- Definition of task list
- Monitoring



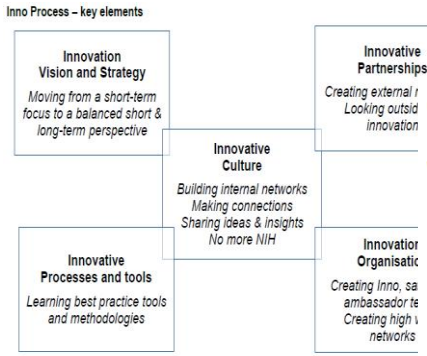
Roadmapping: Typical Fields

Societal Impacts	
Products and Services	
Technologies	
Socio-economic Framework Conditions	

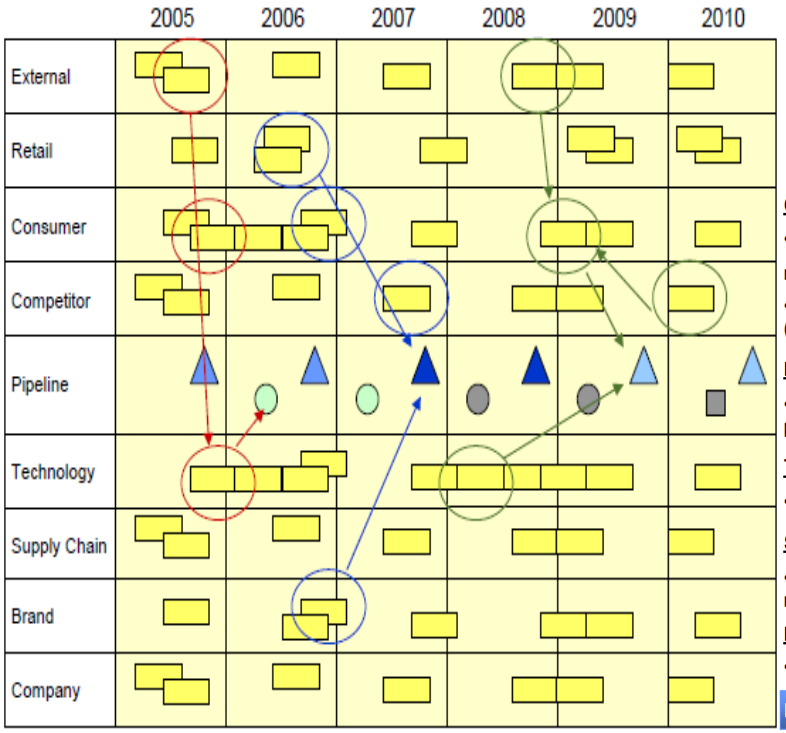


Arrows: Direction of impact

Innovation Process: Roadmapping Example



Connections between insights automatically (and systematically) lead to high value ideas



The WC Alessi Example

Consumer

- „cheap" rim block design identified to be main obstacle for further market penetration increase
- Nicely scented rim blocks seen to be "daily / affordable luxury" (CEE)

External

- Increasing importance of „design" as marketing instrument in parallel industries

Technology

- Henkel has leading knowledge in two chamber technology

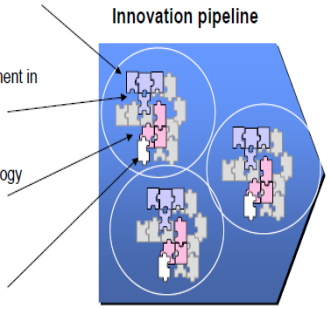
Supply Chain

- production in Hungary allows flexible and competition manufacturing

Brand:

- WC Brands to be enriched emotionally

Innovation: WC Two-Chamber Rim block designed by Alessi



Public presentation of Henkel Innovation Team

Roadmapping: Results

Advantages of Roadmapping

- Visualisation of complex processes
- Putting assumptions in concrete terms
- Definition of dimension, relation, events, milestones
- Focussing of complex relations and interdependencies on pivotal aspects
- Interdisciplinarity by participation of different expert groups

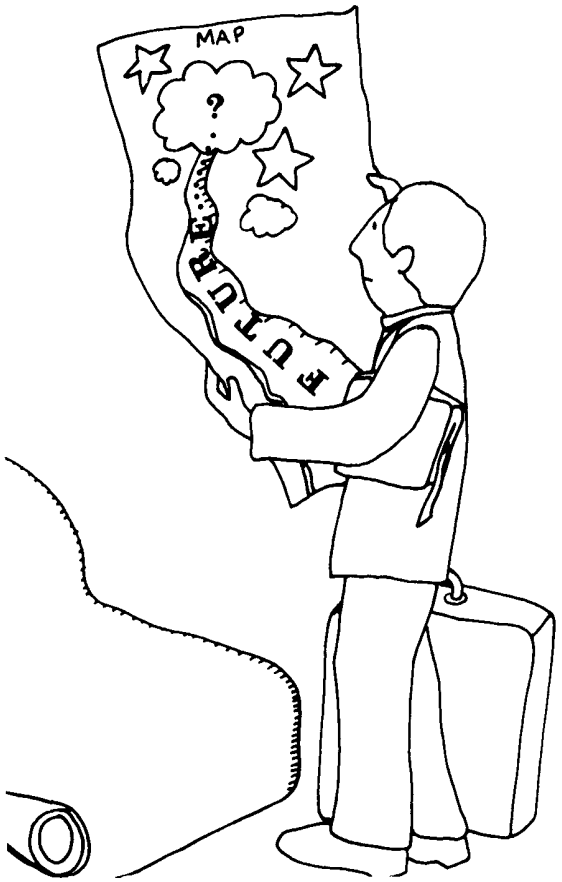
Results

- Identification of:
  - Important factors
  - Future developments (Trend analysis)
  - Critical path dependencies
  - Lock in situations (“Hen and egg problems”)
  - positive and negative impacts
- Definition of milestones
- Derivation of actions needed and tasks

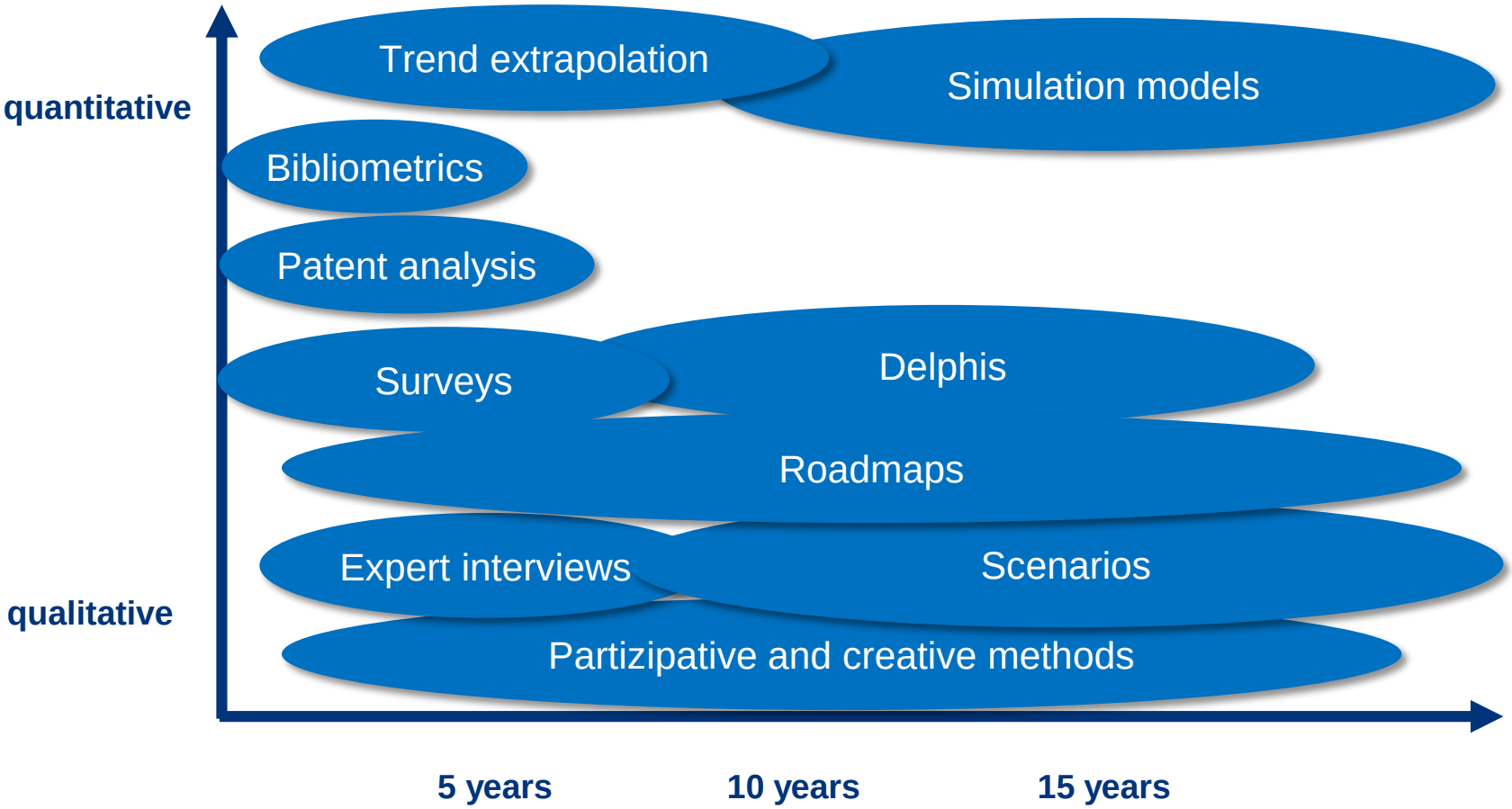
Looking from the present time into the future
versus
Looking from the future into the present day

Overview

- Looking Back
- Technology Foresight
- Innovation Processes
- Methods, Tools, Resources
- **Conclusion**



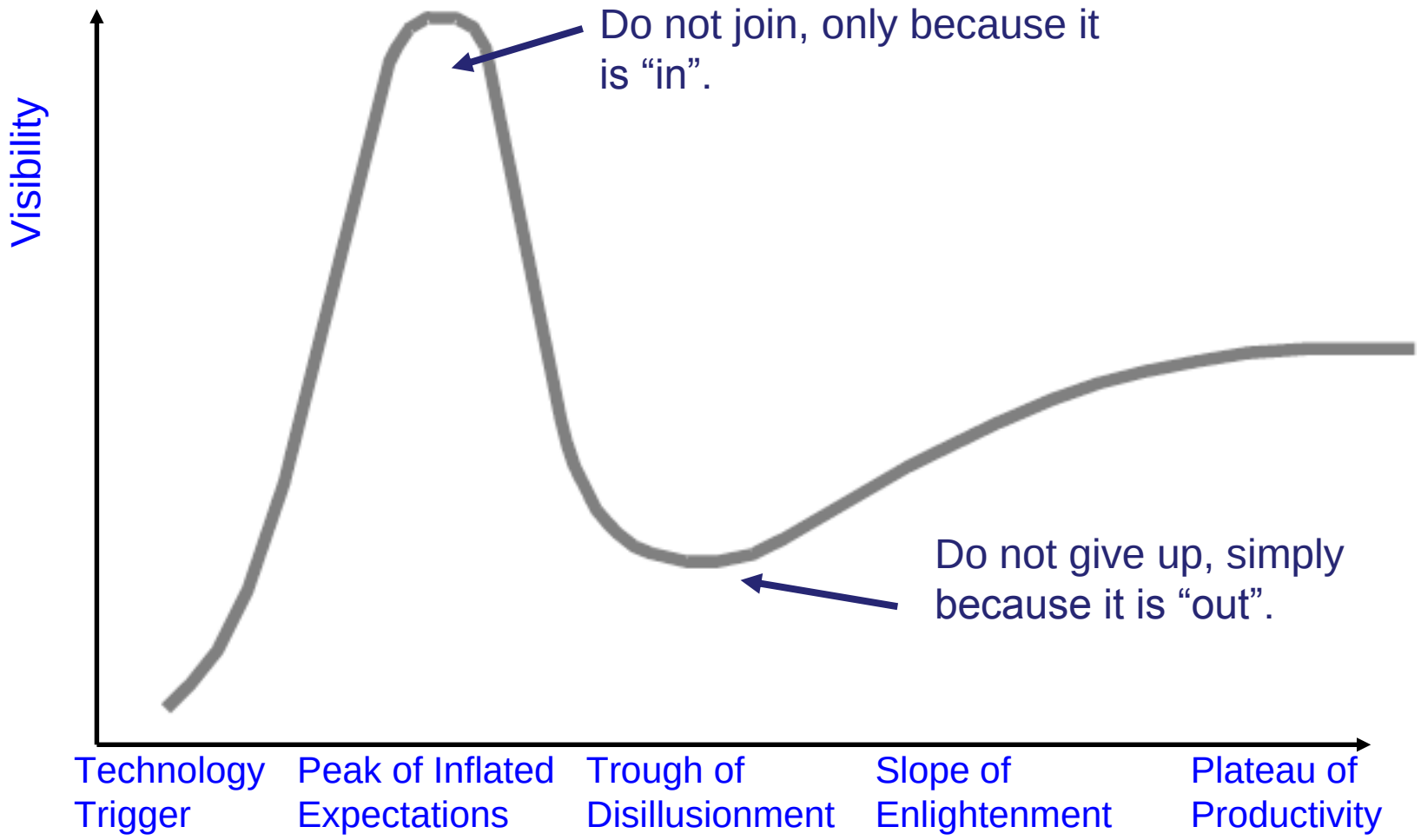
Many Pertinent Methods



Frequent Flaws in Foresight

- Linear extrapolation of trends
- Basic innovations: Underestimation of scope of applications
- Incremental innovations: Underestimation of time till market
- Technological feasibility mistaken for market demand
- No continuous monitoring
- Quantification, even where it is impossible or inappropriate
- Negligence of not quantifiable factors

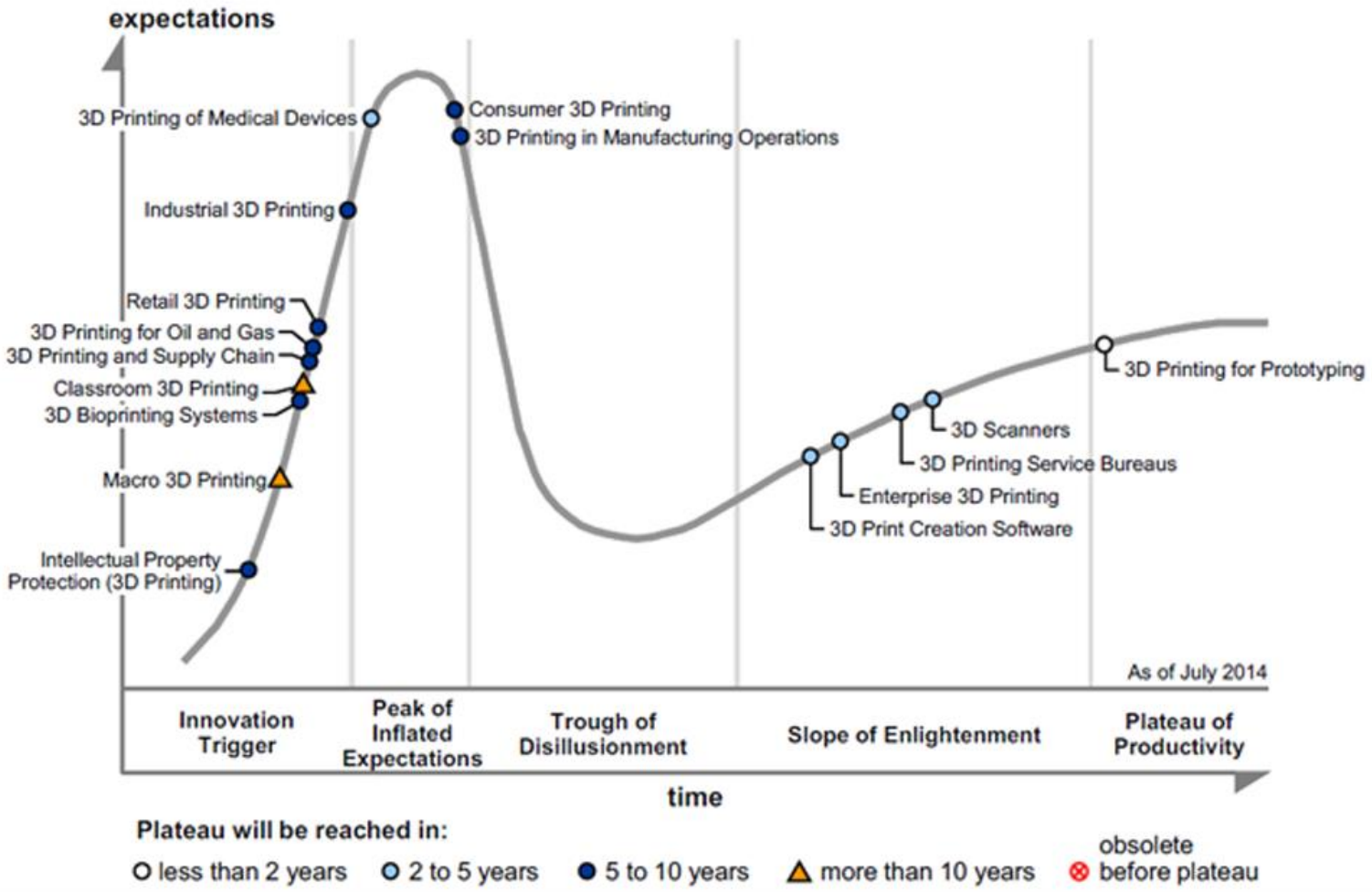
Hype Cycle: Insights for Innovation



http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

Hype Cycle – Example: 3D Printing

Figure 1. Hype Cycle for 3D Printing, 2014



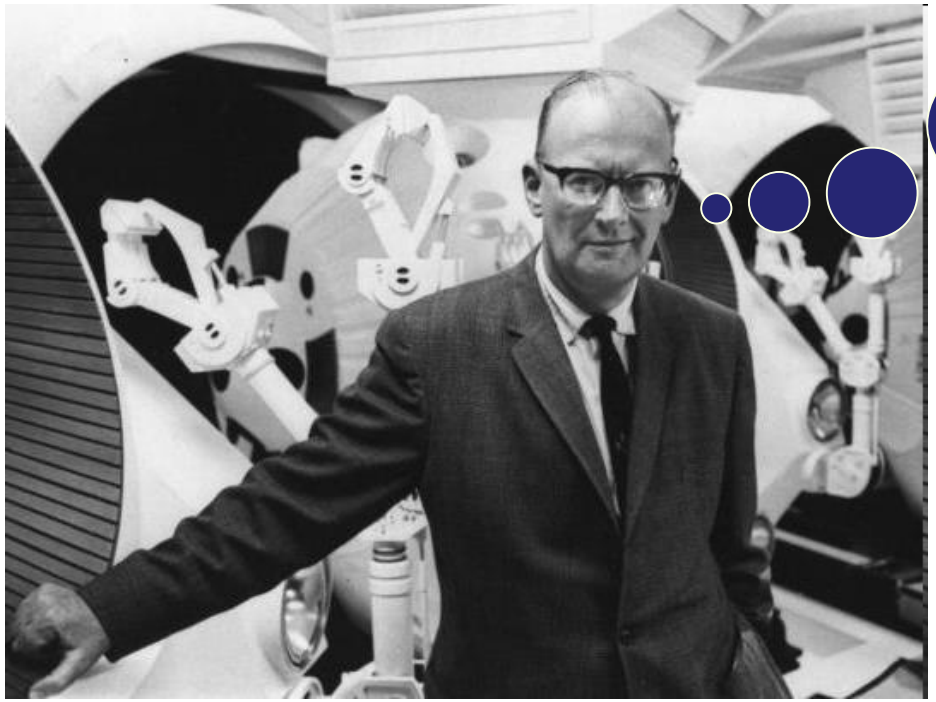
Future: 3D Printing Everywhere

http://www.dhl.com/content/dam/Local_Images/g0/aboutus/SpecialInterest/Logistics2050/szenario_study_logistics_2050.pdf

Summary

- Technology foresight provides insights in technology trends, drivers and future potentials.
- Methods for TF include trend analysis, delphi, roadmapping etc.
- All methods have specific advantages and limitations.
- Horizon scanning provides the necessary basis for all other tools.
- Interpretation of scanning results is crucial.
- Beware of the hype cycle!

A Final Comment

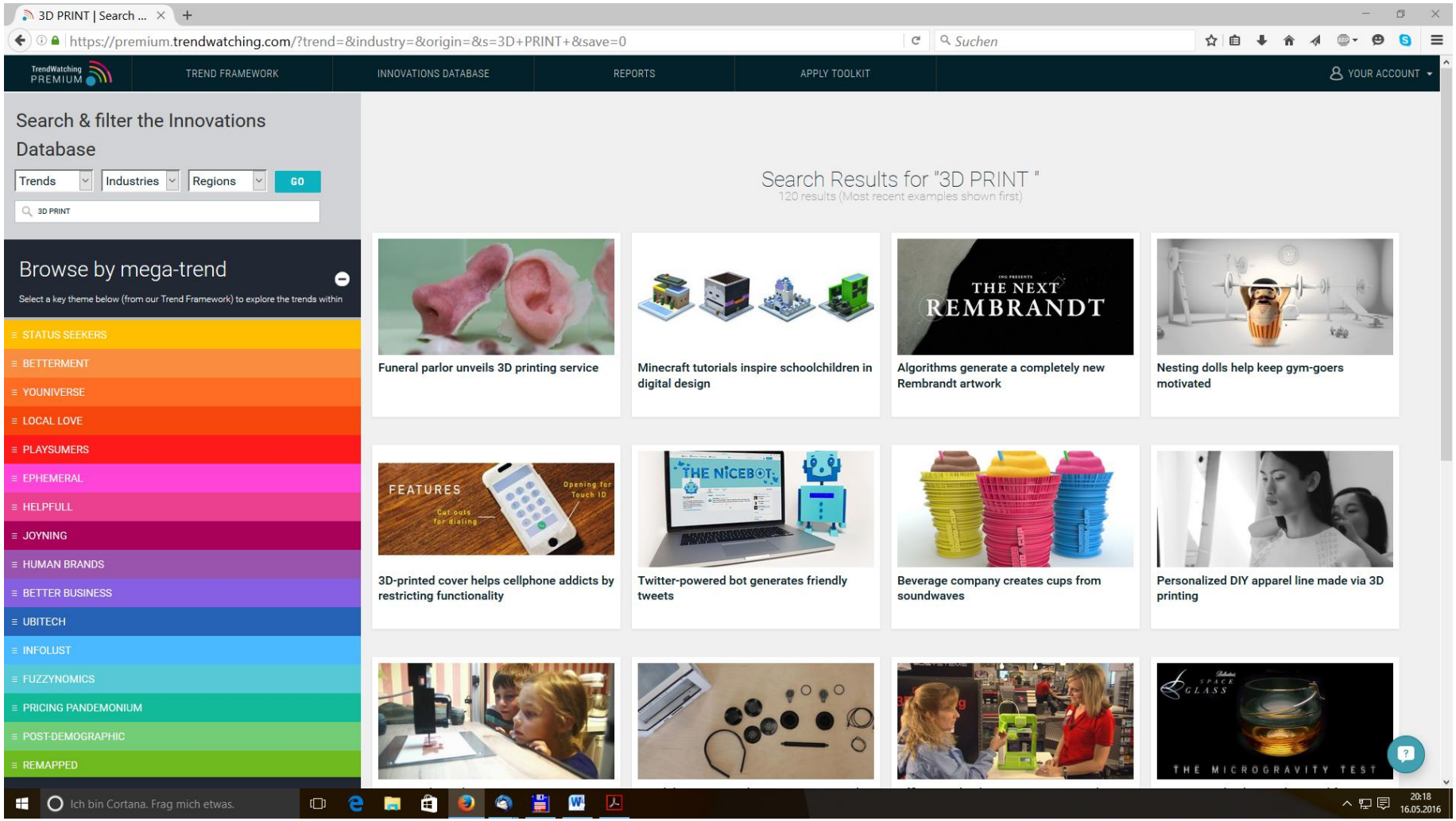


Arthur C. Clarke
(1917 – 2008)

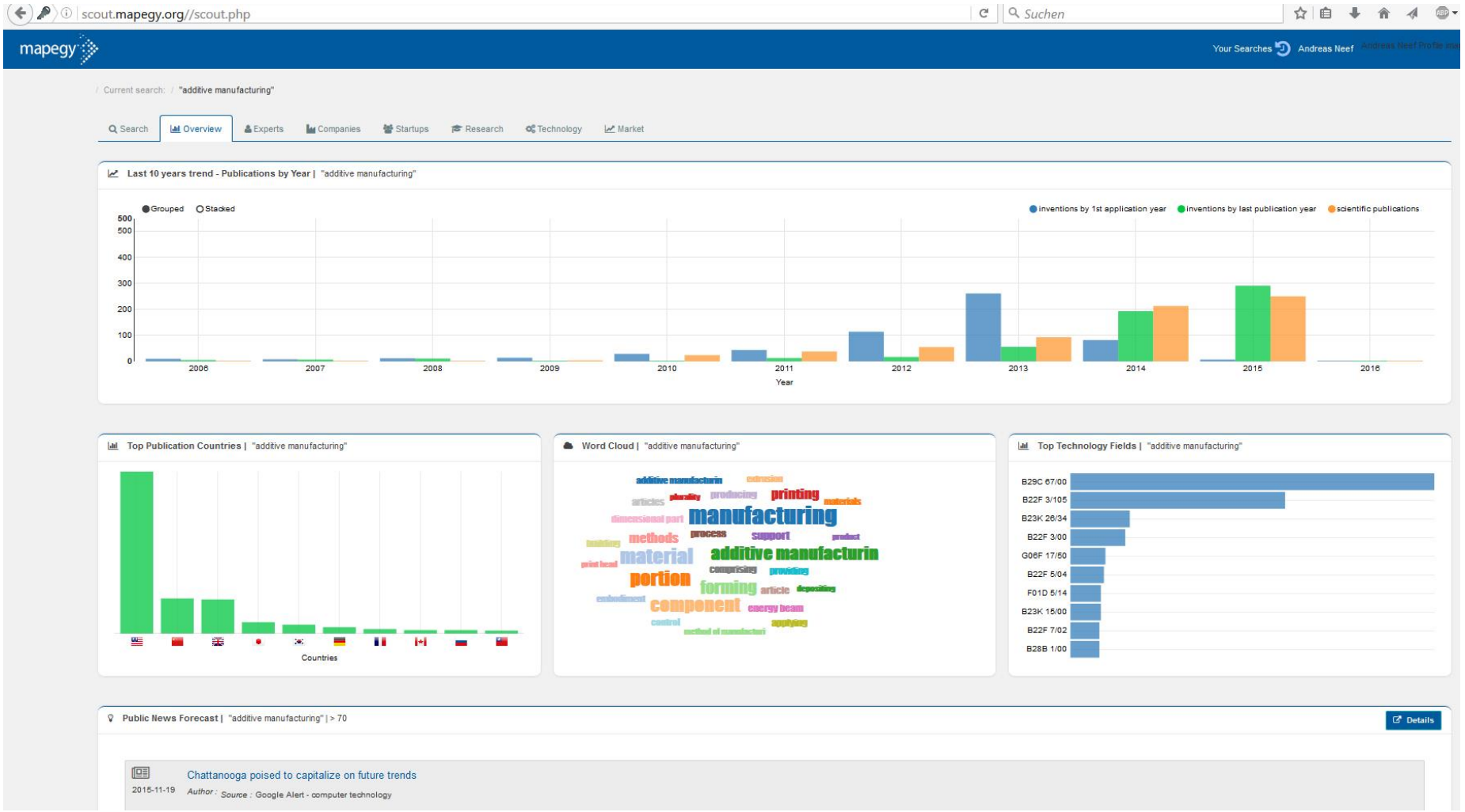
"The only way of discovering the limits of the possible is to venture a little way past them into the impossible."

PART 2
EXERCISE

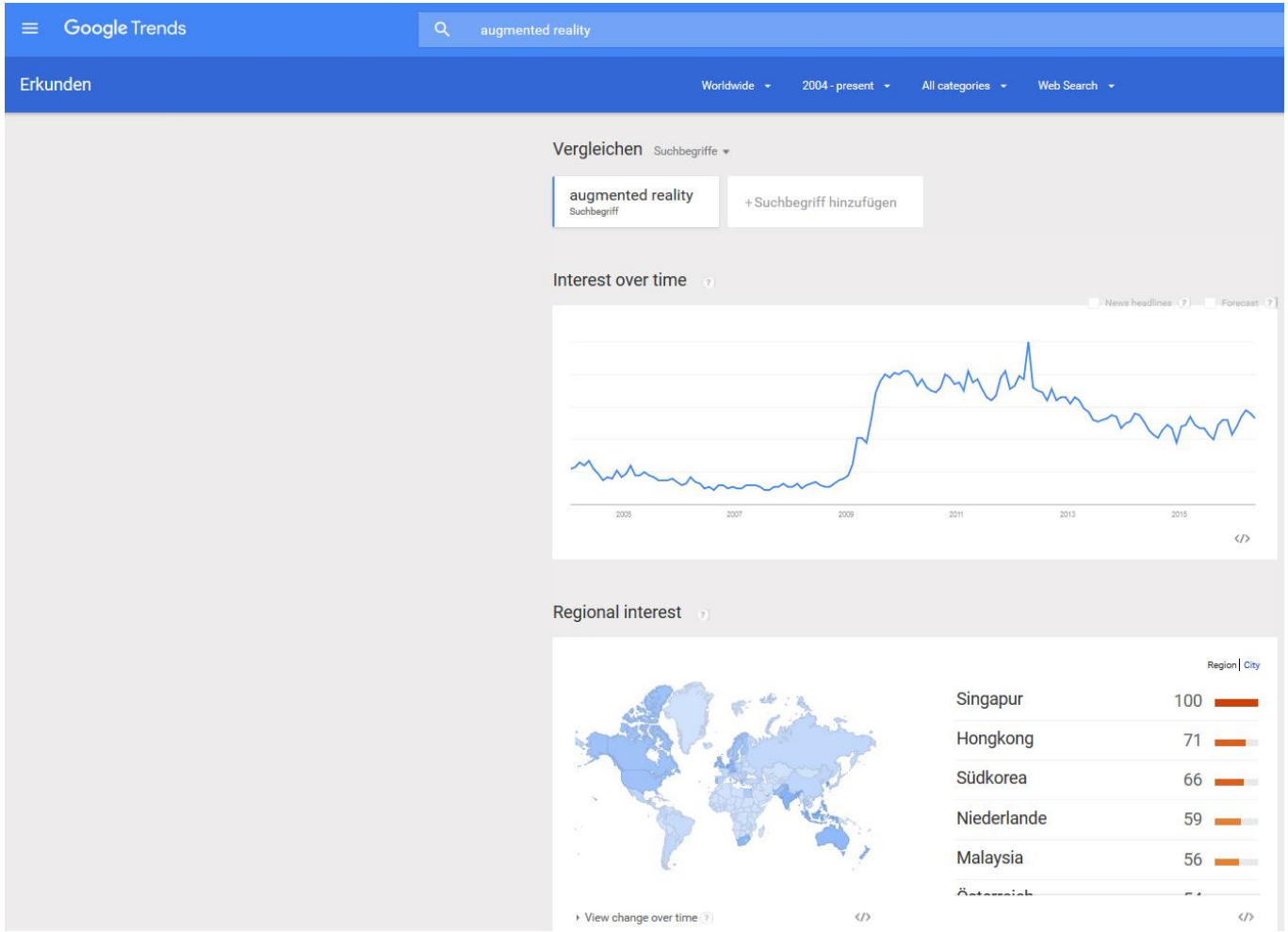
Sources & Resources
Example: Trendwatching



Sources & Resources Example: Mapegy



Sources & Resources
Example: Google Trends



Exercise

With Google Trends
(https://www.google.com/trends/)

1. Define start set of search words/concepts
2. Do search, collect main search findings
3. Look for searches with related or similar words/concepts (proposed by Google Trends)
4. Interpret results