SCIENTIFIC RESEARCH METHODOLOGIES AND TECHNIQUES

Unit 12: ROADMAPPING AND FUTURE PLANNING (I)

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PhD PROGRAM IN ELECTRICAL AND COMPUTER ENGINEERING

1. *FUTURES* RESEARCH

What is it?

Futures research - the science, art and practice of postulating possible, probable, and preferable futures.

It includes analyzing the sources, patterns, and causes of change and stability in the attempt to develop foresight and to map possible futures

Some methods:

- **Delphi method**
- **Trends identification and analysis**
- **Scenario development**
- **Roadmapping**
- **...**

A good information source:

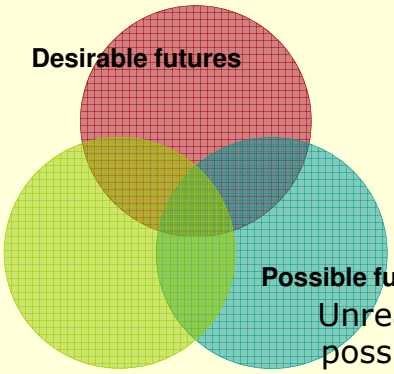
The Millennium Project
World Federation of UN Associations

www.unmillenniumproject.org

See also: www.ifla.org/IV/ifla61/61-weid.htm

The aim

Long-term notions
of the good society



Probable futures
Likely temporal development of societal problems

Possible futures
Unrealized but realisitic possibilities of problem solutions

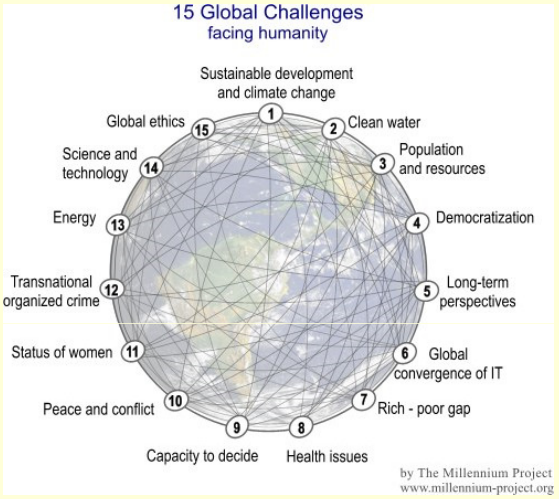
"Futures research" methodologies

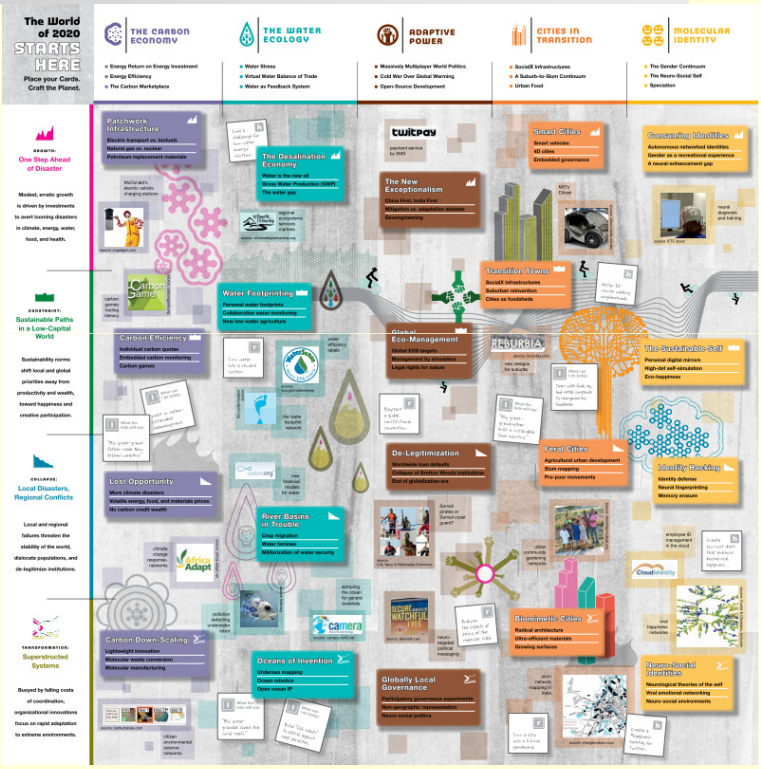
1. Introduction to the Futures Research
1.5 Evaluation and organization of Methods
2. Environmental Scanning
3. The Delphi Method
4. Real-Time Delphi
5. The Futures Wheel
6. The Futures Polygon
i7. Trend Impact Analysis
8. Cross-Impact Analysis
9. Wild Cards
10. Structural Analysis
11. The Systems Perspectives
12. Decision Modeling
l13. Substitution Analysis
14. Statistical Modeling
l15. Technology Sequence
16. Morphological Analysis
17. Relevance Trees
18. Scenarios
19. Interactive Scenarios (software)
20. Robust Decision making
21. Participatory Methods
22. Simulation and Games
23. Genius Forecasting and Intuition
24. Visioning for Strategic Planning
25. Normative Forecasting
26. TRIZ
27. S&T Road Mapping
28. Field Anomaly Relaxation (FAR)
29. Text Mining for Technology Foresight
30. Agent Modeling (demo software)
31. Prediction Markets
32. Forecasting By Artificial Neural Networks
33. State of the Future Index
34. SOFI Software System
35. Multiple Perspective Concept
36. A Toolbox for Scenario Planning
37. Heuristics Modeling
38. Personal Futures
39. Causal Layered Analysis
40. Linking Methods
41. Integration, Comparisons, and Frontiers

[Glenn, 2008]

www.clingendael.nl/cscp/events/20081216/20081216_presentatie_glenn.ppt

"Futures research" examples





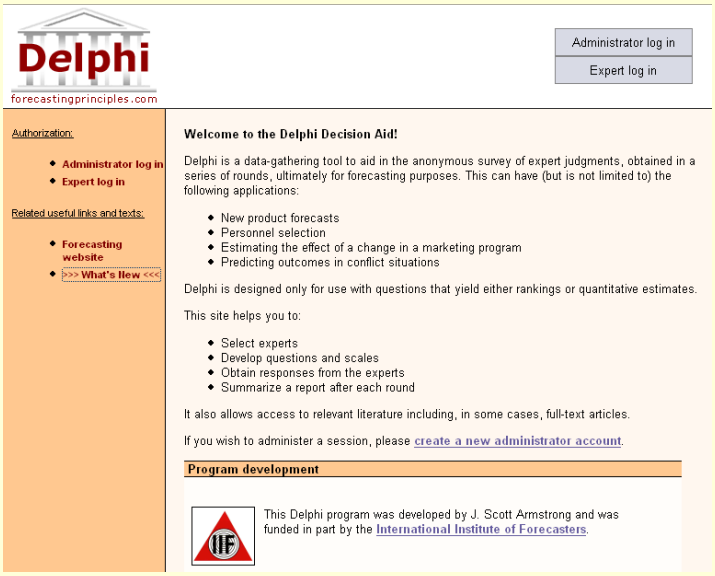
www.iftf.org/system/files/deliverable/SR1293_IFTF2010TYF_MapoftheDecade_1.pdf

Delphi method

"The Delphi Method is based on a structured process for collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback "

"The Delphi method is a systematic interactive forecasting method for obtaining forecasts from a panel of independent experts "

"A means of eliciting and combining expert judgments while avoiding the pitfalls of conference room confrontations." [Glenn, 2008]

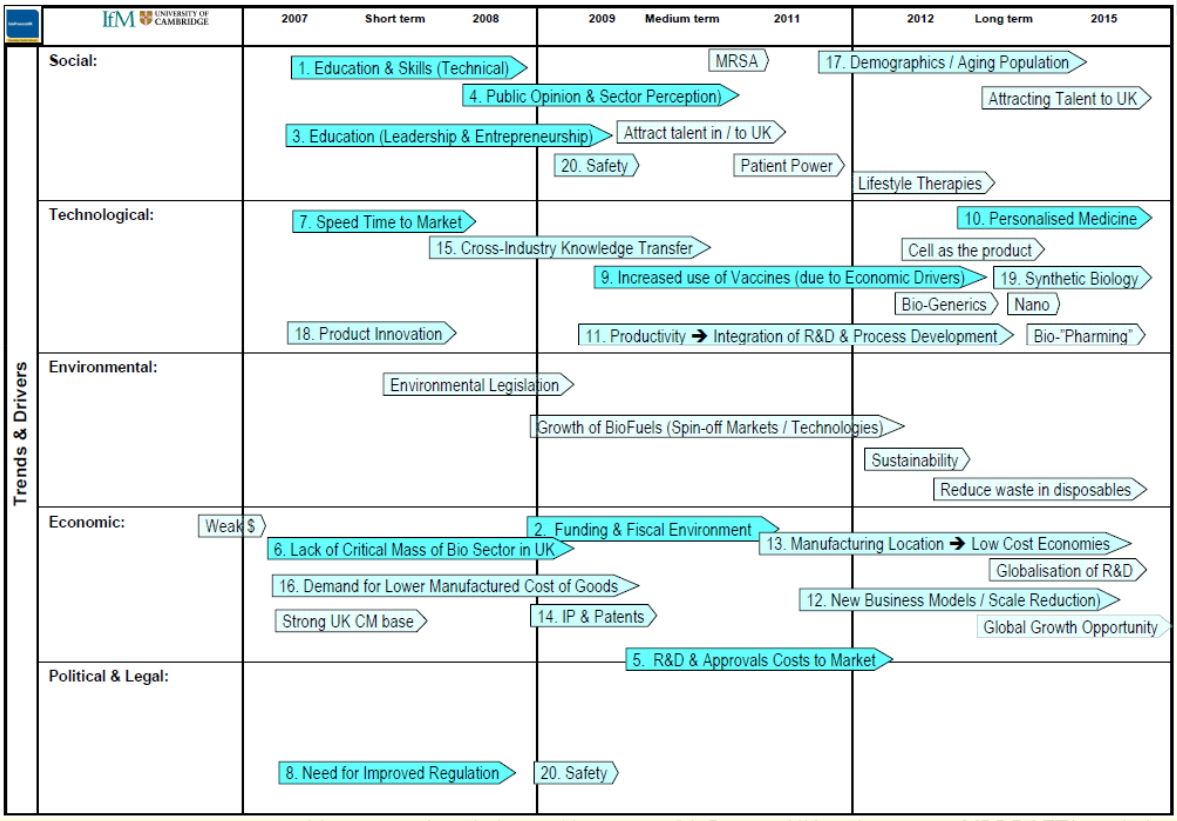


Software example:
http://armstrong.wharton.upenn.edu/delphi2/

Delphi method ...

1. Formation of a team to undertake and monitor a Delphi.
2. Selection of one or more panels to participate in the exercise.
   Customarily, the panelists are experts in the area to be investigated.
3. Development of the first round Delphi questionnaire
4. Testing the questionnaire for proper wording (e.g., ambiguities, vagueness)
5. Transmission of the first questionnaires to the panelists
6. Analysis of the first round responses
7. Preparation of the second round questionnaires (and possible testing)
8. Transmission of the second round questionnaires to the panelists
9. Analysis of the second round responses
   (Steps 7 to 9 are reiterated as long as desired or necessary to achieve stability in the results.)
10. Preparation of a report by the analysis team to present the conclusions of the exercise

Trends and drivers



www.bioprocessuk-website.org/documents/bioProcessUKroadmapreportMBDRAFTforwebsite.pdf

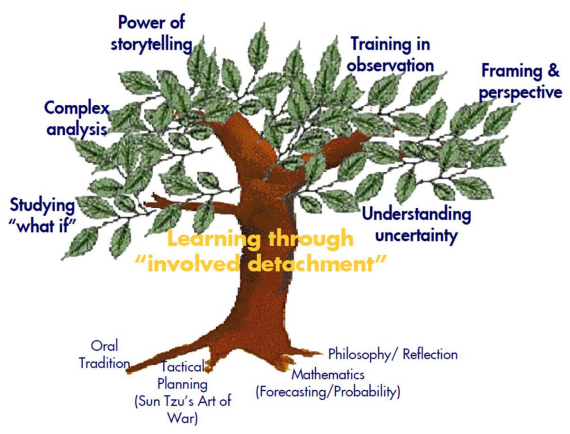
Scenarios planning

A scenario is a story with plausible cause and effect links that connects a future condition with the present, while illustrating key decisions, events, and consequences throughout the narrative.

Scenario planning is a method for learning about the future by *understanding the nature and impact of the most uncertain and important driving forces affecting our world.* www.well.com/~mb/scenario_planning/

Scenarios resemble a set of stories, written or spoken, built around carefully constructed plots.

[Glenn, 2008]



Roots of scenario thinking [Davis, 2002]

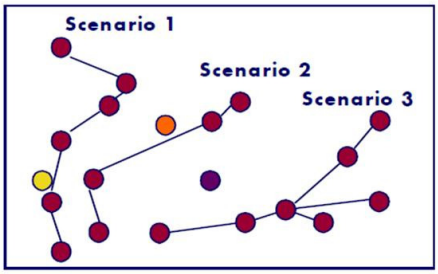
Scenarios: An explorer's guide
www-static.shell.com/static/aboutshell/downloads/our_strategy/shell_global_scenarios/scenario_explorersguide.pdf

Scenarios as a Tool for the 21st Century
www.casin.ch/web/bulletinboard/geddavisscenariosastool2002.pdf

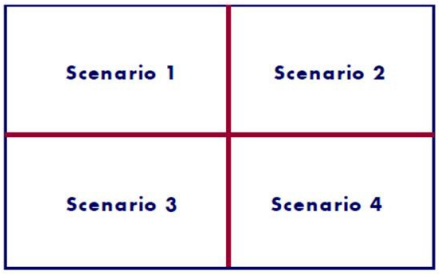
Types of scenarios

emerge from discussion and exploration of drivers and trends

choose two or more of those drivers to structure scenario worlds



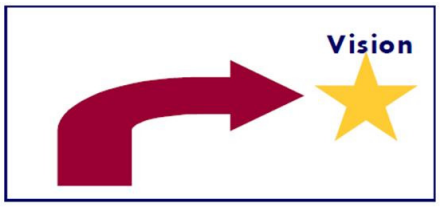
Inductive



Deductive

Incremental

similar to the official future - the one written in our strategic plans - but different enough to move the organisation in a different direction



Normative

the futures that we believe 'should' happen

[Davis, 2002]

Scenario building

Basic steps in a scenario planning exercise are:

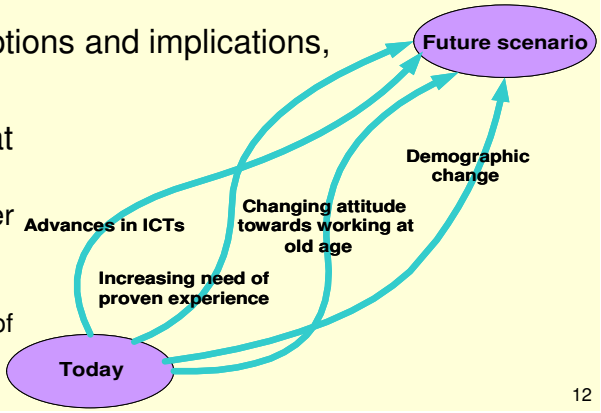
Stage 1: determine a focal issue or critical decision to 'anchor' the process

Stage 2: identify and analyze the internal and external driving forces after the decision
(these drivers are usually categorized into 'predetermined elements', those which we have a good idea about how they will play out over time - for example, demographics, and 'critical uncertainties', those which we have no real understanding of how they will develop into the future)

Stage 3: build scenarios (using inductive or deductive approaches)

Stage 4: identify robust potential strategic options and implications, and determine strategic options

Stage 5: identify drivers and other issues that need to be monitored over time (these are often called 'early warning signals' - to see whether something identified in a scenario is 'coming true' or is less likely to happen).
This last step is often neglected, but it is critical in terms of embedding strategic thinking in the organization.



Scenario example

A scenario in active ageing

José is apprehensive today. In fact he has been worried lately. Everything was different two years ago when he and his friend had this idea for an innovative low consumption air conditioning device and started their FreshAir company. The two engineers soon developed the new equipment thanks to their dedication and enthusiasm. But now they are facing difficulties. They don't know much about marketing or internationalization, although they understand the need to target a global market. Unfortunately they spent all their resources in the start-up phase and now cannot afford to get assistance from one of those big consultancy companies … Either something happens or may have to close and fire their employees soon…

Three weeks later …
José and his colleague are having a meeting with Carlos and Ana, two members of the local branch of the Regional Development Agency (RDA). After some initial contacts, Carlos and Ana spent some time in the company making an analysis of its problems and today they are presenting their conclusions. The diagnosis seems logical to José. It is clear that FreshAir needs some coaching and specialized guidance in two crucial areas – focused marketing and internationalization.
But they cannot afford the high costs of such specialized assistance. RDA, an organization funded by the local government and that aims to promote local businesses, made the analysis for free. Unfortunately they do not have the expertise to help in the next phase …
Guessing the worries passing through José's mind, Ana told them that there is a potential solution. Then she mentioned the ActiveSeniors association …

Pedro is a retired professional, member of ActiveSeniors. Based on his specific expertise and experience in marketing, he was invited to join a team involving 2 other members of ActiveSeniors with competencies in internationalization and air conditioning. Together with Carlos and Ana from RdA, this team started a temporary collaborative network with people from FreshAir. After 3 months the first results are starting to show up. The ActiveSeniors team not only provided technical assistance and guidance, but also helped FreshAir establish some contacts with a new market in India. Now the business prospects for the young company started to seem brighter…

Pedro is quite satisfied for having this opportunity to work on a topic where his experience was a real added value. He very much appreciated the diagnosis and preparatory work done by RDA, which allowed him and his senior colleagues to focus on the core issues. Working in a team was a great experience. The small payment Pedro received is also great to complement his pension and give him some better living conditions. FreshAir and RDA could mobilize some resources to pay a small fee to the 3 members of ActiveSeniors, a value much lower than the typical consultancy prices that could never be afforded by FreshAir.
Carlos and Ana got a special recognition from their boss at RDA for being successful in helping a local company and thus creating better economic prospects for the region.
José and his friend re-gained their enthusiasm and they really appreciated the value of this collaboration endeavor with RDA and ActiveSeniors. They certainly plan to keep the contact and look forward to using again this amazing pool of expertise and experience available at ActiveSeniors.

[ePAL project, 2008]

2. ROADMAPPING CONCEPT

Roadmapping concept

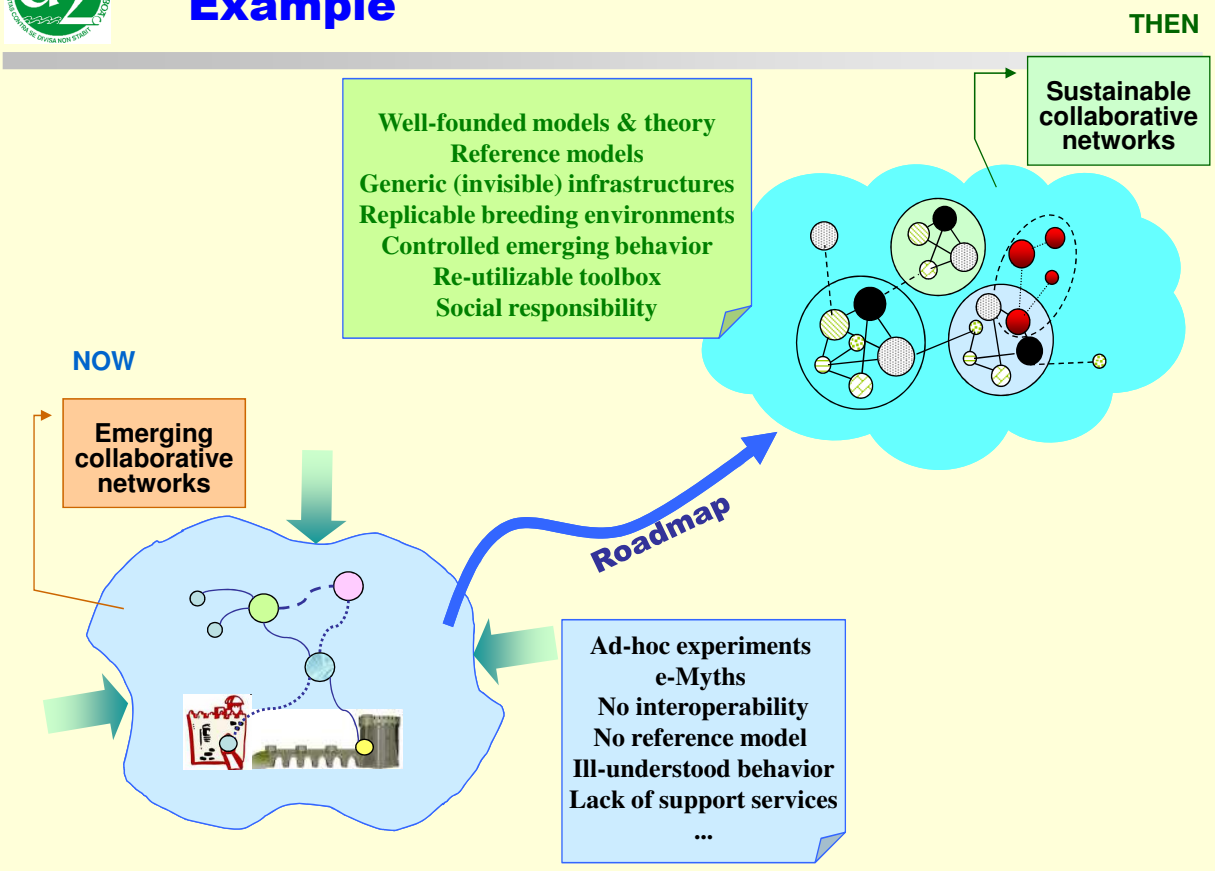
"A 'roadmap' is an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of change in that field."

[Galvin 2002]

"Roadmapping is a popular metaphor for planning and portraying the use of scientific and technological resources, elements and their structural relationships over a period of time. The process of roadmapping identifies, evaluates and selects strategic alternatives that can be used to achieve desired objectives, and the resulting roadmaps summarise and communicate the results of key business decisions".

[Vähäniitty, et al. 2004]

Example



Types of roadmaps

- Science and research roadmaps
- Cross-industry roadmaps
- Industry roadmaps
- Technology roadmaps
- Product roadmaps
- Product-technology roadmaps
- Project and issue roadmaps

Types of roadmaps ...

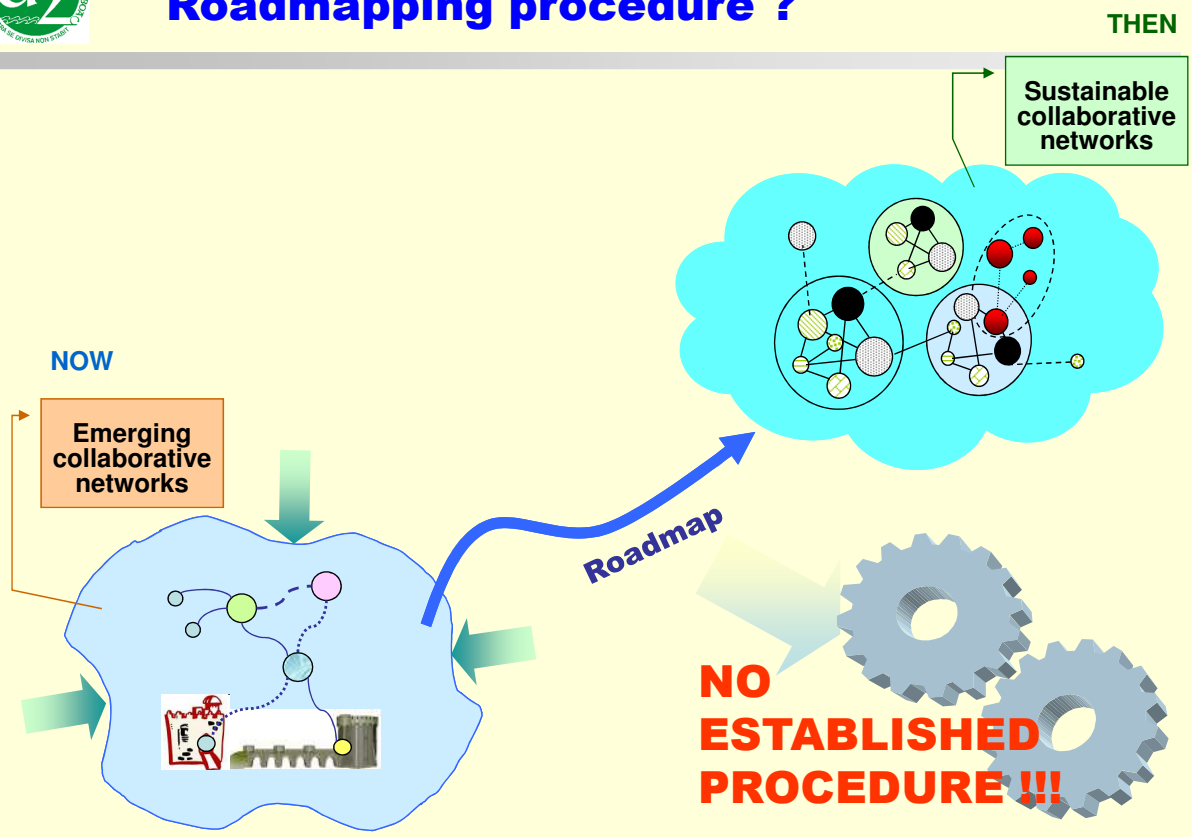
Roadmapping Topics

	Definition and Strategy "Know-why"	Direction "Know-what"	Technology "Know-how"	Action Plan "To-do"
Science and Technology Roadmaps	• Scope of the Field • Technology Applications	• Technical Challenges • Architecture • Trends, Discontinuities, and Objectives	• Technology Elements and Evolution • Competitive Technologies and Costs	• Action Programs • Technology Investment • IP and Standards • Risk Roadmap
Industry and Government Roadmaps	• Industry Structure and Position • Customer Drivers • Industry Direction	• Technical Challenges • Architecture • Trends and Disruptions • Learning and Targets	• Technology Elements and Evolution • Technology Alternatives • Future Costs	• Action Programs • Technology Investment • IP and Standards • Risk Roadmap
Product – Technology and Platform Roadmaps	• Market Structure and Size • Customer Drivers • Competitive Strategy	• Product Roadmap • Architecture • Product Drivers and Targets • Feature evolution	• Technology Elements and Evolution • Competitive Position • Target Costing	• Action Programs • Technology Investment • IP and Standards • Risk Roadmap

http://www.albrightstrategy.com/framework.html

3. ROADMAPPING METHODOLOGY

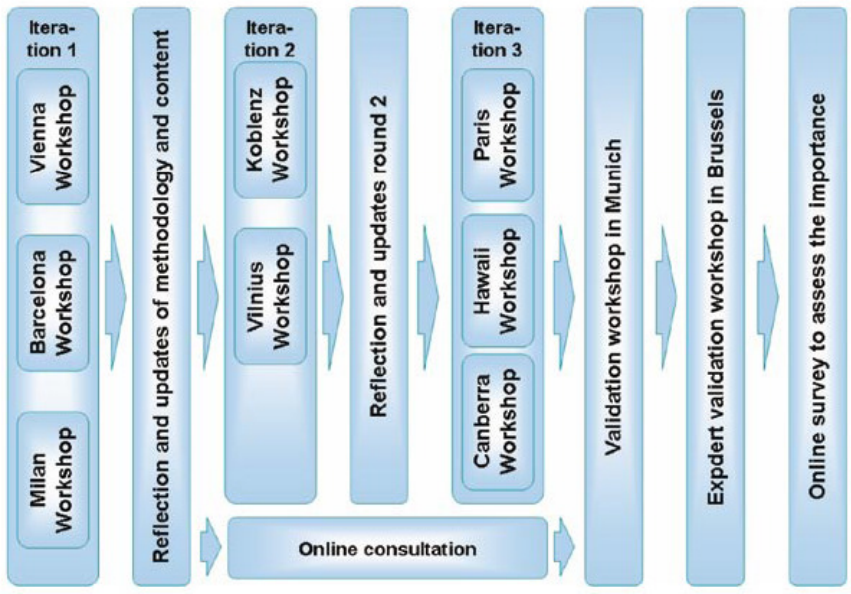
Roadmapping procedure ?



Roadmapping procedure ?

One frequent approach: Organizing activities around a series of workshops

Example: *eGovRTD2020 roadmapping workshops*



http://www.uni-koblenz.de/FB4/Contrib/EGOVRTD2020/FinalBook.pdf

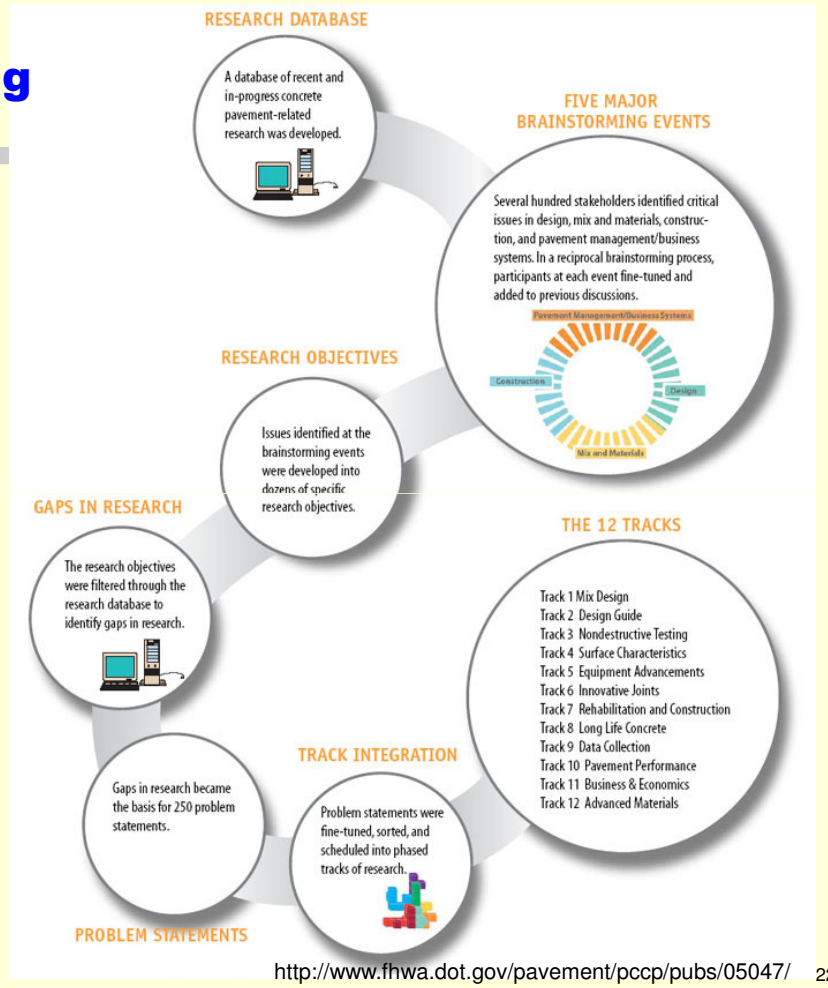
Difficulties:

Without a preliminary study, initial workshops can be quite innefficient

Some participants may mislead the discussions

Roadmapping procedure ?

An example in Concrete Pavement Road Map



U.S. Department of Transportation
Federal Highway Administration

http://www.fhwa.dot.gov/pavement/pccp/pubs/05047/

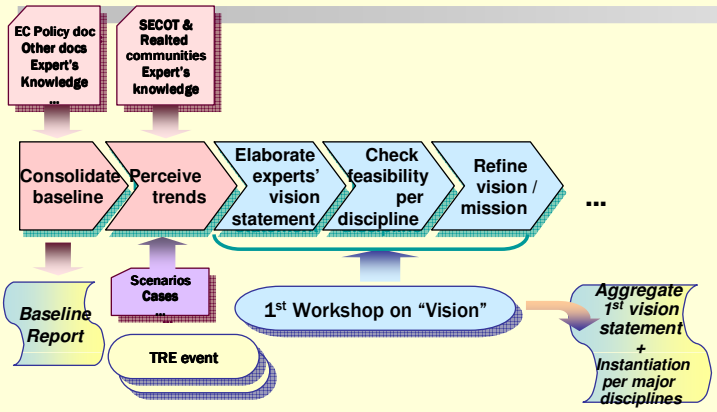
VOmap project

VOmap aimed at identifying and characterizing the

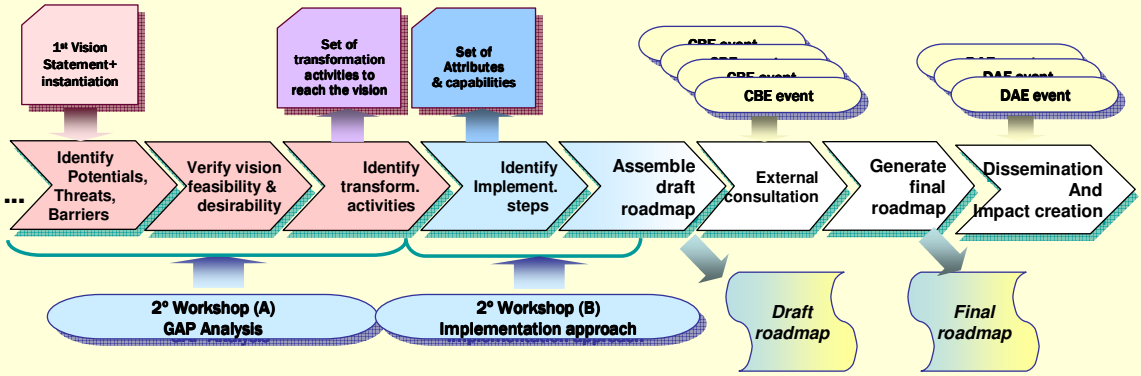
- key research challenges
  - required constituency
    - implementation model

for a comprehensive initiative to affirm the European leadership on dynamic collaborative virtual organizations

10-step procedure



1 Characterize and consolidate the baseline
2 Perceive trends and design scenarios
3 Elaborate first vision statement and instantiations
4 Fill the GAP: Where we are – to – Where we wish to go
5 Propose a plan of actions (a first set of unordered transition steps)
6 Verify the planned actions
7 Plan the timing and other characterization of actions
8 Finalize the definition of the roadmap chart
9 Perform consultation and refinement
10 Perform consolidation



[Camarinha-Matos, Afsarmanesh, 2004]

VOmap roadmapping procedure

1 Characterize and consolidate baseline

VO projects experience

VOSTER portfolio

THINKcreative SoA

National initiatives

Industry surveys

Other roadmaps

Baseline consolidation process & workshop

R1 Baseline

2 Perceive trends and design scenarios

THINKcreative Delphi

National initiatives

Published scenarios

Internal scenarios

Trends characterization

Scenarios characterization

R2 Identified trends

R3 Future scenarios

VOmap roadmapping procedure ...

3 Elaborate first vision statement and instantiations

R1 Baseline

VOmap goals

Preliminary Vision 1

R2 Identified trends

Preliminary Vision 2

R3 Future scenarios

VOmap experts recommendation

1st workshop on vision

R4 1st Vision & Instantiations

Building the vision

- *Building the Vision* is a main step in creating the *roadmap*
- *Roadmap* provides an *active plan* of how to reach the *desired Vision constellation for the future*

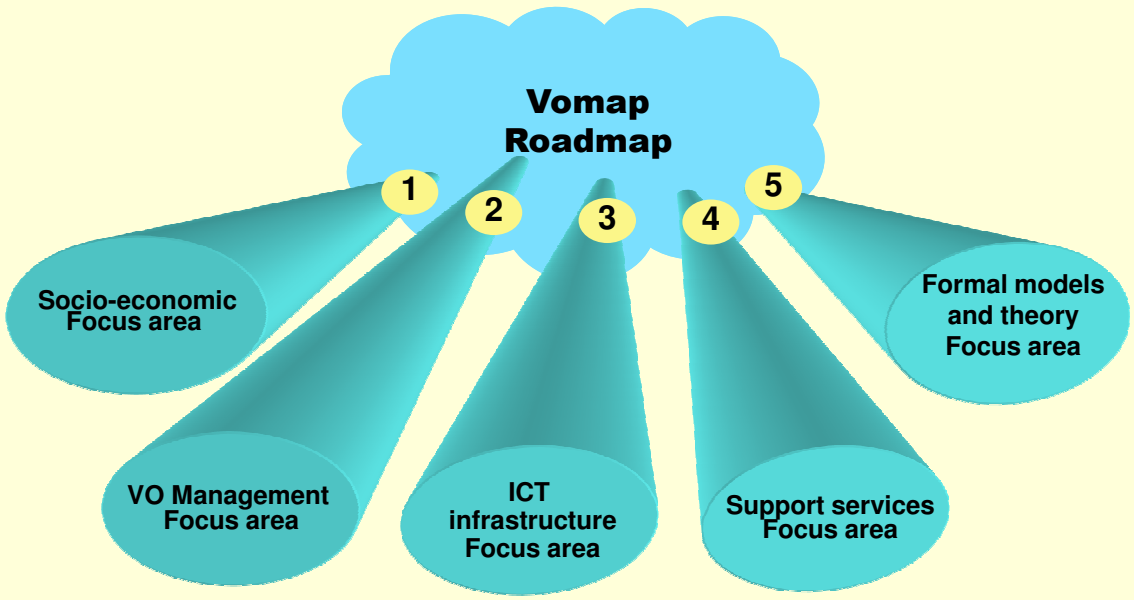
- Vision building is not a mechanism to foresee the future !
- *But to define the future state that we wish to reach*

To *establish a vision*:

- *Significant market and technology trends*
- *Expert's recommended requirements for future success of the VOs*
- *The state-of-the-art & Consolidated baselines*
- *Elaboration and characterization of plausible future scenarios*
- *…*

Roadmapping is planning, not forecasting !

VOmap focus areas

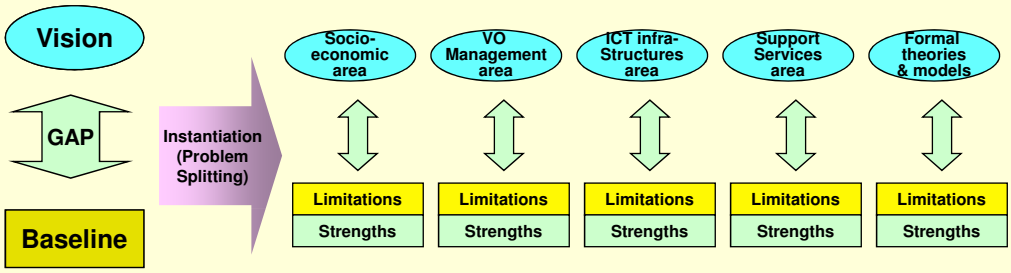


Multi-disciplinary contributions

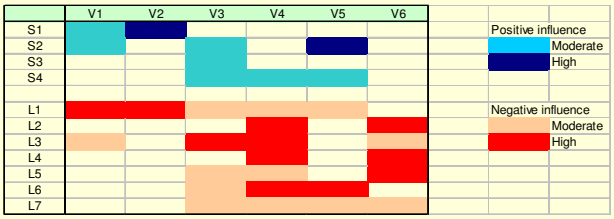
VOmap roadmapping procedure ...

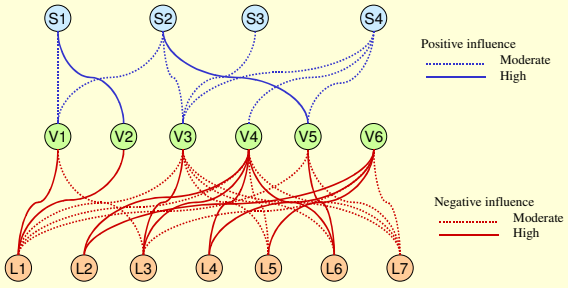
4

Filling the GAP: "Where we are" – to – "Where we go"



Influence maps

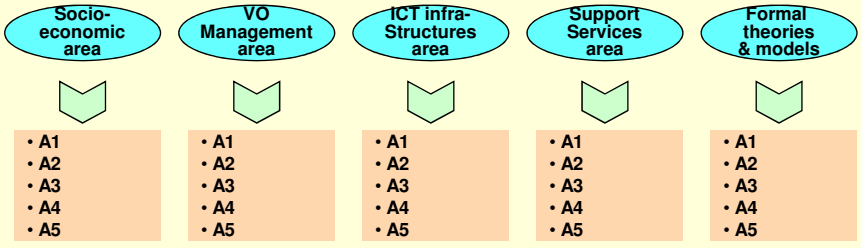




VOmap roadmapping procedure ...

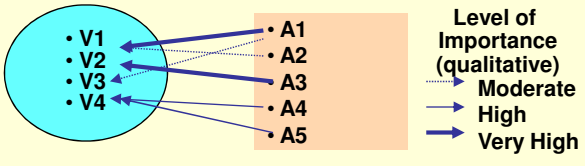
5

Propose a plan of actions (a set of unordered transition steps)



6

Verify the planned actions



Covering the vision

Level of Importance (qualitative)
→ Moderate
→ High
→ Very High

VOmap roadmapping procedure ...

7

Plan the timing and other characterization of actions

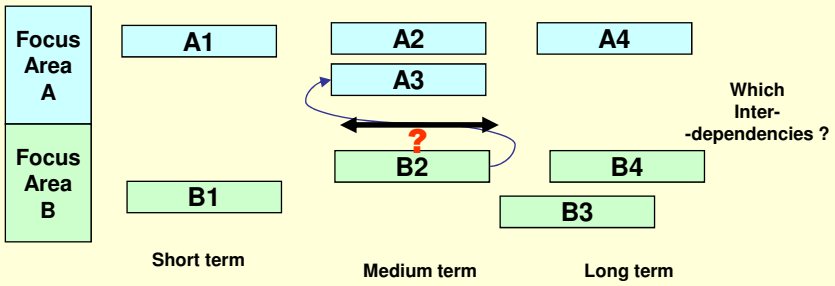
- A1
- A2
- A3
- A4
- A5

\+ SCHEDULE
- Short term
- Medium term
- Long term

\+ OTHER ITEMS
- Who
- Resources
- ...

8

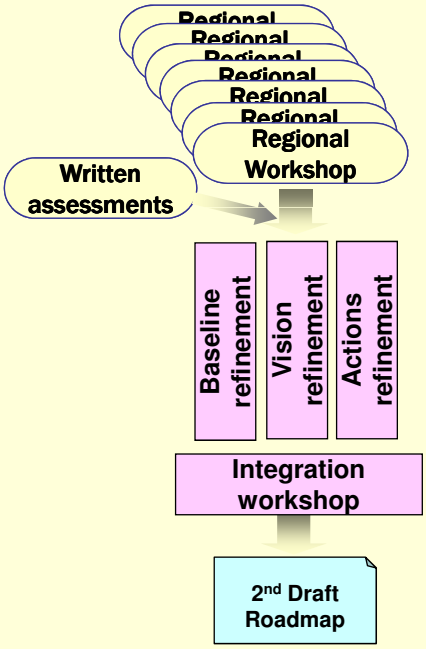
Finalize the definition of the roadmap chart



VOmap roadmapping procedure ...

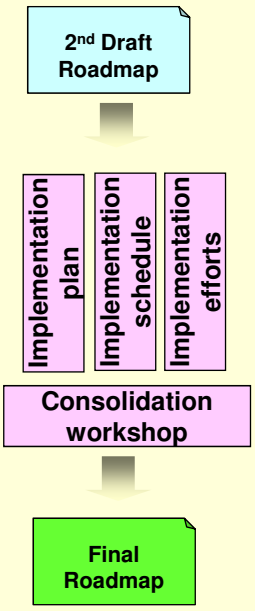
9

Perform consultation and refinement



10

Perform consolidation



How does a vision statement look like?

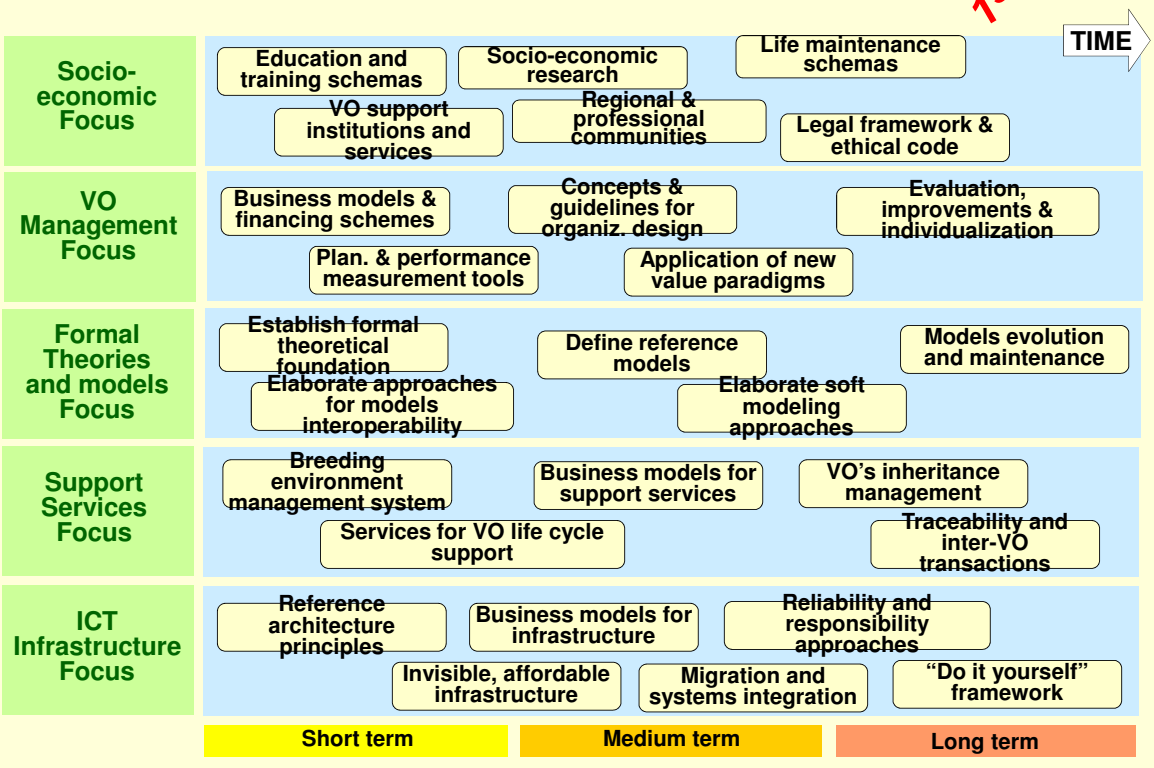
"In 2015 the majority of organizations and individuals will be part of sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations, in response to fast changing economic and social conditions.

- Well founded models of collaboration
- Management systems for breeding environments replicable to a large variety of sectors
- Generic and transparent infrastructure and re-utilizable service toolbox, based on interoperability standardization
- Extensive use of pervasive computing
- VO management principles adapted to emerging behavior in complex networks
- Accepted mechanisms to handle innovation and new value systems
- Social responsibility, including "life maintenance"
- Better understanding and handling of VO-related cultural/regional issues
- Definition of moral / ethical code for VOs
- Comprehensive (international) legal frameworks for VOs

As a result, a strong and cohesive social fabric is built in response to turbulence and uncertainty."

How does a roadmap look like?

VOmap 1st attempt

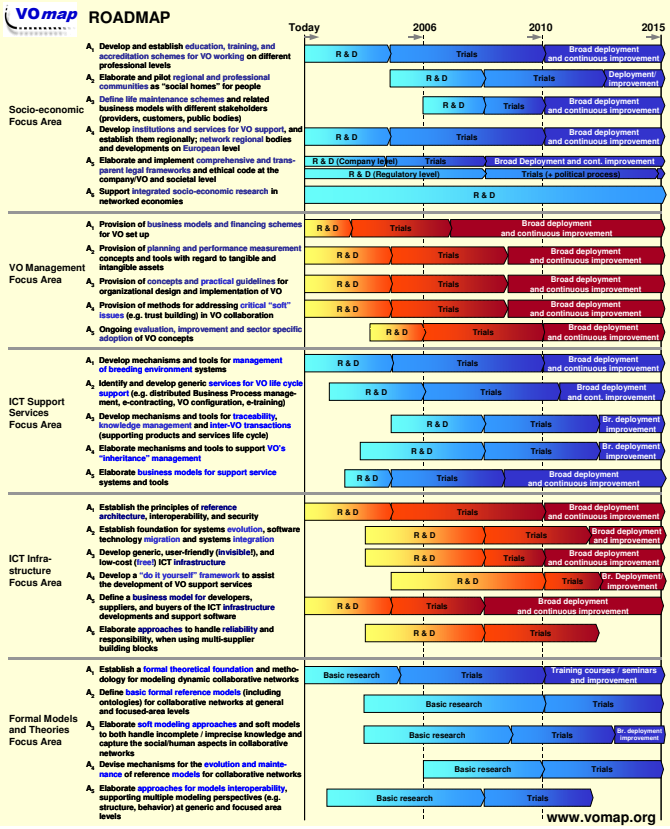


How does a roadmap look like?

VOmap 2nd attempt

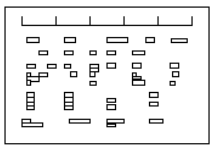
Implementation Mechanisms

R&D
Trials
Deployment & improvement

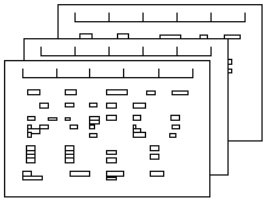


How does a roadmap look like?

A roadmap can be represented at several levels of detail.



Toplevel roadmap — Single page — Poster — part of many presentations

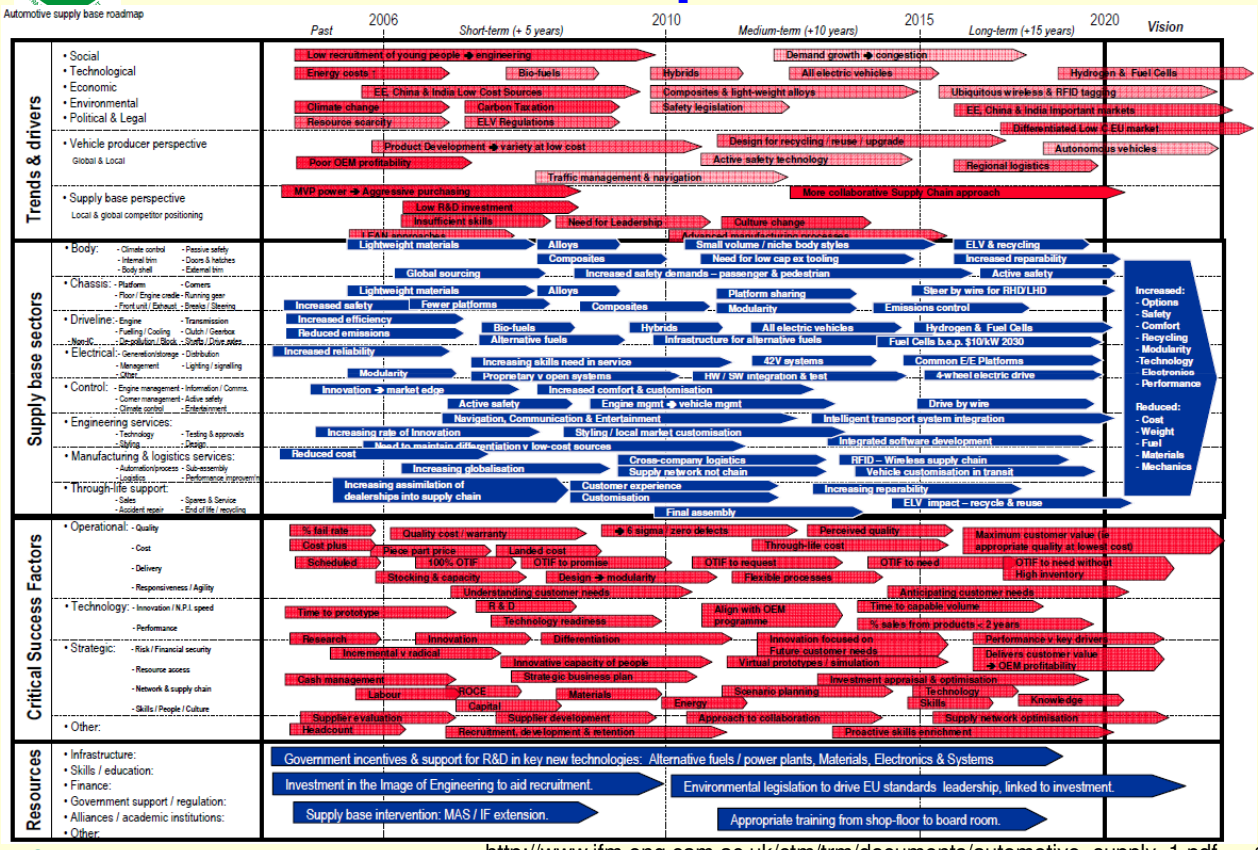


Supporting roadmaps — Single page per view or per driver — Poster — part of many presentations

Supporting reports — Document per relevant subject

[Muller, 2008]

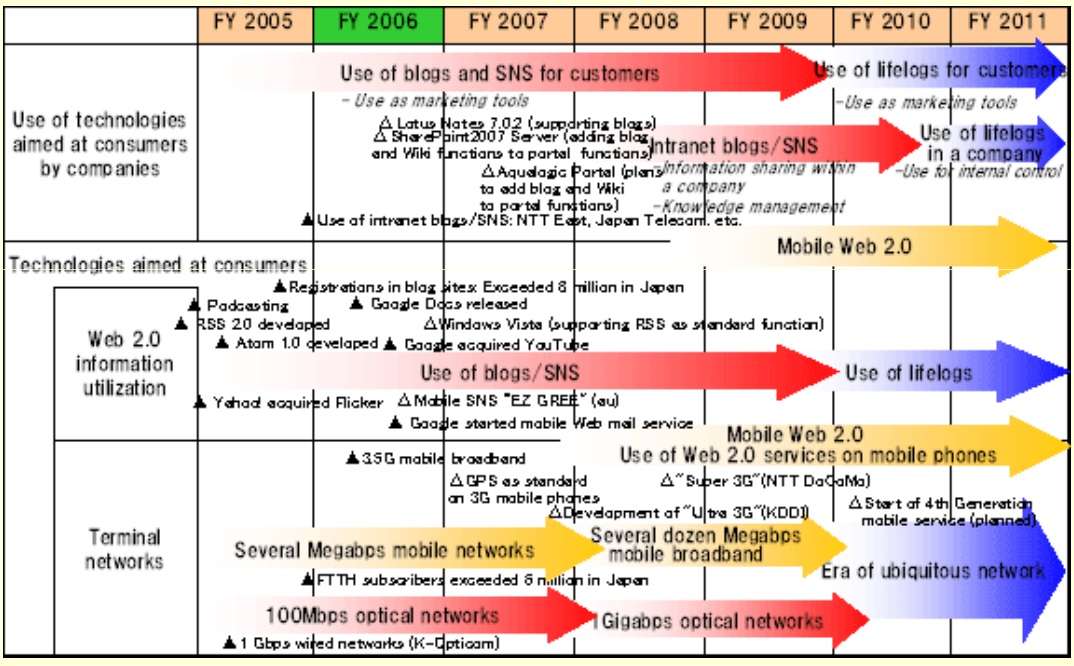
How does a roadmap look like?



http://www.ifm.eng.cam.ac.uk/ctm/trm/documents/automotive_supply_1.pdf

How does a roadmap look like?

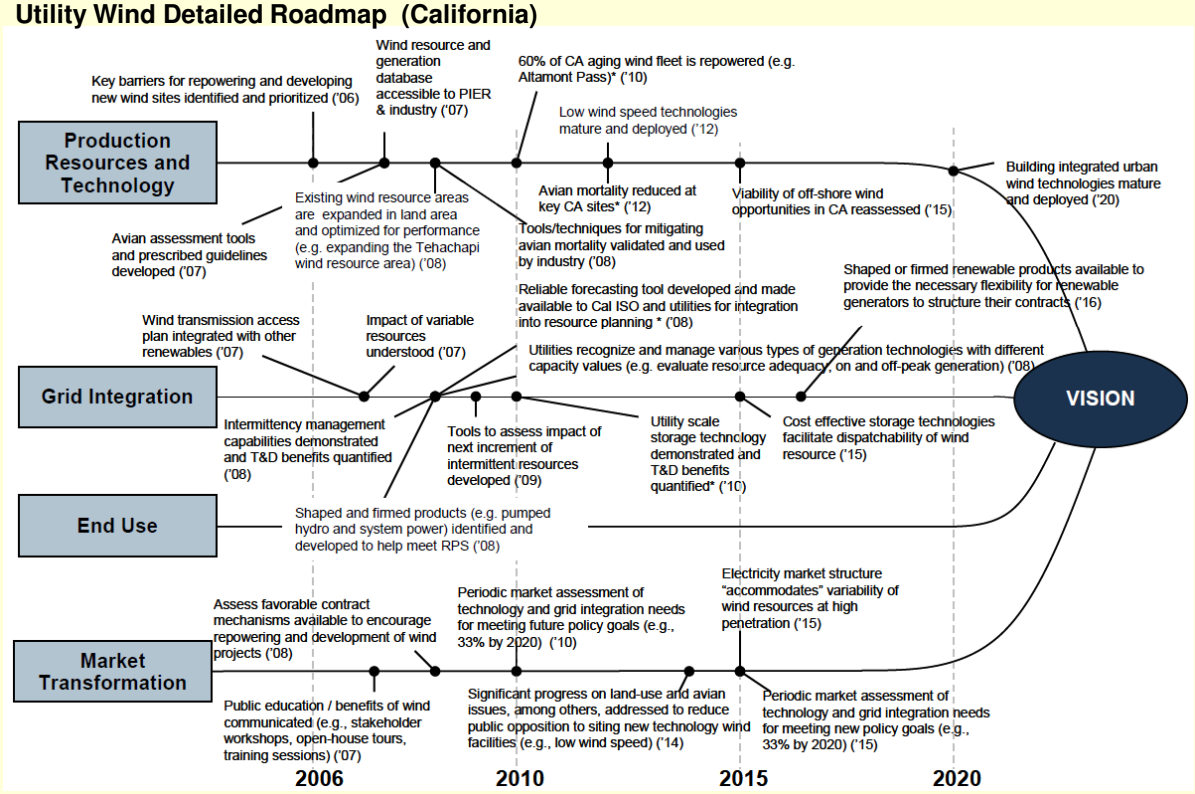
"IT Road Map" of Web 2.0 Technology Up Until 2011



http://www.nri.co.jp/english/news/2006/061110.html

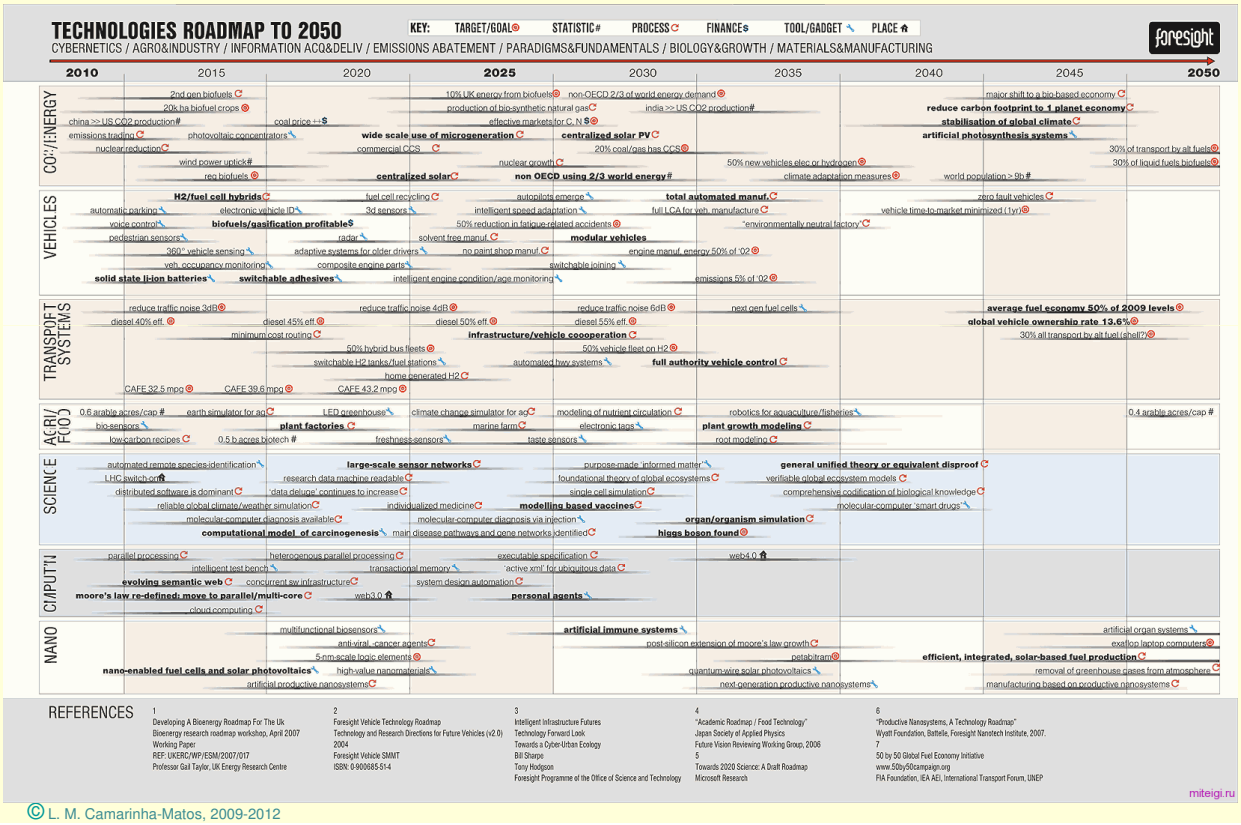
How does a roadmap look like?

Utility Wind Detailed Roadmap (California)



http://www.energy.ca.gov/2007publications/CEC-500-2007-035/CEC-500-2007-035.PDF

How does a roadmap look like?



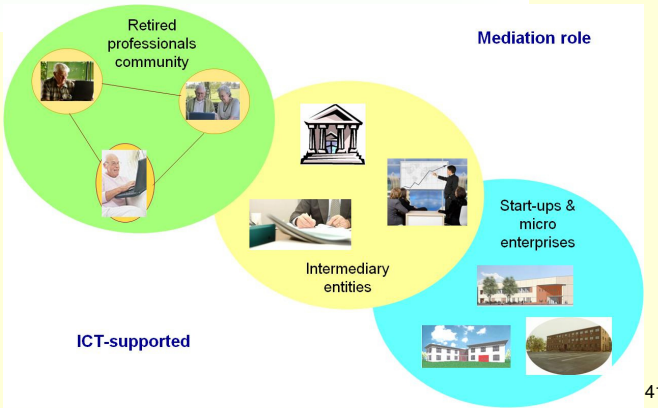
ePAL project

ePAL aimed at:

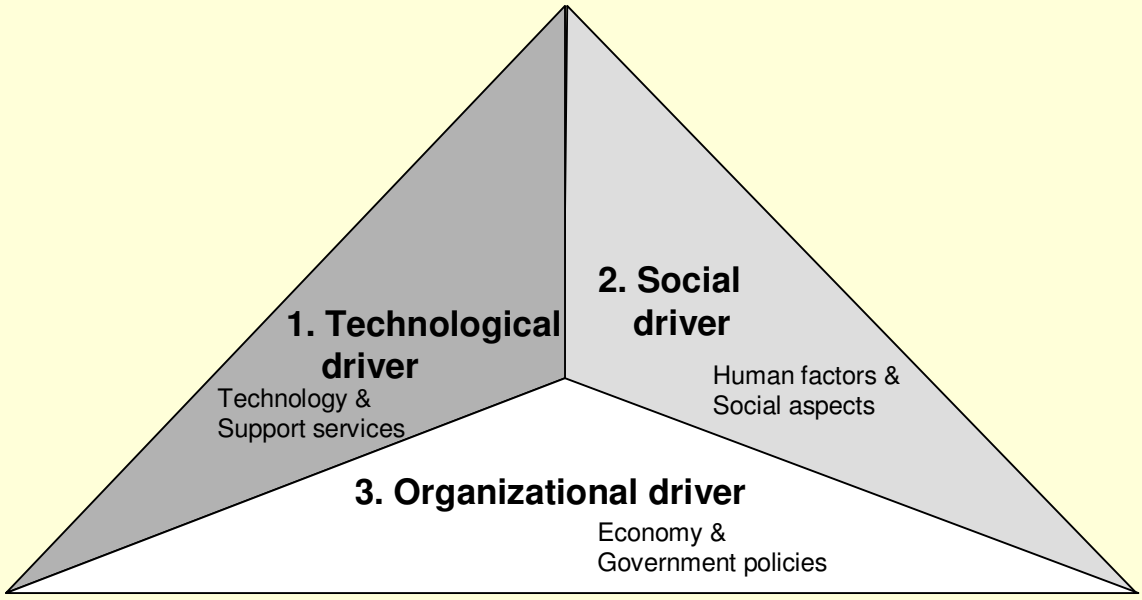
- **Introducing new approaches and ways to create actively contributing professional communities in society**
  - **supporting framework for leveraging elderly's talents and expertise**
  - **creates value for the benefit of the Europe's economy.**

- **Supporting a balanced transition towards retirement**

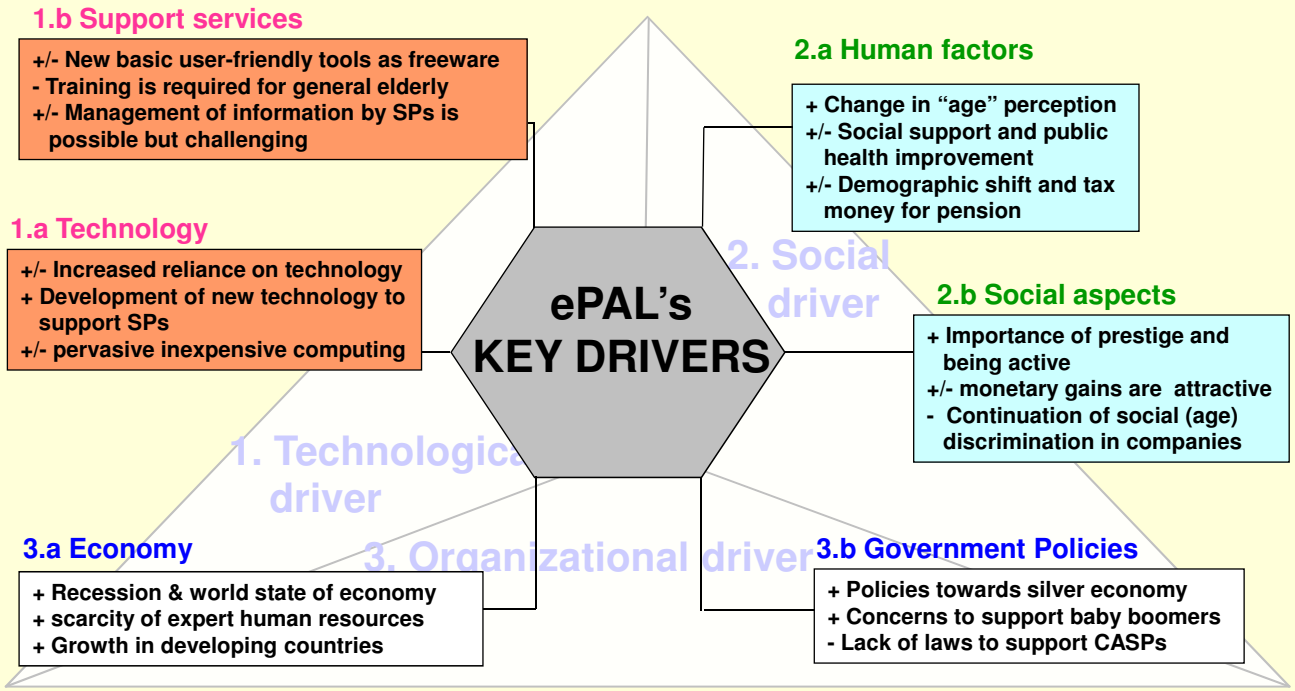
- **Placing Europe as the leader in promoting active ageing / ageing well worldwide.**



ePAL focus areas and drivers

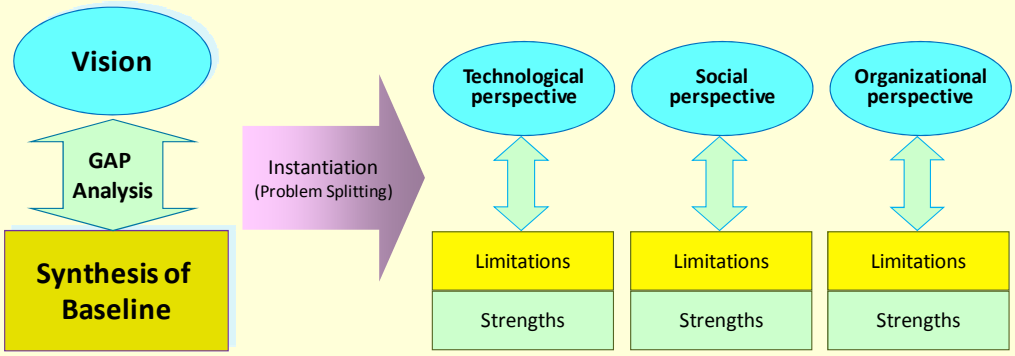


ePAL key drivers and trends

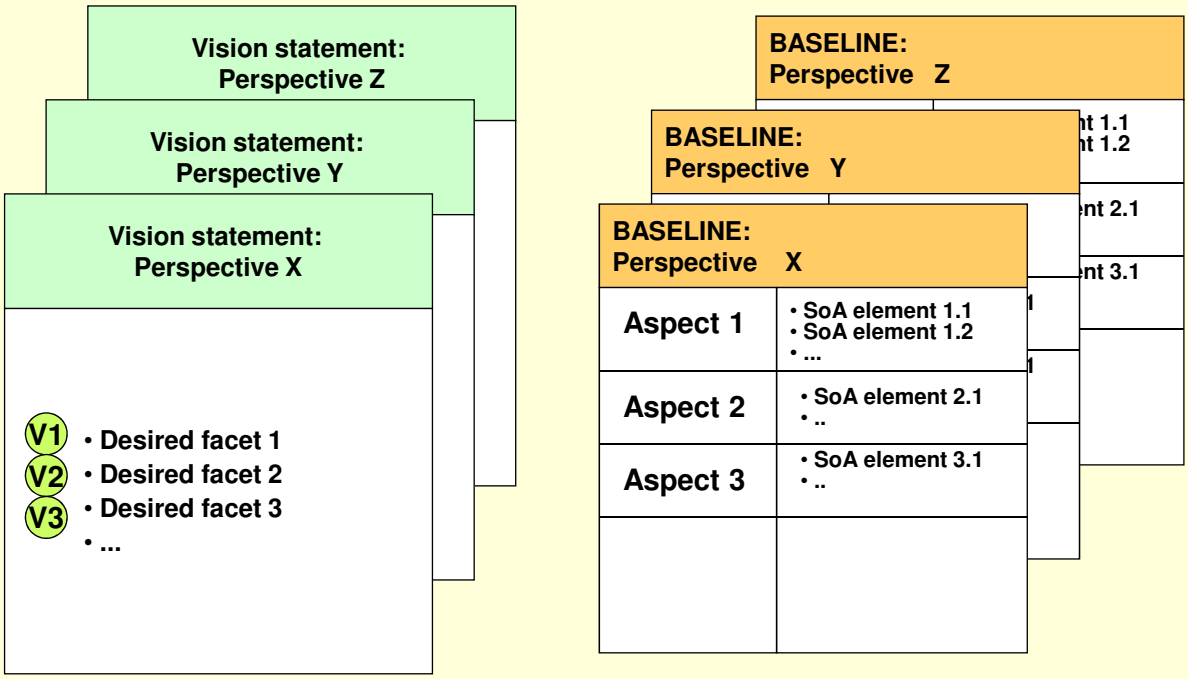


ePAL refinement – GAP analysis

	Helpful to achieving the vision	Harmful to achieving the vision
Internally originated – European Union level	**S**trengths • Strength 1 • Strength 2 • …	**W**eaknesses • Weakness 1 • Weakness 2 • …
Externally originated – Surrounding environment	**O**pportunities • Opportunity 1 • Opportunity 2 • …	**T**hreats • Threat 1 • Threat 2 • …



ePAL refinement – GAP analysis



ePAL refinement – implementation models

In order to define a research plan it is also necessaqry to identify promissing organizational structures

Individual Stakeholder: <Identification>
Description:
Characterizing dimensions: **d1. <dimension>: <description>** **d2. <dimension>: <description>** **...**
(Potential) role(s) related to extending professional active life of seniors:

Organizational Structure: <Identification>
Description: ***Participants:***
Characterizing dimensions: **d1. <dimension>: <description>** **d2. <dimension>: <description>** **...**

ePAL refinement – implementation models ...

Initiative: <Identification>	
Organizational form:	
Characterizing dimensions:	
d1. <dimension>	Relevant aspects of the organizational form regarding this dimension
d2. <dimension>	
...	

Stakeholder: <Identification>		
Offers:	***Constraints:***	***Needs:***
<Which "value" can be contributed by this stakeholder for a future silver economy?> • ... • ... • ...	<Contsraints that might affect the delivery of "value" by this stakeholder> • ... • ... • ...	<Needs / expectations this stakeholder has regarding a future silver economy> • ... • ... • ...

Roadmapping method – A scientific approach

Classical scientific method

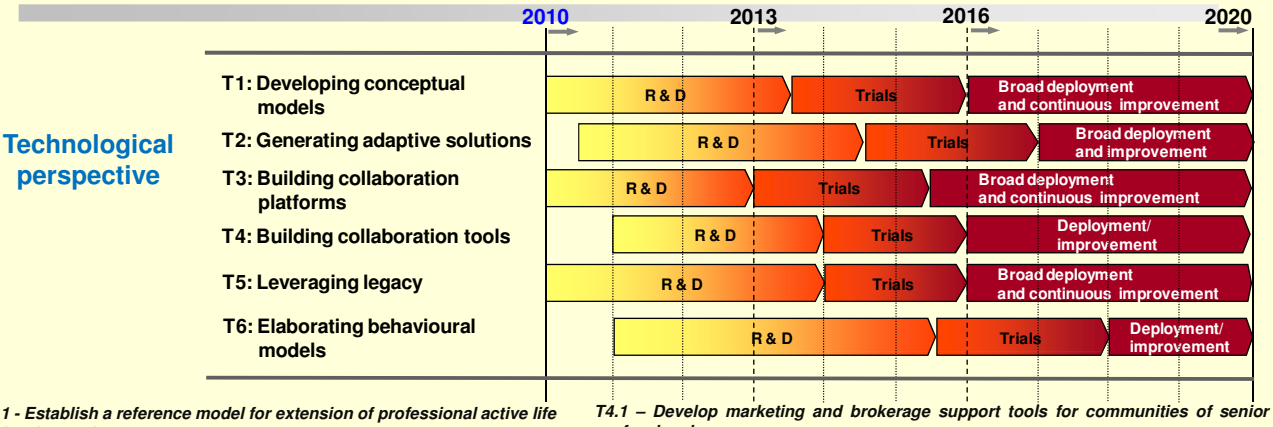
1. Research question / Problem
2. Background / Observation
3. Formulate hypothesis
4. Design experiment
5. Test hypothesis / Collect data
6. Interpret / Analyze results
7. Publish findings

Adopted roadmapping method

0. Define roadmap objectives & scope
1. Charaterize and consolidate the baseline
2.a Perceive trends
2.b Design scenarios
3. Elaborate 1st vision statement and instantiations
4. Gap analysis
5. Propose a plan of actions
6. Verify the plan of actions
7. Perform consultation and refinement
8. Refine vision and plan of actions
9. Finalize roadmap chart – timing, resources
10. Consolidate roadmap
11. Dissemination & impact creation

[Camarinha-Matos, Afsarmanesh, 2009]

ePAL ROADMAP – IMPLEMENTATION PLAN



T1.1 - Establish a reference model for extension of professional active life and active ageing.
T1.2 - Elaborate common ontologies for communities of senior professionals.
T1.3 - Develop contractual and business models for communities of senior professionals.

T2.1 - Develop self-adaptive interface systems.
T2.2 - Develop self-customizable collaboration environments empowering seniors to better use ICT.
T2.3 - Develop technology assistance wizards.
T2.4 – Increase involvement of seniors in the design of new technologies for seniors.

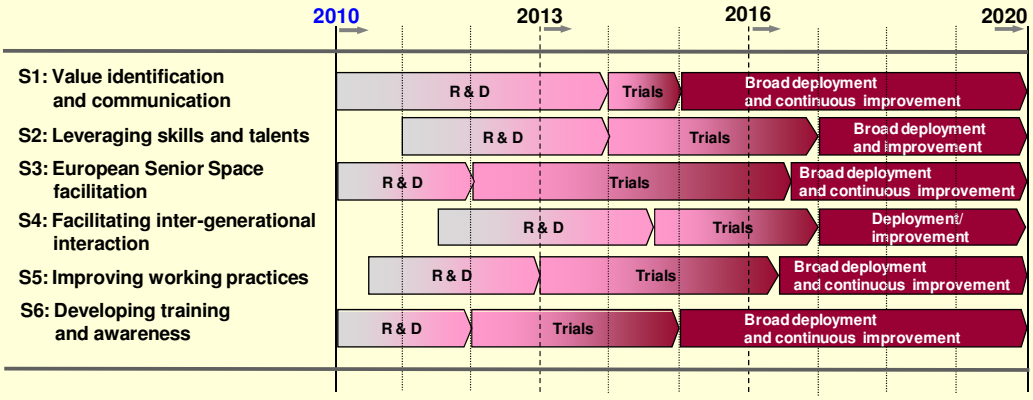
T3.1 - Develop advanced functionalities and systems for management of communities of senior professionals.
T3.2 - Develop affections / emotions management systems for communities of senior professionals.
T3.3 – Design and support reference governance systems for communities of senior professionals.
T3.4 - Develop trust building management systems for communities of senior professionals.

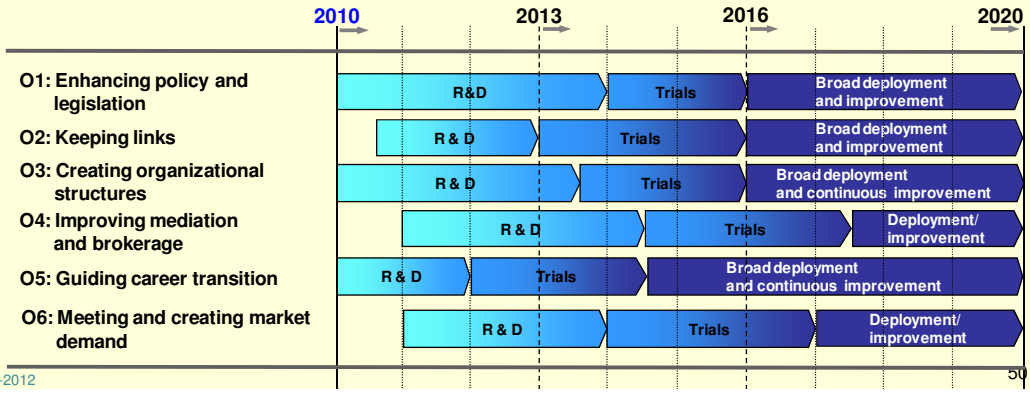
T4.1 – Develop marketing and brokerage support tools for communities of senior professionals.
T4.2 - Develop tools for virtual team creation, negotiation and e-contracting.
T4.3 - Develop tools for virtual team management and collaborative problem solving support.
T4.4 - Develop models and tools for management of Intellectual Property and performance.

T5.1 – Define conceptual models of talents and develop user-centred knowledge acquisition tools
T5.2 - Create reward mechanisms (system of incentives) to attract user-generated knowledge.
T5.3 – Develop knowledge assets assessment and intellectual property models.
T5.4 - Mechanisms to promote inter-generational inheritance.

T6.1 – Develop a conceptual base for behavioural modelling.
T6.2 - Develop data-mining / machine learning approaches for behavioural patterns discovery.
T6.3 - Develop forecasts and simulation methods and tools for behavioural analysis.
T6.4 - Develop models and tools for emotional health management.

ePAL ROADMAP – IMPLEMENTATION PLAN ...





Camarinha-Matos, L.M.; Afsarmanesh, H. (2004), A roadmapping methodology for strategic research on VO, in *Collaborative Networked Organizations – A research agenda for emerging business models*, cap. 7.1, Kluwer Academic Publishers, ISBN 1-4020-7823-4.

Camarinha-Matos, L.M.; Afsarmanesh, H. ; Loeh, H.; Sturm, F.; Ollus, M. (2004), A strategic roadmap for advanced virtual organizations, in *Collaborative Networked Organizations – A research agenda for emerging business models*, cap. 7.2, Kluwer Academic Publishers, ISBN 1-4020-7823-4, 2004.

Camarinha-Matos, L.M.; Afsarmanesh, H. (2009), The Need for a Strategic R&D Roadmap for Active Ageing, *Proceedings of PRO-VE'09, 7-9 Oct 09, Thessaloniki, Greece, Leveraging knowledge for innovation in Collaborative Networks*, Springer, pp. 669-680.

http://en.wikipedia.org/wiki/Futures_techniques

http://www.bled-forum.org/materiali/ppt/petek/ana_jakil.ppt

http://horizon.unc.edu/projects/seminars/futuresresearch/

Glen, J. C. (2008). Brief Overview of Some Futures Research Methods
http://www.clingendael.nl/cscp/events/20081216/20081216_presentatie_glenn.ppt

Davis, G. (2002). Scenarios as a Tool for the 21st Century
www.casin.ch/web/bulletinboard/geddavisscenariosastool2002.pdf

Muller, G. (2008). Roadmapping - http://www.gaudisite.nl/RoadmappingPaper.pdf

California Energy Commission - PIER RENEWABLE ENERGY TECHNOLOGIES PROGRAMRESEARCH DEVELOPMENT AND DEMONSTRATION ROADMAP
http://www.energy.ca.gov/2007publications/CEC-500-2007-035/CEC-500-2007-035.PDF

Roadmap examples: http://emi-web.inel.gov/roadmap/examples.html