SCIENTIFIC RESEARCH METHODOLOGIES AND TECHNIQUES

Unit 12: ROADMAPPING AND FUTURE PLANNING (I)

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REMEMBER: Types of grantseekers

Reactive Grantseekers

- Wait for a grantseeking opportunity to present itself.
- Attempt to develop an innovative, creative, well-organized approach to solving a problem while they are in a state of frenzied confusion.
- Difficult to develop a successful approach while under the pressure caused by acting reactively.

Proactive Grantseekers

- **Begin with a need or problem they wish to solve through grant funding.**
- **In order to determine the projects to pursue, they outline the opportunities in advance. Outlining opportunities does not entail writing down all solutions.**
- **By generating a list of needs (problems, areas of interest, and so on) they begin to develop a proactive system based on locating funding sources that are interested in the same problems … therefore likely to invest in their solutions.**

HOW TO PREPARE A STRATEGIC RESEARCH AGENDA?

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1. *FUTURES* RESEARCH

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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

With our choices we can shape the future.

Some methods:

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

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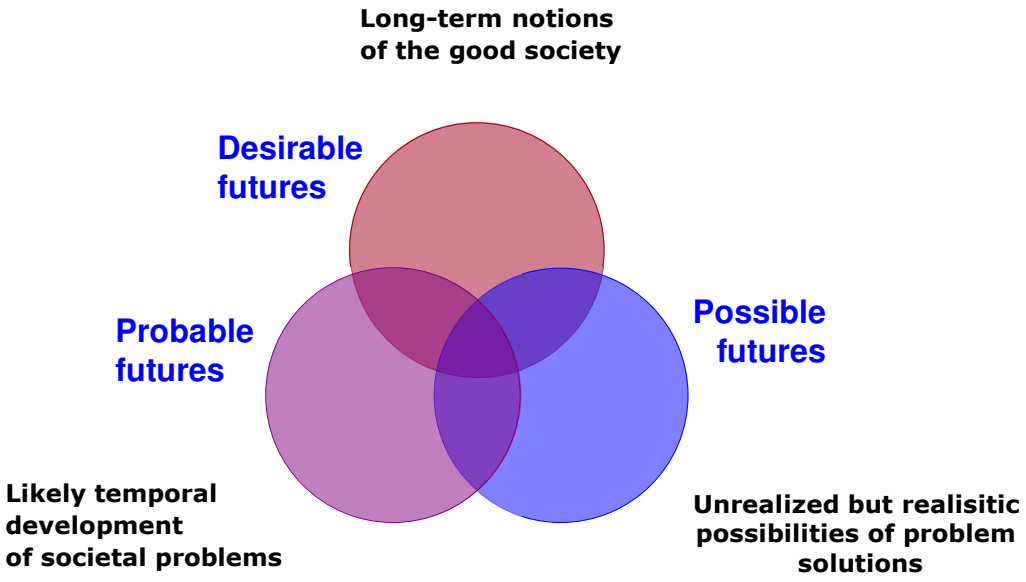
The aim



Not so much on forecasting accuracy, but rather on planning and opening minds to consider new possibilities and changing the policy agenda

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The Millenium Project

Vision: A global foresight network of Nodes, information, and software, building a global collective intelligence system recognized for its ability to improve prospects for humanity. A think tank on behalf of humanity, not on behalf of a government, or an issue, or an ideology, but on behalf of building a better future for all of us.

http://www.millennium-project.org/

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A periodic edition of the Millenium Project:

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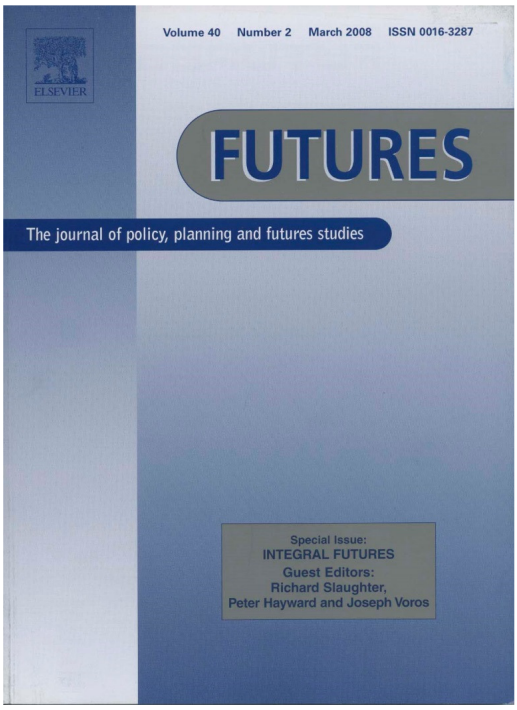
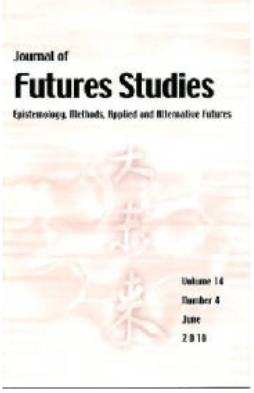
Other sources



Elsevier
Started in 1968
IF: 1.111



Tamkang University, Taiwan
Started in 1996

Inderscience
Started in 2004

SAGE
Started in 2007

Emerald
Started in 1999

Springer
Started in 2013

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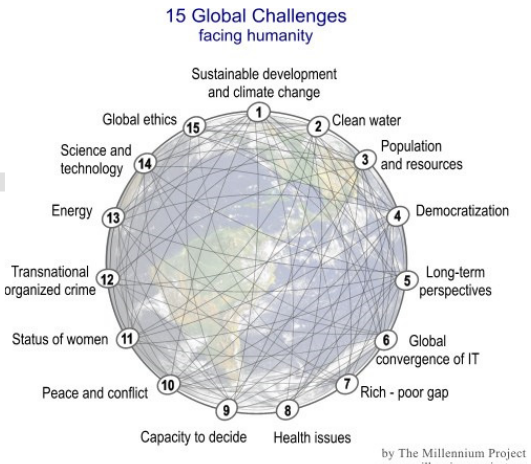
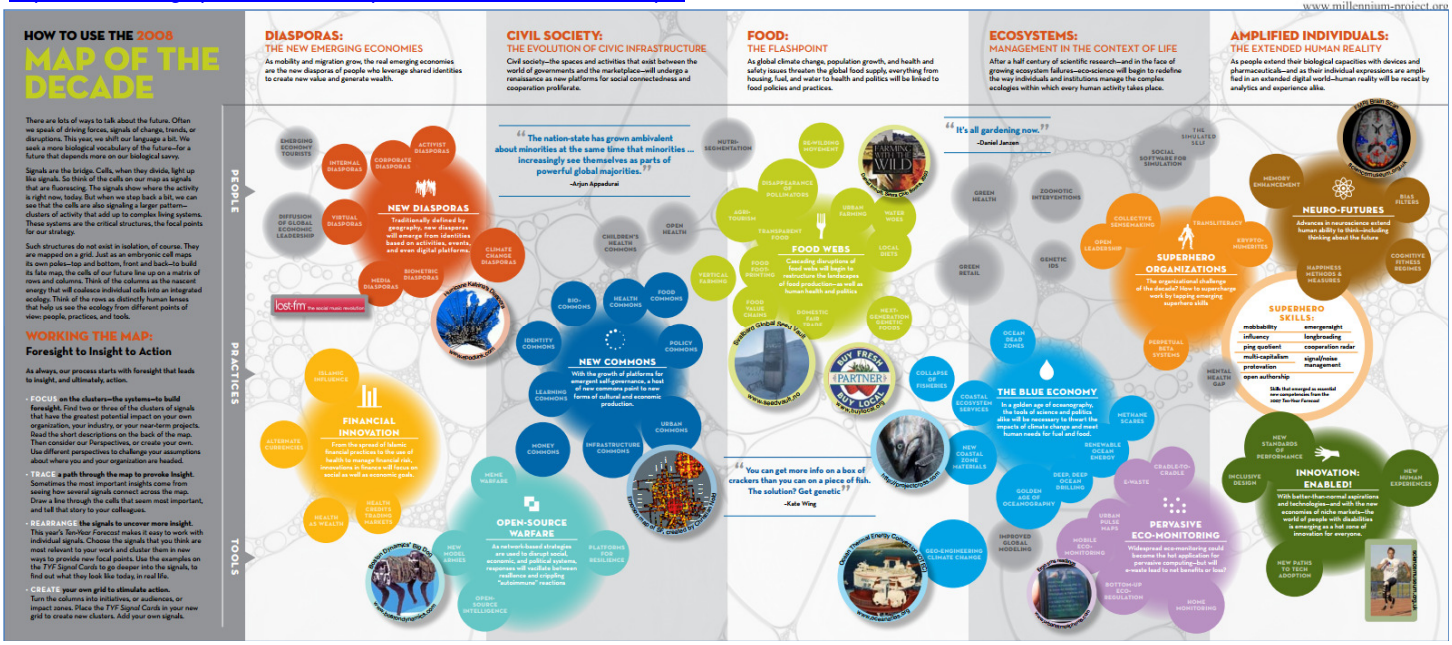
Futures research

"Macro" Examples



http://www.iftf.org/uploads/media/map_of_the_decade_2008_sm.pdf



Futures research: UN Agenda 2030

https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

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Futures thinking

Conventional Business Thinking	Futures Thinking
Immediate term	Depth of vision
Own business focus	Cross-disciplinary
Attention to detail	Broad vision
Techno-economic trends focus	Trends **and** emerging issues
Problem approach	Systems approach
Less attention to connections	Interactions and cross-impact
Continuity assumption	Wild cards and discontinuities
Bottom line focus	Strategic focus
Undiscussables	Speak the unspeakable
Short term focus	Long term orientation
A single future	Alternative futures
Mainstream thinking	Mind changers
Past and present dominate decision making	Future dominates decision making

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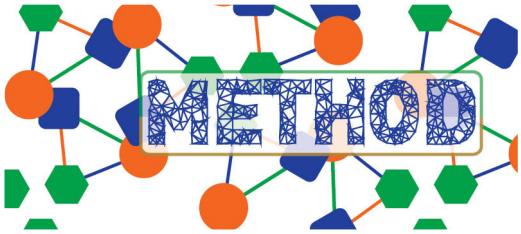
Futures research methods

Attempts to define systematic processes to deal with this difficult subject – strategy planning with very incomplete and uncertain information ... often in disruptive environments.



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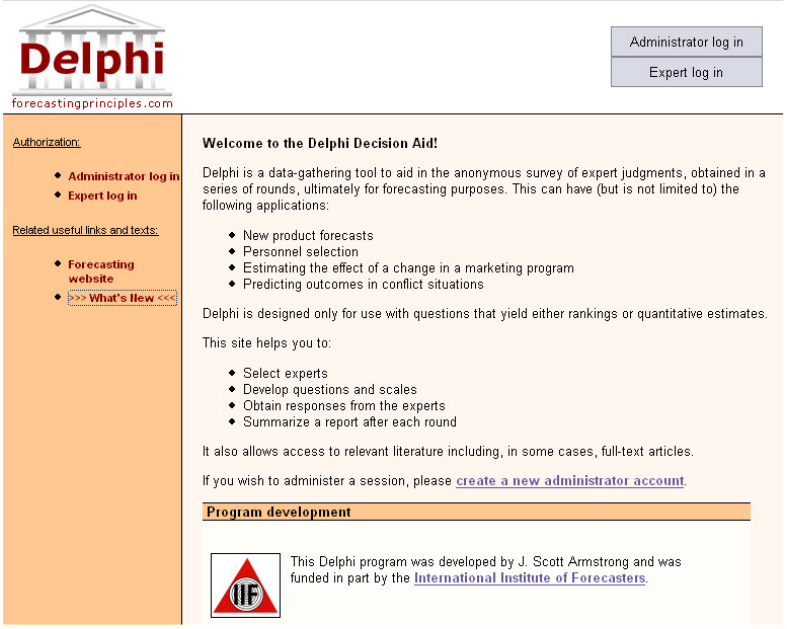
Delphi method

"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/

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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**

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Delphi method ...

A variant: Real Time Delphi

A kind of "roundless" Delphi: "The respondents participate by filling out an online questionnaire, and the results — both numerical and qualitative — are updated as responses are recorded in "real time.
Respondents can — and are encouraged to — revisit the questionnaire as many times as they want. Each time, they are shown their own responses as well as the updated answers of the others, and they can revise and change their own inputs based on this feedback."

http://www.millennium-project.org/rtd-general/

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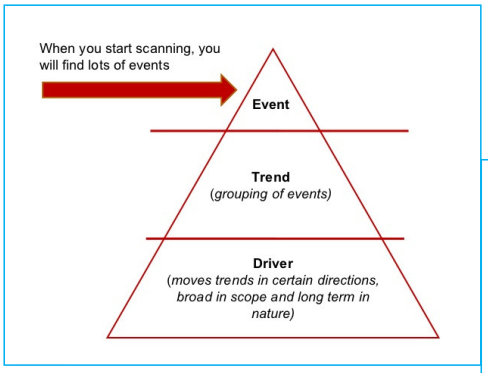
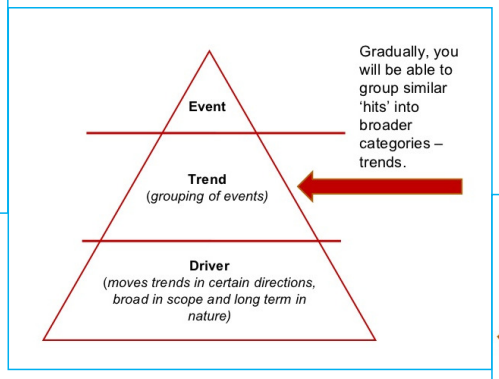
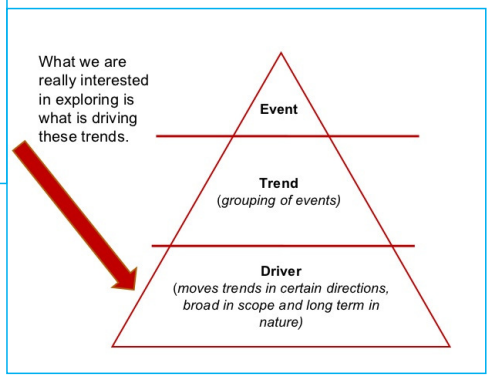
Environmental scanning

"The study and interpretation of the political, economic, social and technological events and trends which influence a business, an industry or even a total market"
(Kroon 1995)



Environmental scanning is the art of systematically exploring and interpreting the external environment to better understand the nature of trends and drivers of change and their likely future impact on your organization (or "system")





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Environmental scanning …

STEEP FACTOR	EXAMPLES OF AREAS FOR SCANNING
Social	Demographics, population shifts, migration, generations Standards of living Value systems Socio-economic conditions Education (although you might want to make this a separate classification) Ethic/religious factors Crime, safety and security Family Health Attitudes to work and employment Leisure Lifestyle changes Consumer attitudes and opinions Fads and Fashions
Technology	Technology for service delivery Technological developments generally, including emerging technologies Convergence, competition and dependencies Nanotechnology Information and communications Technology legislation
Economy	All aspects of economic activity, global, national or organisations. Work and employment, occupations Consumer behaviour Globalisation
Environmental	All natural factors Physical and geographical conditions Ecosystems Resources Sustainability
Politics	Often includes legal issues. Global connections National factors

Some steps:

- **What to Look For: Focusing your Scan**
- **Where to Look: Sources**
- **Knowing When a Scanning Hit is Useful**
- **Counter Trends and Wildcards**
- **Recording your Scanning Hits**
- **Interpreting and Reporting Your Scanning**

E.g. events, innovations, policy shifts, social developments and changes in the way people use technology

Low-probability, high-impact events

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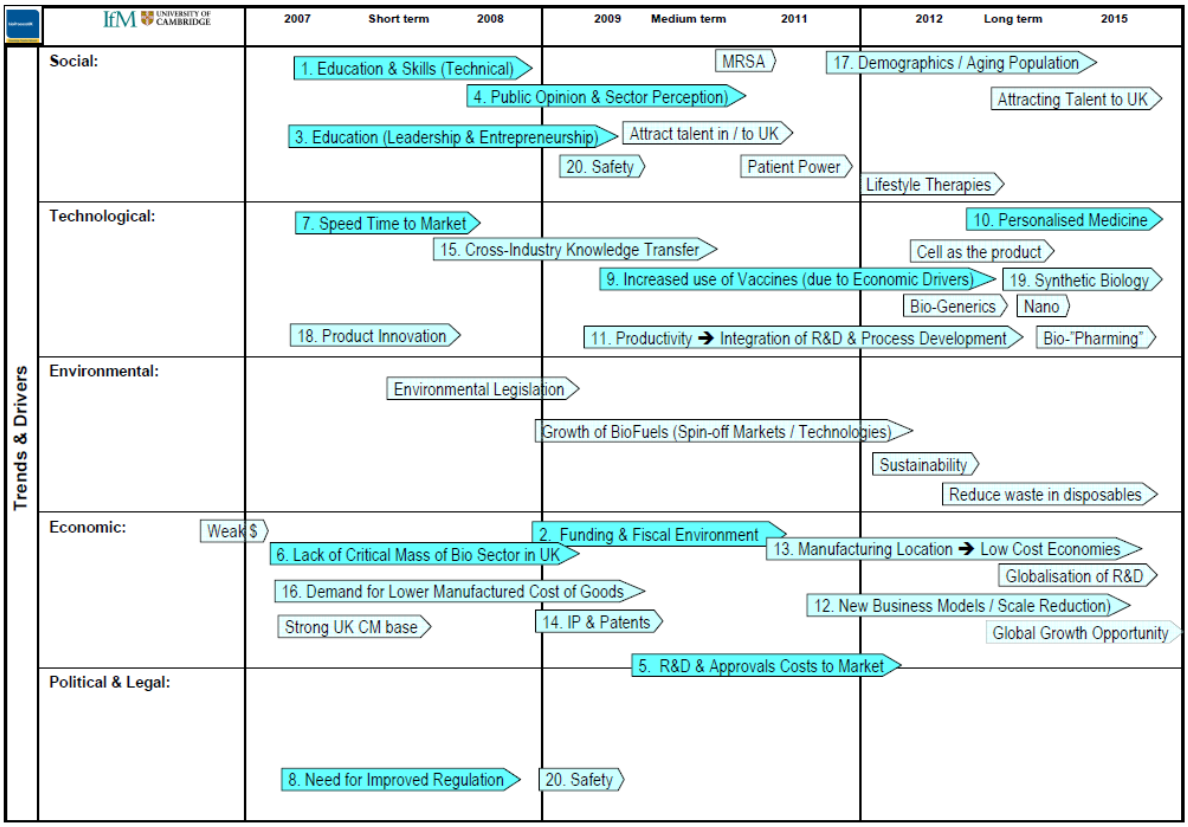
Trends and drivers



An old example by now … but it illustrates a *representation style*

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Trends and drivers ...

TAKING ACTION. DELIVERING VALUE.

Lighting Market Trends and Drivers

Sustainability Emphasis	Legislation and Rising Energy Costs	Product Innovation	Requirements
• LEED • Green building strategies and codes • Reduction in energy consumption of building systems • CO_2 reduction efforts, corporate carbon footprint reduction initiatives • Corporate social responsibility	• Federal, state, local, and utility programs to promote lighting upgrades • Rising energy costs • Environmental safety and compliance • Building and lighting code compliance • Legal restrictions on the manufacture of non-energy efficient products	• Energy efficient product options: Linear Florescent, Induction, LED • Total light management controls solutions • Longer product life and reduced maintenance costs • Global manufacturers entering market (LG, Toshiba, Panasonic)	• Reduction in energy usage and maintenance costs • Energy management services • Full turnkey capabilities • Supply chain optimization • Limited capital budgets • Quick ROI pay back

WESCO Position and Foundational Strength					
WESCO lighting specialist team	Strategic supplier relationships	Global Accounts customer base	Industry-leading LEAN value creation programs	Turnkey alliances with ESCO's	Synergies across WESCO groups

...energy efficiency provides a catalyst for lighting growth

http://www.sec.gov/Archives/edgar/data/929008/000119312511215932/dex991.htm

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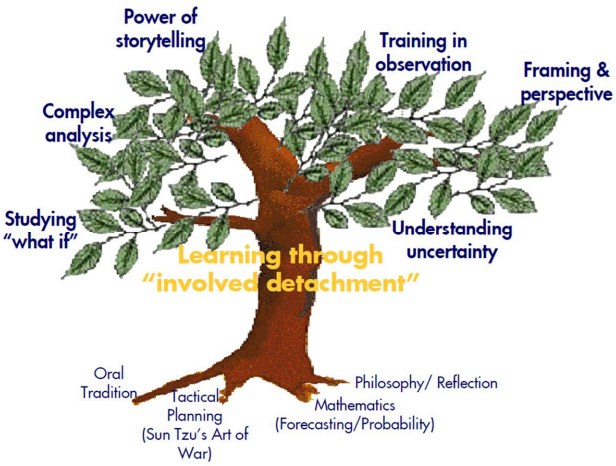
Scenarios planning

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.

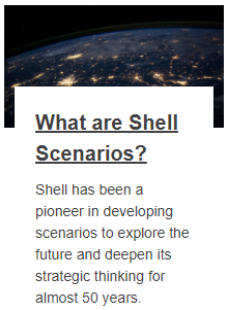
Scenario planning is a method for learning about the future by *understanding the nature and impact of the most uncertain and important driving forces affecting our world.*

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

[Glenn, 2008]



Roots of scenario thinking [Davis, 2002]



Scenarios: examples

http://www.shell.com/energy-and-innovation/the-energy-future/scenarios.html

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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]

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2. ROADMAPPING CONCEPT

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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]

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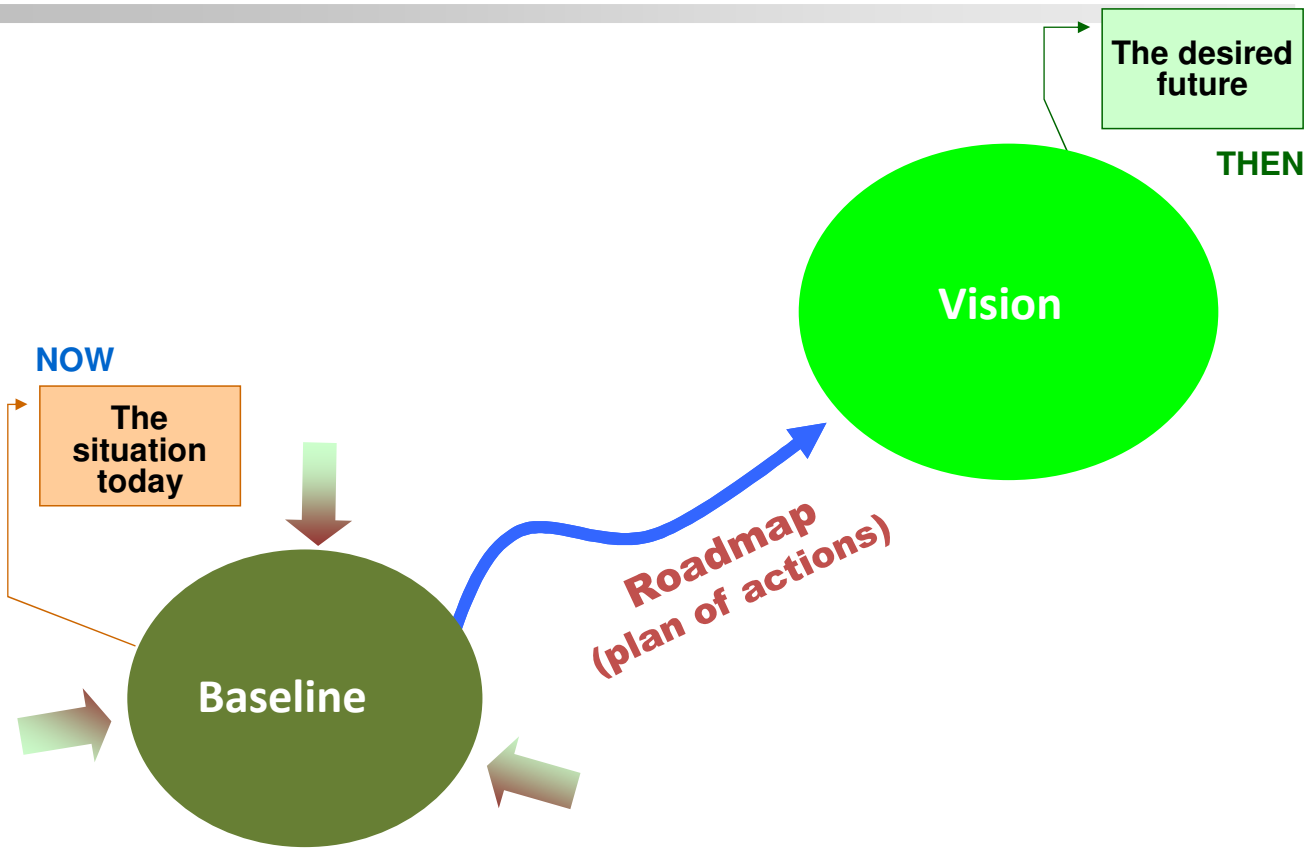
Rational



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Types of roadmaps

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

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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

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3. ROADMAPPING METHODOLOGY

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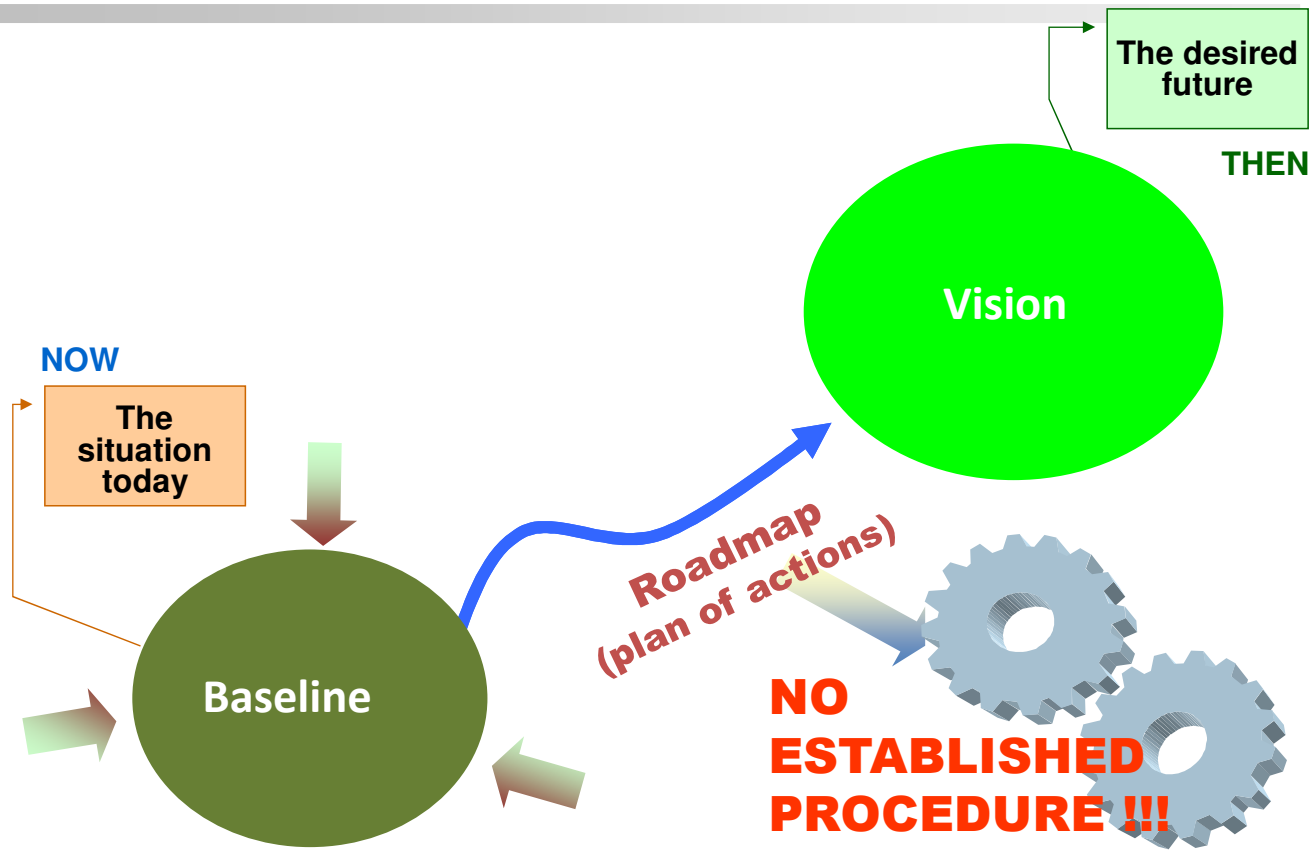
Roadmapping procedure ?



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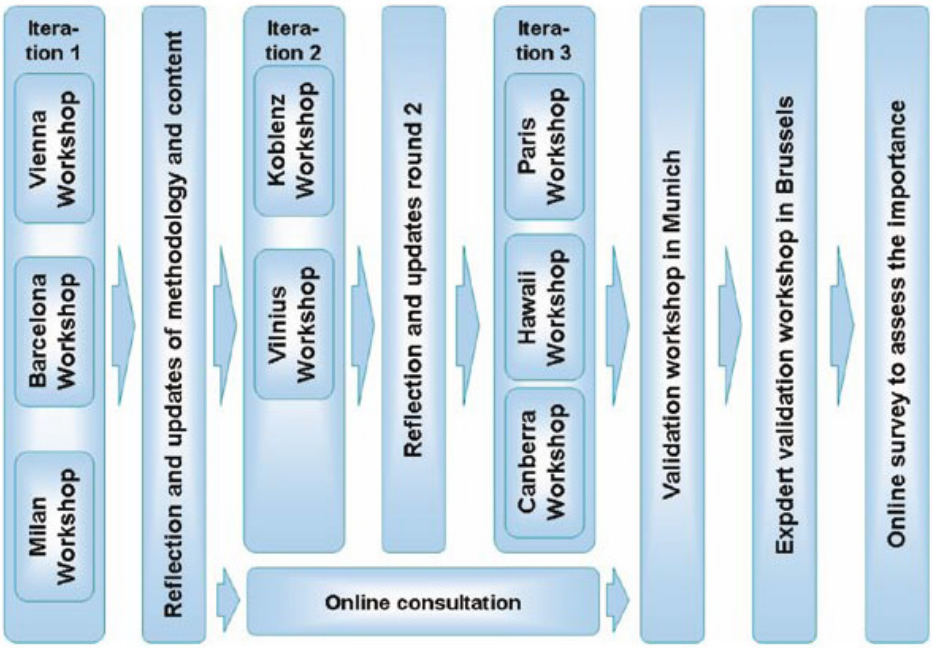
Roadmapping procedure ?

One frequent approach: Organizing activities around a series of workshops

Example: ***eGovRTD2020 roadmapping workshops***



Difficulties:

Without a preliminary study, initial workshops can be quite innefficient

Some participants may mislead the discussions

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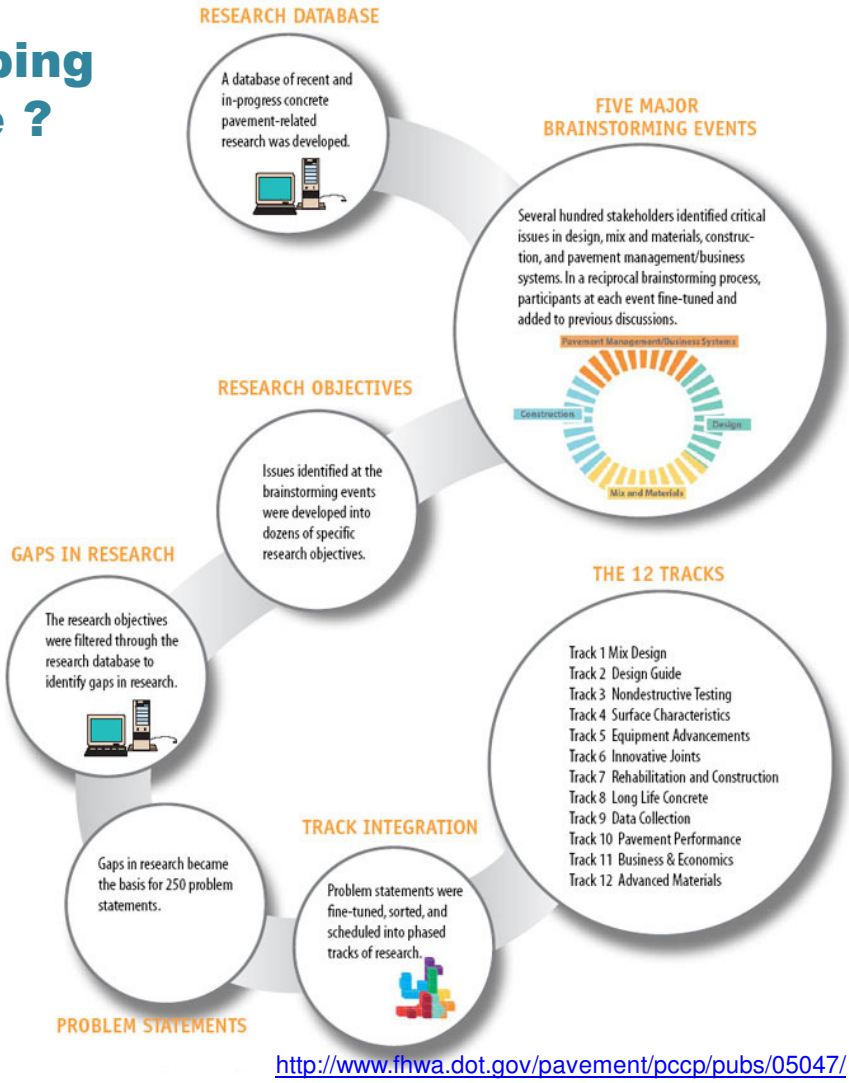
https://air.unimi.it/bitstream/2434/171379/2/FinalBook.pdf

Roadmapping procedure ?

An example in
Concrete Pavement Road Map



U.S. Department of Transportation
Federal Highway Administration

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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

[2004]

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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

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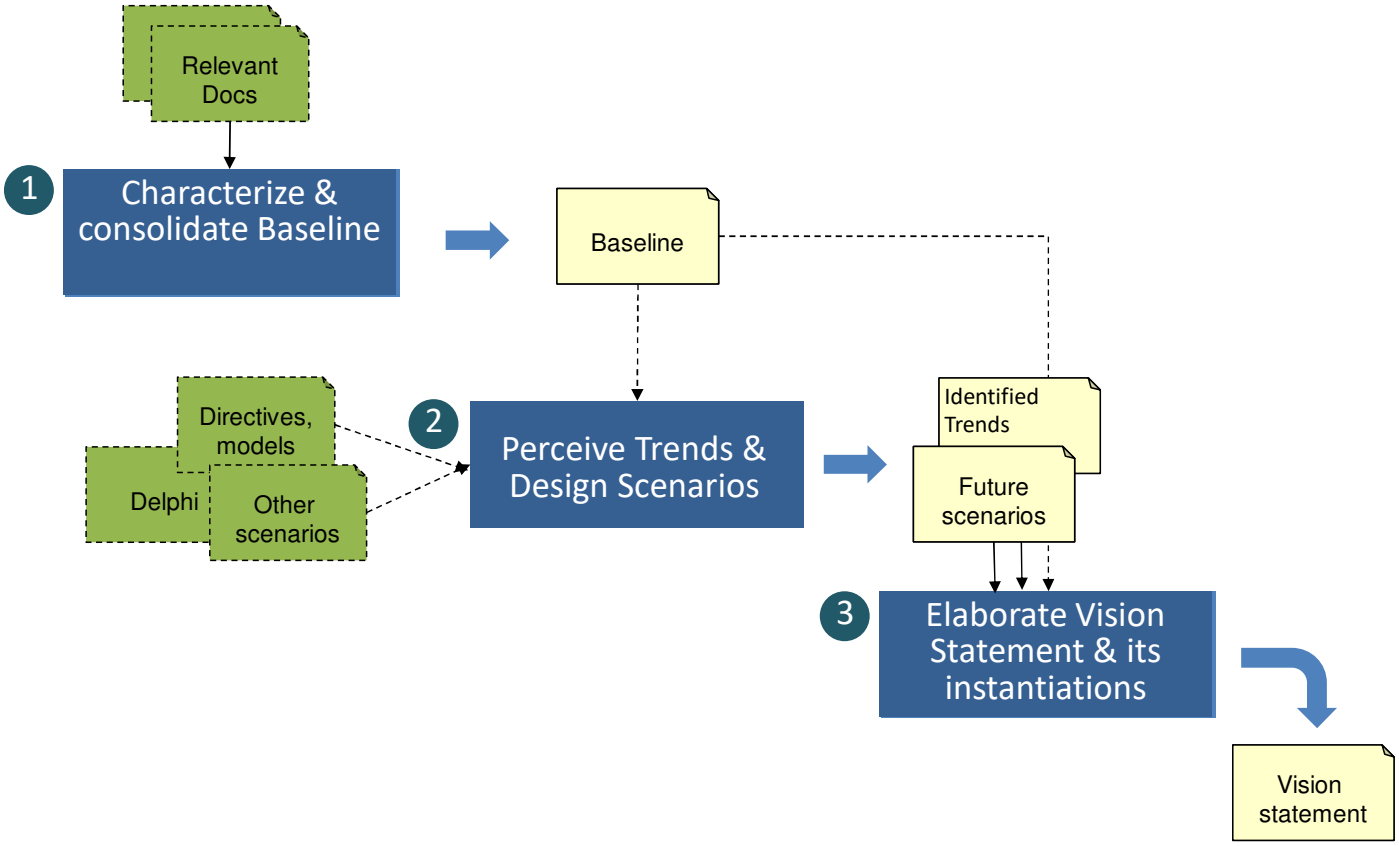
[Camarinha-Matos, Afsarmanesh, 2009]

First steps



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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 !

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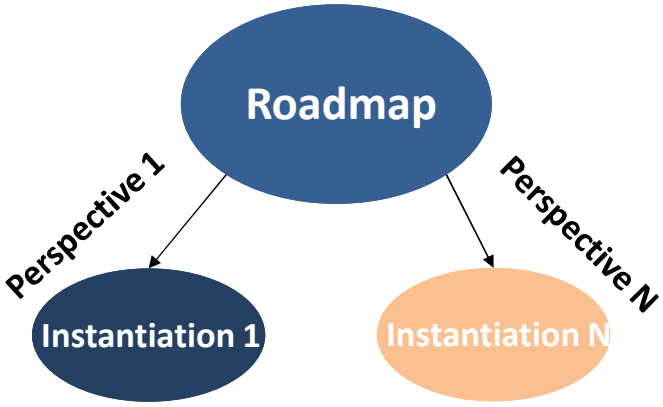
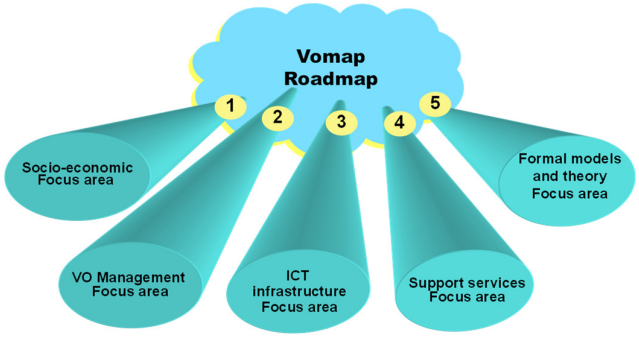
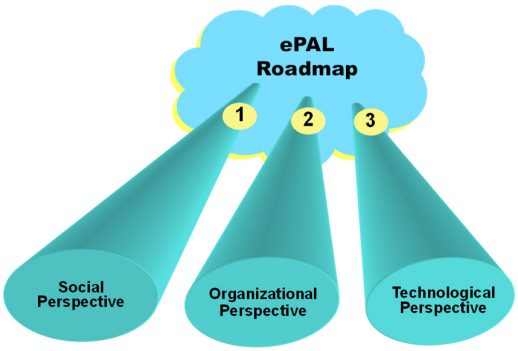
Perspectives / Instantiations







Multi-disciplinary contributions

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Examples

Baseline

- Research on VO has created a critical mass and European-wide *intuitive* understanding of the area.
- Basic supporting infrastructures and relevant technologies are well represented, but the developments are often focused on particular needs and based on ad-hoc experiments, hardly re-utilizable.
- Generic functions or harmonization of achievements are addressed only in a few projects.
- Efforts on general plug-and-play architecture and interoperability are also to a large extent missing.
  - Consequently, no generally accepted reference model or interoperability base are available.
- Although several disciplines are concerned, the main focus has been on the ICT infrastructure. Research on social/organizational, including management, is mainly focused on best practice. Integration with technological development and impacts on structures are not covered. In addition little research is focused on the social and organizational issues created by VOs

VOmap

BRAID

Life Setting: Independent living **Vision facet:** Established infrastructure and networks as the base for the support of independent living by technology	• Increasing availability of Internet and speed of broadband access. • However, in some countries broadband access covers less than half of the rural population and, ageing people, this access is lagging behind. • Market trend towards mobile broadband access at a decreasing price. • Increasing availability and power of mobile computing. • Mobile phones with built-in GPS, facilitating context aware applications. • More applications running on Cloud Computing. • Progress on standardization and interoperability, facilitating the development of the web of services. • Progress on Internet of Things, new sensorial systems and wireless integration, creating the possibility of having more devices in the environment. • Large panoply of mechanisms and tools for safe communications, although still difficult to integrate and configure. • Technological convergence continues to merge multiple media types onto new hybrid devices. • Progress on systems integration around the concept of smart home. • Fast development of ICT represents a barrier for seniors, but broadband access also creates new opportunities for distance learning.

Life Setting: Independent living **Vision facet:** Assistive technology and support services that facilitate independent living	• Advances in assistive/adaptive technologies for augmenting the capabilities of individuals, such as cognitive assistance, daily Living assistance, wellness monitoring, and health monitoring. • Progress in robotics, which may act as replacement for human care, including service and companion robots, and able to monitor and assist elderly people suffering both from cognitive disorders and physical disabilities. However, developments in this field encounter both scientific and economic challenges. • Progress in assistive communication technologies, which allows enhancing the communication abilities of the elderly to engage in desired person-to-person communications and person-to-machine communications. • Customizable user interfaces allow the usage optimization of screen space with adaptive interfaces, for different output channels (PCs, mobile phones, PDAs, etc.), and the inclusion of translation engines. • Experiments on preventing cognitive decline, focused on developments to compensate cognitive loss through assistive technologies. • Growing convergence between biology and ICT tools (e.g. ICT implants that enhance brain/cognitive function, genetic screening, DNA tests). But the use of biometric systems has not yet been fully explored, and ethical issues are likely. • Progress on assistive services for daily living assistance, driving assistance, cognitive assistance, etc.

Life Setting: Independent living **Vision facet:** Monitoring devices and technologies supporting ambient intelligence solutions	• Progress in sensing technologies, creating the possibility of having more effective monitoring and context awareness reasoning functionalities. • Some developments applying reasoning and context awareness. Extraction of knowledge about the activities of the user and the current situation in this environment from low-level sensor data to plan the appropriate short-term and long-term reaction. • The elderly behavior can be observed and compared to typical behaviors, issuing alerts when necessary. • Assistive robots can act as replacement for human care, including service and companion robots. They can monitor and assist elderly people suffering from cognitive disorders and physical disabilities. Developments in this field encounter both scientific and economic challenges. • Early developments on perception / recognition of emotions. • Progress on smart homes development opens new opportunities for developing novel monitoring and intelligent assistance services.

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Examples

Vision statement

"In 2015 most enterprises will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations in response to fast changing market opportunities and conditions.

Main mechanisms:

- Well founded models of collaboration
- Management systems for breeding environments replicable to a large variety of sectors
- Generic and invisible 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
- Active innovation and new value systems management in networks
- Support of social responsibility, including "life maintenance", based on a suitable ethical code
- Comprehensive (international) legal frameworks for VOs

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

Vision instantiation for ICT infrastructures

The ICT infrastructure will be developed as an invisible, affordable, and easy to use enabler of collaborative behaviors in networked organizations.

- Technology-independent reference architecture for the horizontal infrastructure
- Provide support for federated information and resources management
- Flexible control mechanisms supporting the implementation of a large variety of behaviors
- Plug-and-play concept extended to inter-organizational services
- Full e-transaction security is guaranteed
- "Configure yourself" philosophy (user "programmable" infrastructure)

Vision instantiation for socio-economic area

The socio-economic environment will be fully developed to support virtual organizations, stressing the importance of human-related issues at the individual and organizational level, in enabling institutions and in a transparent regulatory environment.

- People being prepared and supported to work as employees or professionals in enterprise networks or other virtual organisation settings
- New mechanisms and institutions to provide for human sense of belonging, long-lasting relationships and stability (social responsibility)
- New institutions and models to support "life maintenance", e.g. social security and personal training and development
- Support for companies by enabling institutions and services to set-up, enter and develop virtual organisations regionally and internationally
- Transparent legal framework, specially in the case of institutional collaboration
- Regional assets and identity leveraged and preserved
- Well founded understanding of social and socio-economic processes and developments in the context of networked economies

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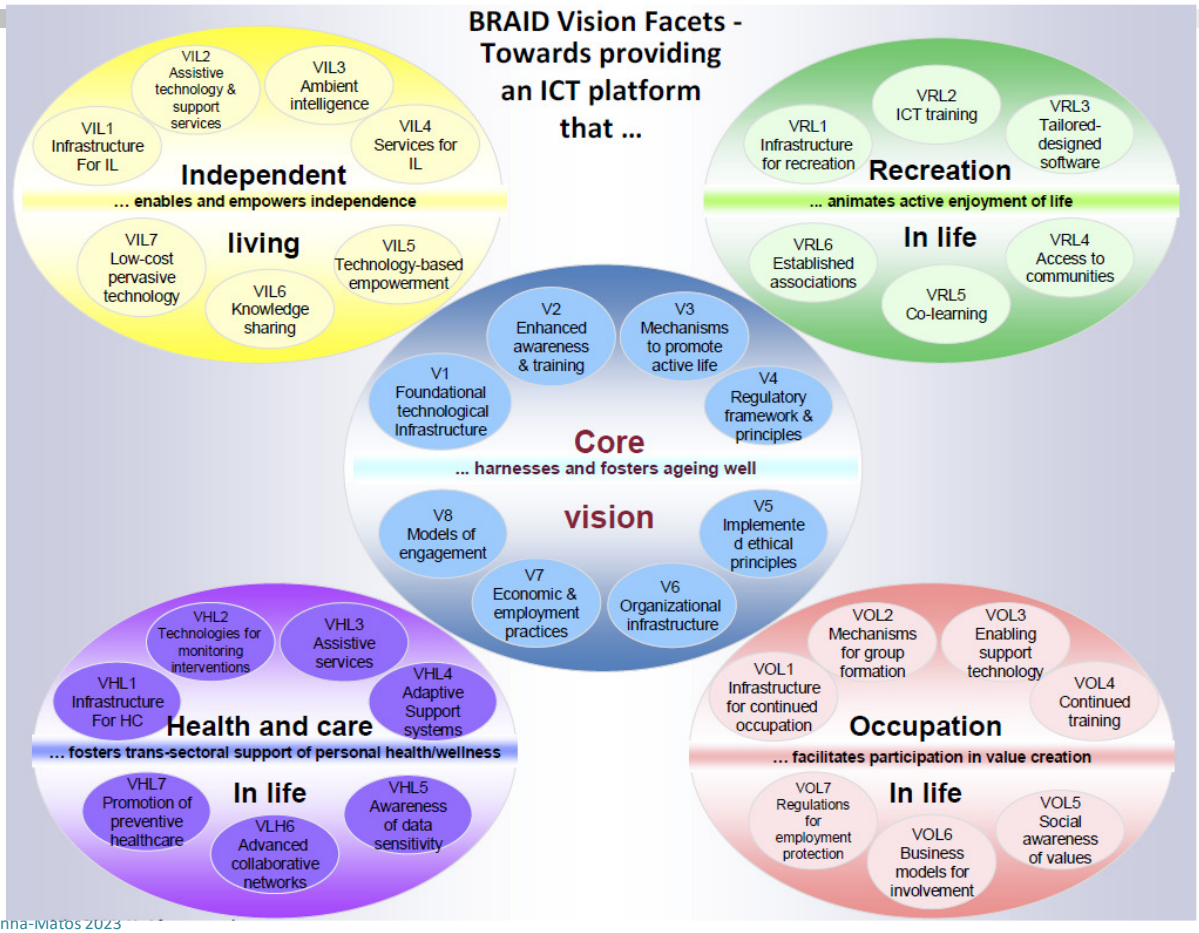
Examples



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How does a vision statement look like?

VISION STATEMENT

In 2020, lighting systems in buildings and other applications will:

- Enhance the performance and well-being of people
- Adapt easily to the changing needs of any user
- Use all sources of light efficiently and effectively
- Function as true systems, fully integrated with other systems (rather than as collections of independent components)
- Create minimal impacts on the environment during their manufacturing, installation, maintenance, operations, and disposal

As a result, people will understand, value, and utilize the tangible, personal benefits provided by these lighting systems.

Vision 2020
The lighting technology roadmap
www.nrel.gov/docs/fy00osti/27996.pdf

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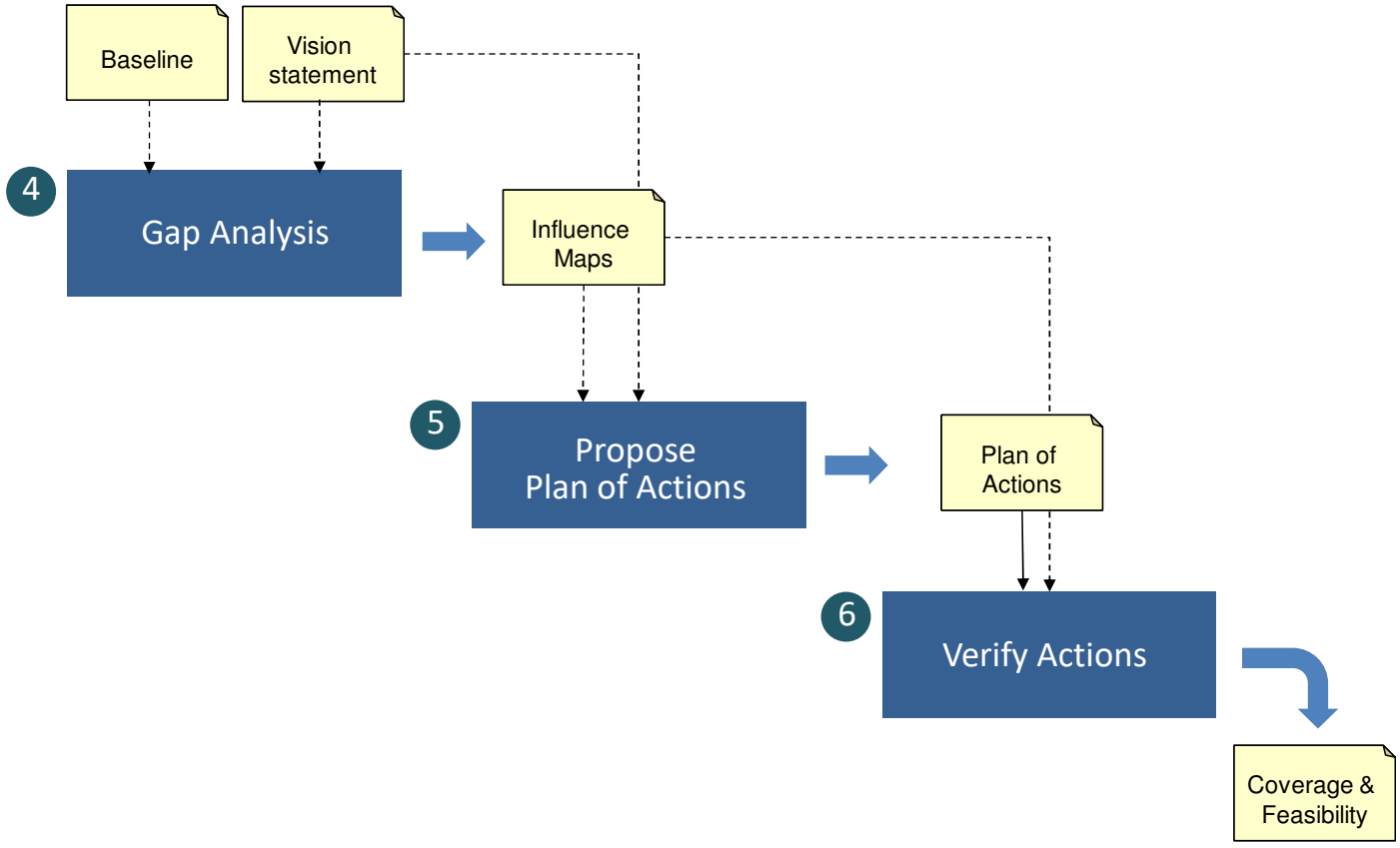
Next steps …



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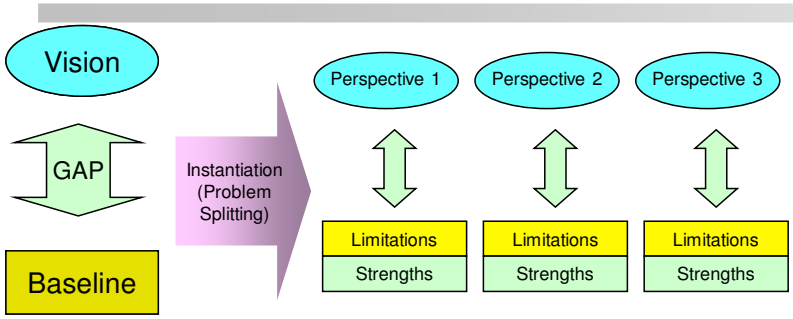
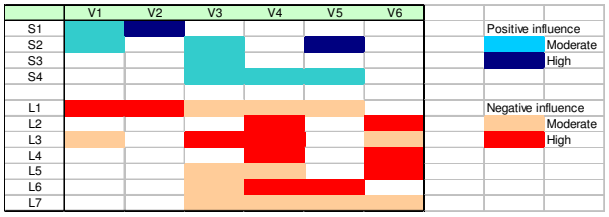
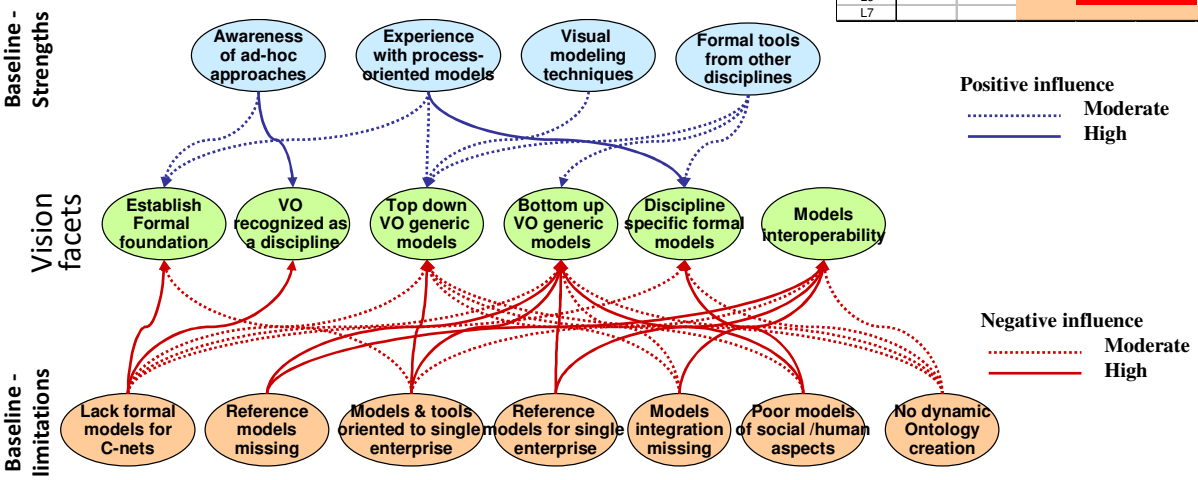
Example – Gap analysis







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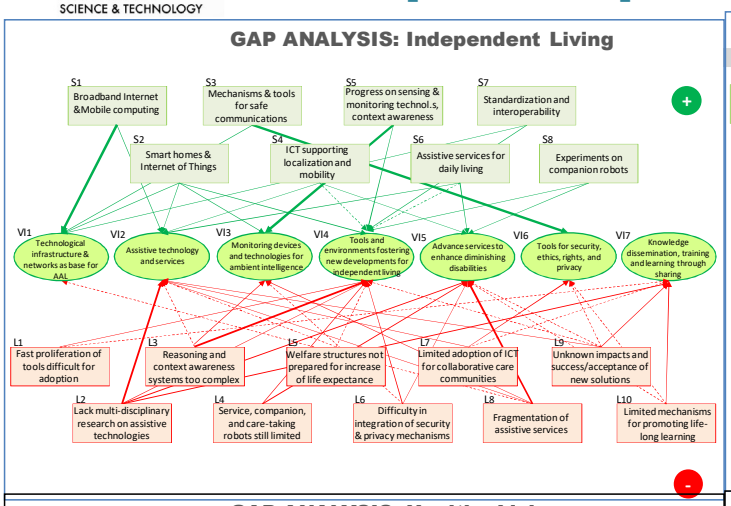
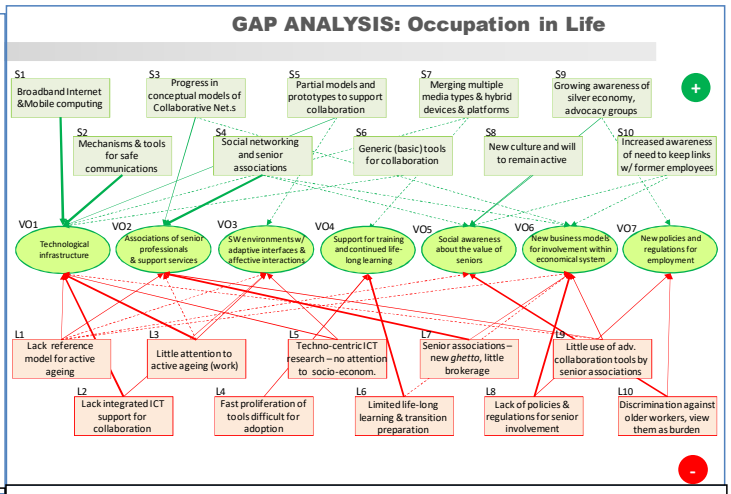
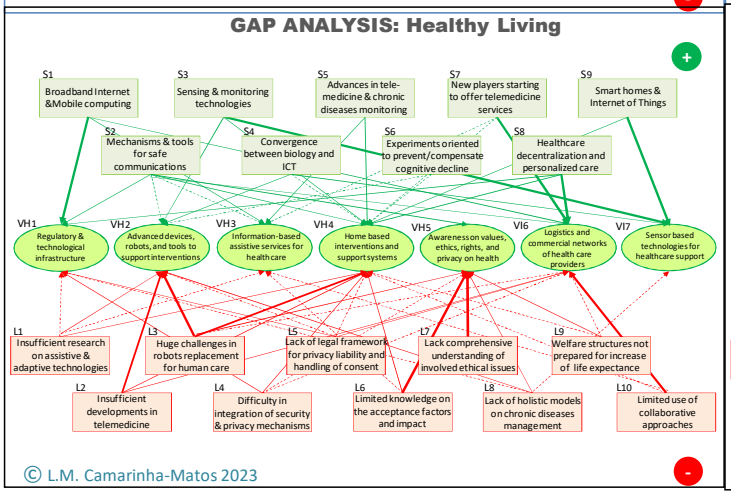
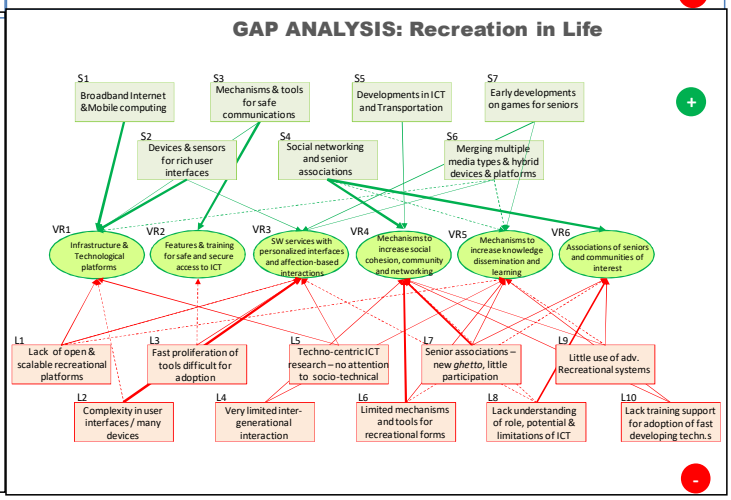
Example – Gap analysis









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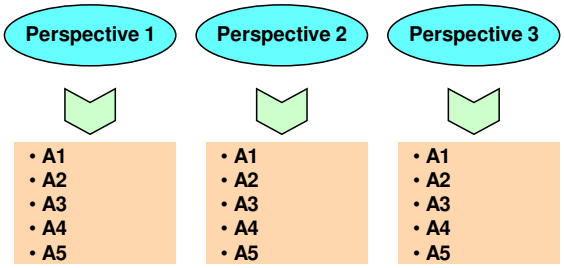
Example – Plan of actions



Actions Perspective X

- A1 ■ Establish a formal theoretical foundation for modeling dynamic collaborative networks
- A2 ■ Elaborate approaches for models interoperability, supporting multiple modeling perspectives (e.g. structure, behavior) at generic and focused area levels
- A3 ■ Define basic formal reference models (including ontologies) for collaborative networks at general and focused-area levels
- A4 ■ Elaborate soft modeling approaches and soft models to both handle incomplete / imprecise knowledge and capture the social/human aspects in collaborative networks
- A5 ■ Devise mechanisms for evolution and maintenance of reference models for collaborative networks

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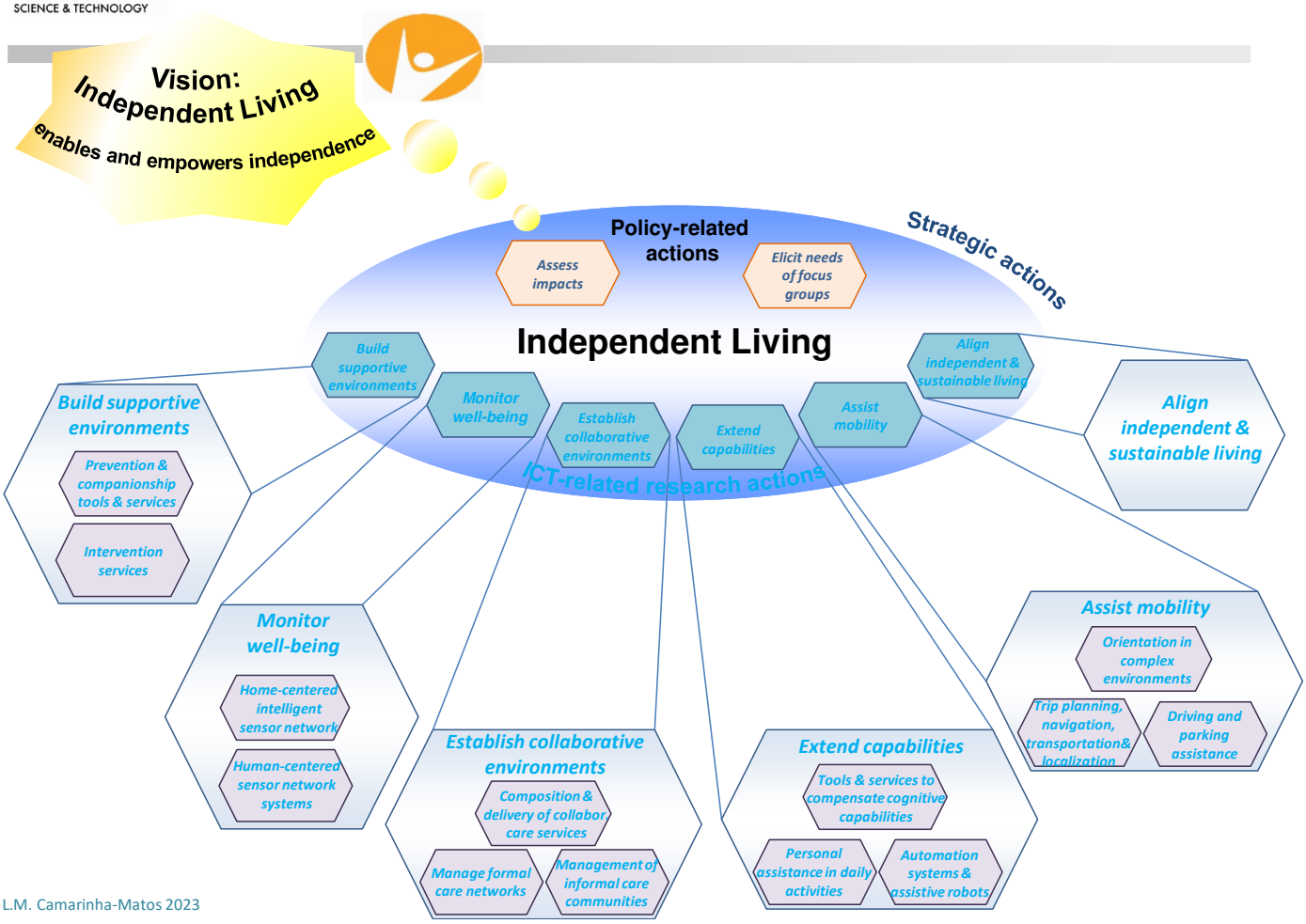
Example – Plan of actions



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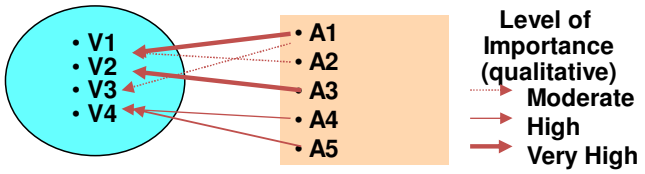
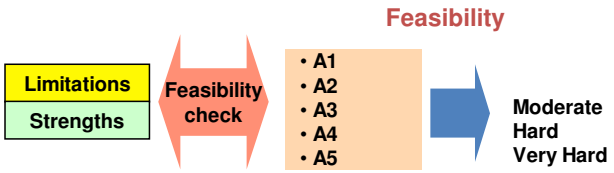
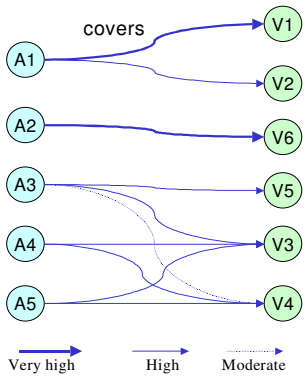
Example – Verification





Covering the vision



Feasibility check

	S1	S2	S3	S4	L1	L2	L3	L4	L5	L6	L7	Difficulty
A1												Moderate
A2												Moderate
A3												Mod/hard
A4												Hard
A5												Hard

	Strong help from	Strongly limited by
	Moderate help from	Moderately limited by
	Limited help from	Partially limited by

Covering the vision ?

or

Covers	V1	V2	V3	V4	V5	V6
A1						
A2						
A3						
A4						
A5						

	Very high
	High
	Moderate

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Example – Verification

VI_1 Technology-independent reference architecture

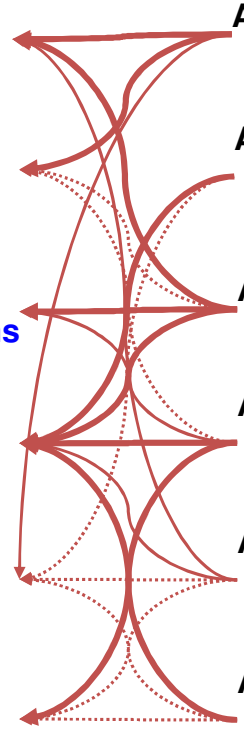
VI_2 Federated information / resources management

VI_3 Flexible control/ coordination mechanisms

VI_4 Plug-and-play support for services

VI_5 e-transaction security *and* privacy

VI_6 "Configure yourself" user "programmable"



A_1 Establish the principles of reference architecture, interoperability, and security

A_2 Establish foundation for systems evolution, software technology migration and systems integration

A_3 Develop generic, user-friendly (invisible!), and low-cost (free!) ICT infrastructure

A_4 Develop a "do it yourself" framework to assist the development of VO support services

A_5 Define a business model for developers, suppliers, and buyers of the ICT infra-structure developments and support software

A_6 Elaborate approaches to handle reliability and responsibility, when using multi-supplier building blocks

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Example – Feasibility

FEASIBILITY: Independent Living

	S1-Broadband Internet & Mobile computing	S2-Smart Homes & Internet of Things	S3-Mechanisms & tools for safe communication	S4-ICT supporting localization and Healthy	S5-Progressive sensing & monitoring (wearables, smart clothing)	S6-Assistive services for daily living	S7-Standardization and interoperability	S8-Experiments on companion robots	L1-Insufficient social fitness/adaptation	L2-Lack of multi-disciplinary research on assistive technologies	L3-Reasoning and context awareness for companion robots	L4-Service, companion, and care-taking robots skill gap	L5-Wide or universal preparedness/increase of the awareness	L6-Difficulty in integration of sensing and actuation mechanisms	L7-Limited adoption of ICT by older people and communities	L8-Fragmentation of assistive services	L9-Unknown impact and success/acceptance driver solutions	L10-Limit. mechanisms to promote healthy ageing	FEASIBILITY
AI1 Monitor Well-Being																			Moderate
AI2 Extend capabilities																			Moderate
AI3 Build supportive environments																			Hard
AI4 Establish collaborative environments																			Hard
AI5 Assist mobility																			Hard
AI6 Align independent and sustainable living																			Very Hard
RI1 Assess impacts																			Very hard
RI2 Train for new environments																			Moderate

FEASIBILITY: Occupation in Life

	S1-Broadband Internet & Mobile computing	S2-Smart Homes & Internet of Things	S3-Mechanisms & tools for safe communication	S4-Sensing & monitoring (wearables, smart clothing)	S5-Progressive sensing & monitoring (wearables, smart clothing)	S6-Assistive services for daily living	S7-Standardization and interoperability	S8-Innovative and artificial intelligence	S9-Growing integration of other economy sectors	S10-Increased connectivity and smart networks	L1-Lack of service ready	L2-Lack of support ICT support for companies	L3-Lack of access to achieving (work)	L4-Risk of exclusion of tech difficult for elderly	L5-Technical ICT issues	L6-Lack of learning & knowledge	L7-Social exclusion	L8-Lack of adaptation of regulations for social inclusion	L9-Lack of collaboration/ability for social associations	L10-Overcomm. Lack of trust, overcomm. Lack trust/privacy	FEASIBILITY
AO1 - Build collaboration platforms and systems																					Moderate
AO2 - Generate adaptive solutions and services																					Hard
AO3 Leverage legacy																					Moderate
AO4 - Create a model framework																					Hard
AO5 - Create trusted knowledge network																					Moderate
AO6 - Join online and offline collaboration																					Moderate
RO1 - Improve working practices																					Very hard
RO2 - Enhance policy and legislation																					Very hard
RO3 - Guide career transition																					Hard

FEASIBILITY: Healthy Living

	S1-Broadband Internet & Mobile computing	S2-Smart Homes & Internet of Things	S3-Sensing & monitoring (wearables, smart clothing)	S4-Convergence between biology and technology	S5-Wearables, implants, medicine & chronic disease monitoring	S6-Experiments oriented to investigation tools	S7-New devices, clothing & other wearable services	S8-Healthcare ecosystem and personalization	S9-Smart homes & Internet of Things	L1-Insufficient research on assistive & adaptive technologies	L2-Insufficient Data for AI in healthcare	L3-Huge steps in cases replacement for medical care	L4-Difficulty in integration of security and privacy in IoT devices	L5-Lack of legal framework for privacy	L6-Limited knowledge on the acceptance factors and impact	L7-Limited knowledge/understanding of evidence/trials/uses	L8-Lack of holistic approach to healthcare delivery improvement	L9-Wellness services impact on quality of life/ age	L10-Lack of collaboration opportunities	FEASIBILITY
AH1 - Develop health monitoring systems																				Moderate
AH2 - Establish safe infrastructure																				Hard
AH3 - Design integrated assistive services																				Hard
AH4 - Develop interventions																				Hard
AH5 - Establish healthcare ecosystem																				Very Hard
AH6 - Introduce innovative therapeutic approaches																				Very Hard
RH1 - Develop regulatory framework																				Hard
RH2 - Establish organizational and business models																				Moderate
RH3 - Raise ICT awareness and skills																				Moderate

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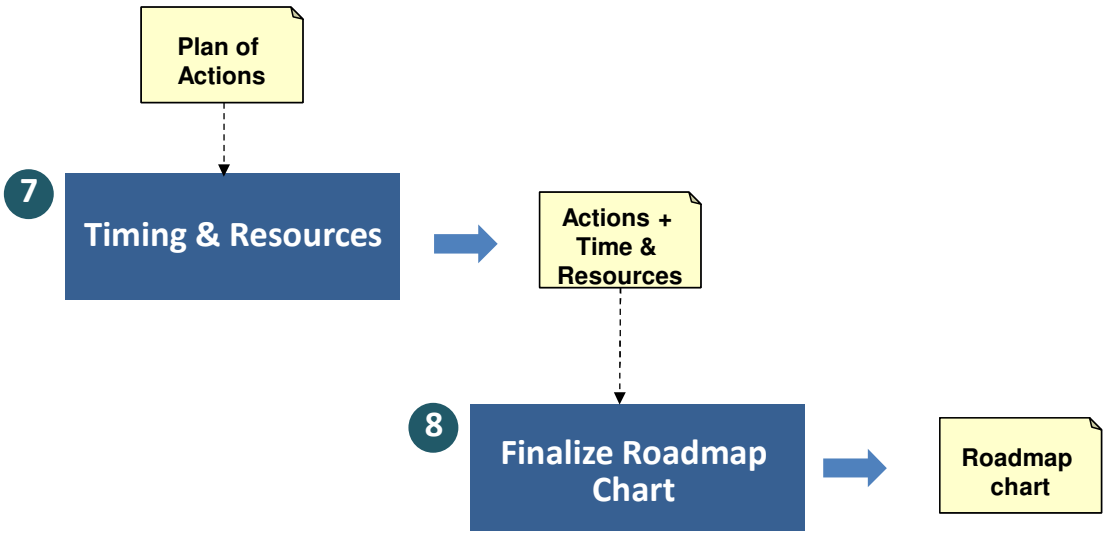
FEASIBILITY: Recreation in Life

	S1-Broadband Internet & Mobile computing	S2-Smart Homes & Internet of Things	S3-Mechanisms & tools for safe communication	S4-Social networking and sense-making	S5-Developments in ICT and Transportation	S6-Emerging multi-sensorial technology devices & platforms	S7-Early developments on games for seniors	L1-Lack of open & scalable recreational platforms	L2-Complexity in use that don't meet the lives	L3-Inertia/fear of and lack difficult for adoption	L4-Lack/inertia in learning and entertainment	L5-Technocentric ICT solutions, not oriented to community	L6-Limited motivation and tools for recreational forms	L7-Science vs citizens – Lack of citizen participation	L8-Lack understanding of risks, potential & implications	L9-Low use of advanced functional systems	L10-Lack training support for the use of ICT in developing sectors	FEASIBILITY
AR1 - Build recreational platforms, solutions and services																		Hard
AR2 - Build novel interfaces																		Moderate
AR3 - Find new recreational channels																		Hard
AR4 - Build participatory communities																		Moderate
AR5 - Create and promote gaming																		Hard
RR1 - Assess recreation impact																		Hard
RR2 - Train for digital lifestyle																		Hard
RR3 - Promote studies in recreation																		Moderate

Further steps



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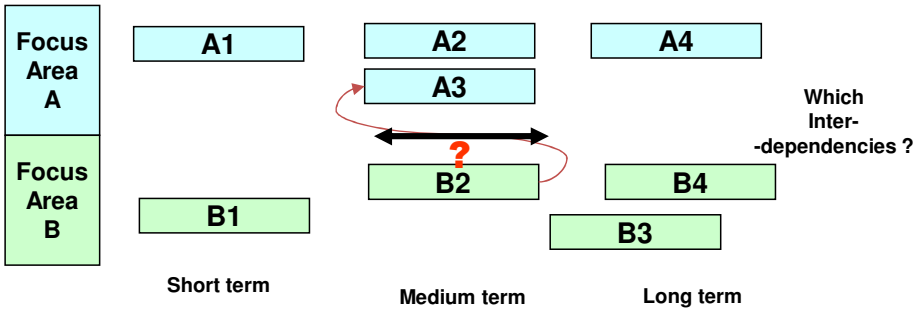
Example – plan details

- A1
- A2
- A3
- A4
- A5

+ **SCHEDULE**
- Short term
- Medium term
- Long term

+ **OTHER ITEMS**
- Who
- Resources
- ...



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How does a roadmap look like?

VOmap 1st attempt

TIME

Socio-economic Focus	Education and training schemas; VO support institutions and services	Socio-economic research; Regional & professional communities	Life maintenance schemas; Legal framework & ethical code
VO Management Focus	Business models & financing schemes; Plan. & performance measurement tools	Concepts & guidelines for organiz. design; Application of new value paradigms	Evaluation, improvements & individualization
Formal Theories and models Focus	Establish formal theoretical foundation; Elaborate approaches for models interoperability	Define reference models; Elaborate soft modeling approaches	Models evolution and maintenance
Support Services Focus	Breeding environment management system; Services for VO life cycle support	Business models for support services	VO's inheritance management; Traceability and inter-VO transactions
ICT Infrastructure Focus	Reference architecture principles; Invisible, affordable infrastructure	Business models for infrastructure; Migration and systems integration	Reliability and responsibility approaches; "Do it yourself" framework
	Short term	Medium term	Long term

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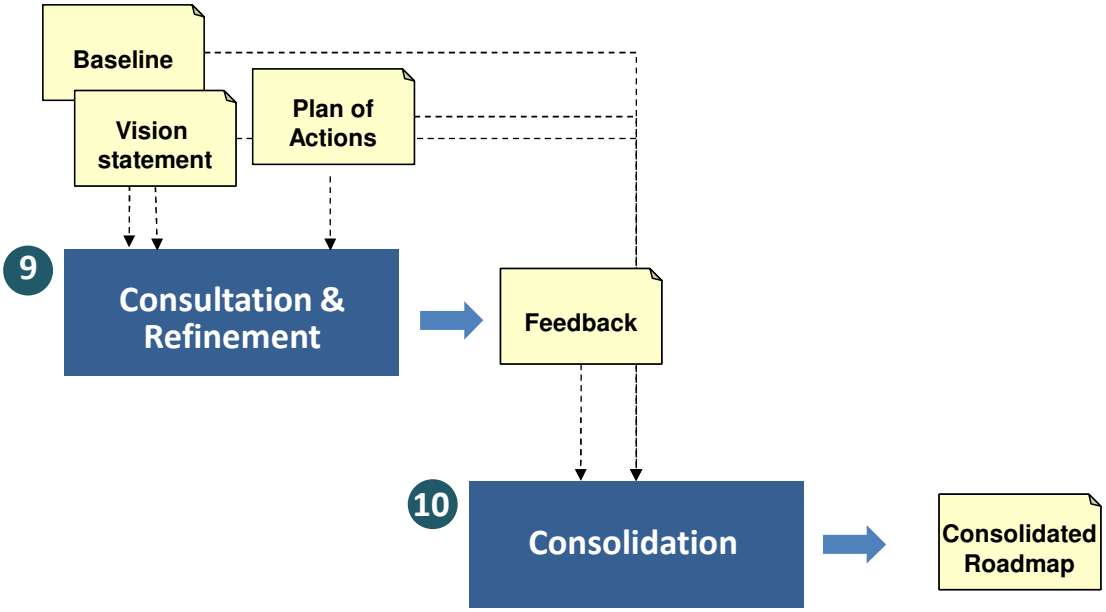
Verification & Consolidation



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Example – Consultation workshops

Group discussion
Argumentation
Amendment

Voting

Summarizing conclusions

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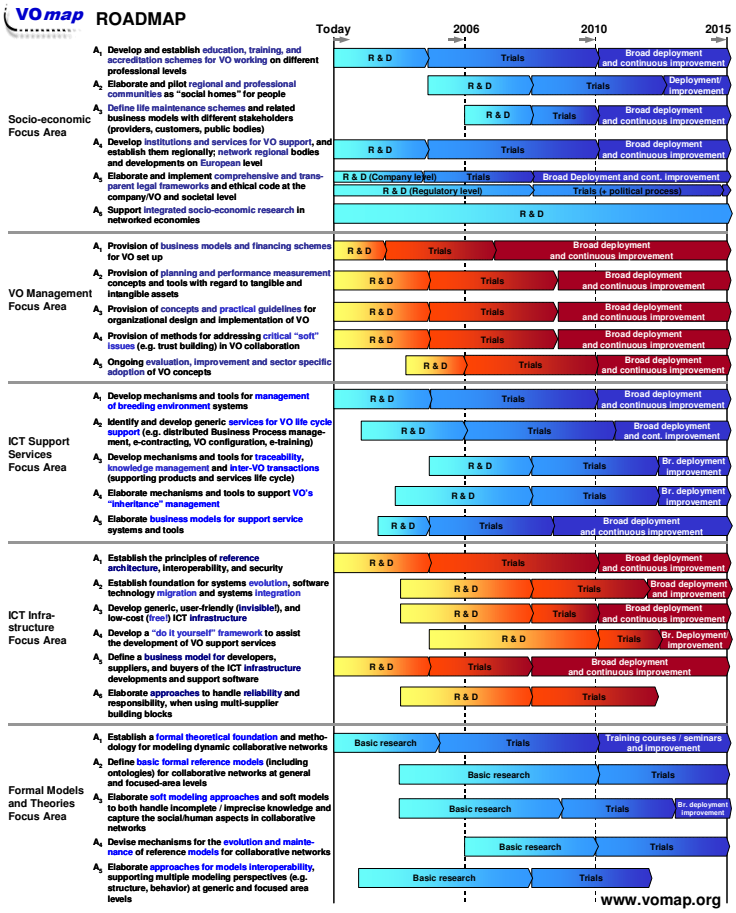
How does a roadmap look like?

VOmap 2nd attempt

Implementation Mechanisms

R&D
Trials
Deployment & improvement



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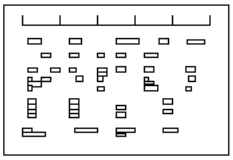
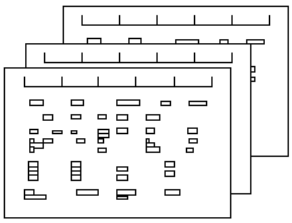
How does a roadmap look like?

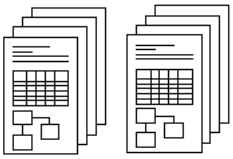
A roadmap can be represented at several levels of detail.



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]

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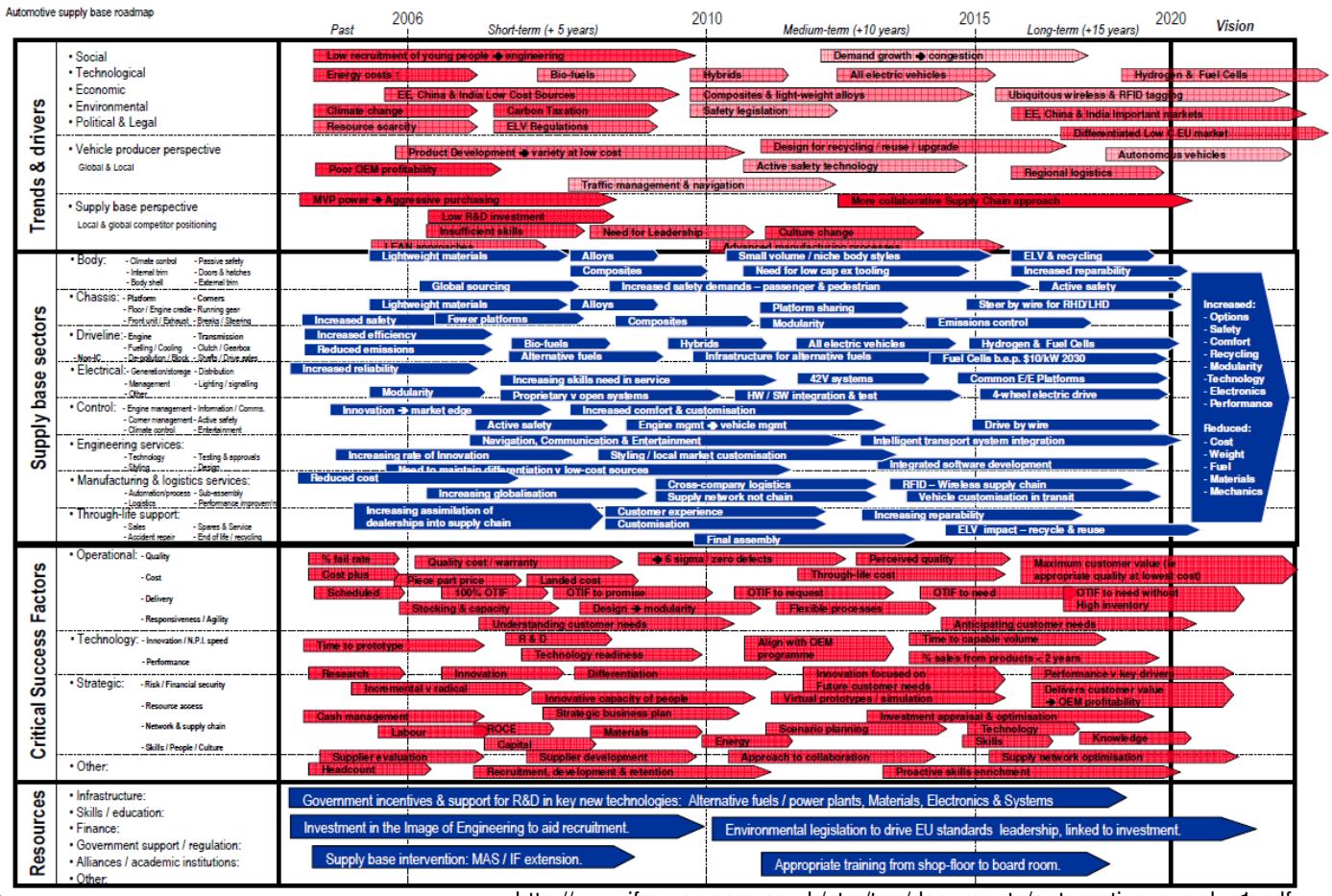
How does a roadmap look like?



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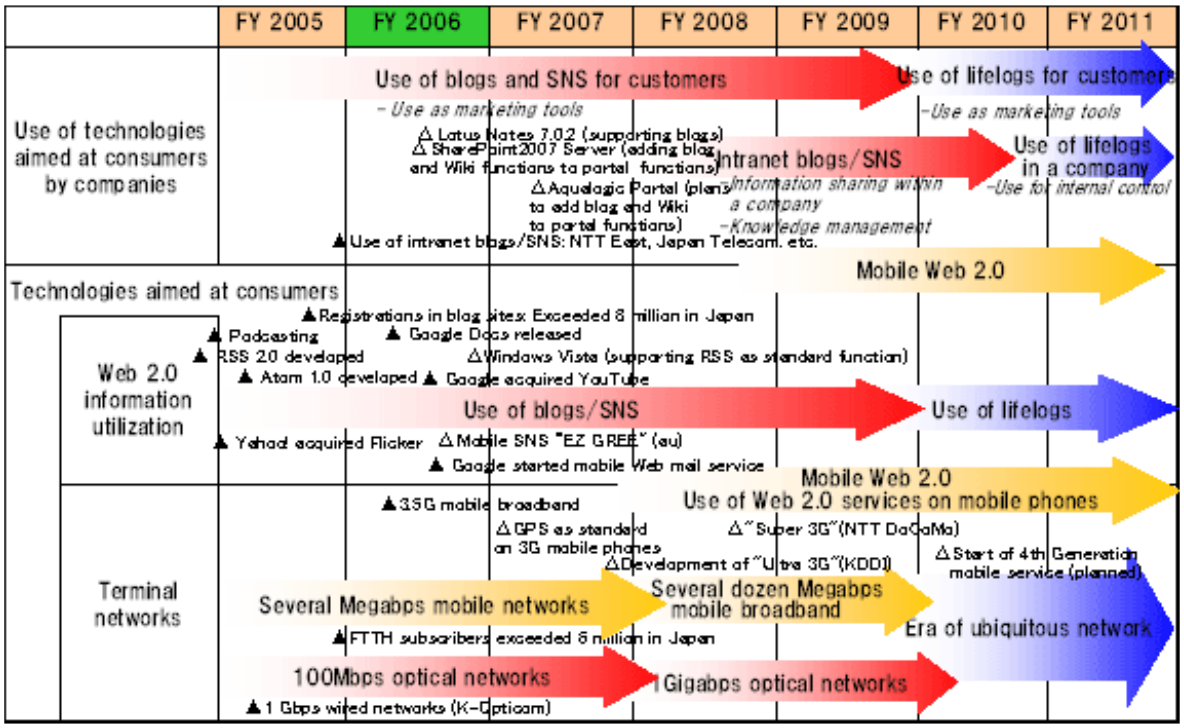
http://www.ifm.eng.cam.ac.uk/ctm/trm/documents/automotive_supply_1.pdf

How does a roadmap look like?

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



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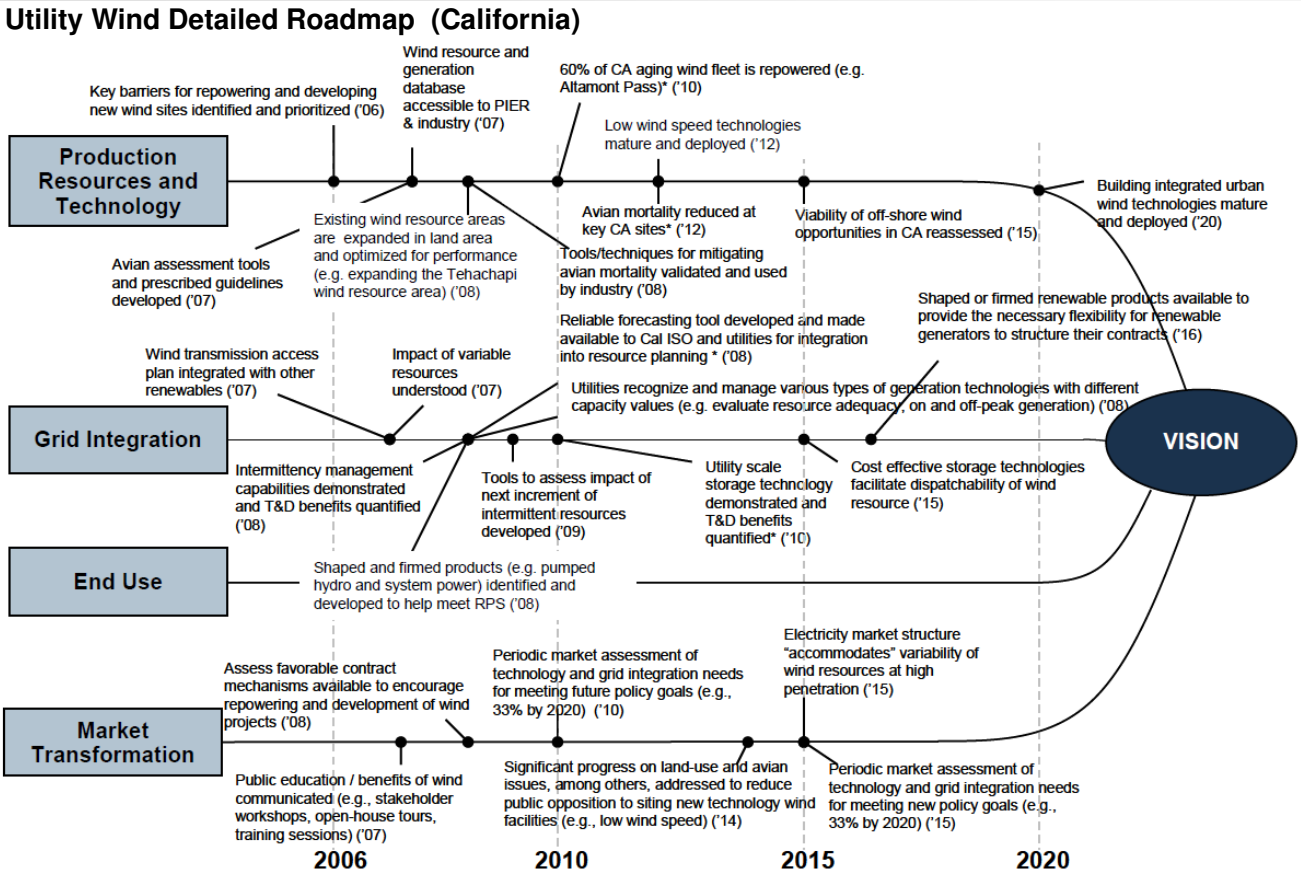
How does a roadmap look like?



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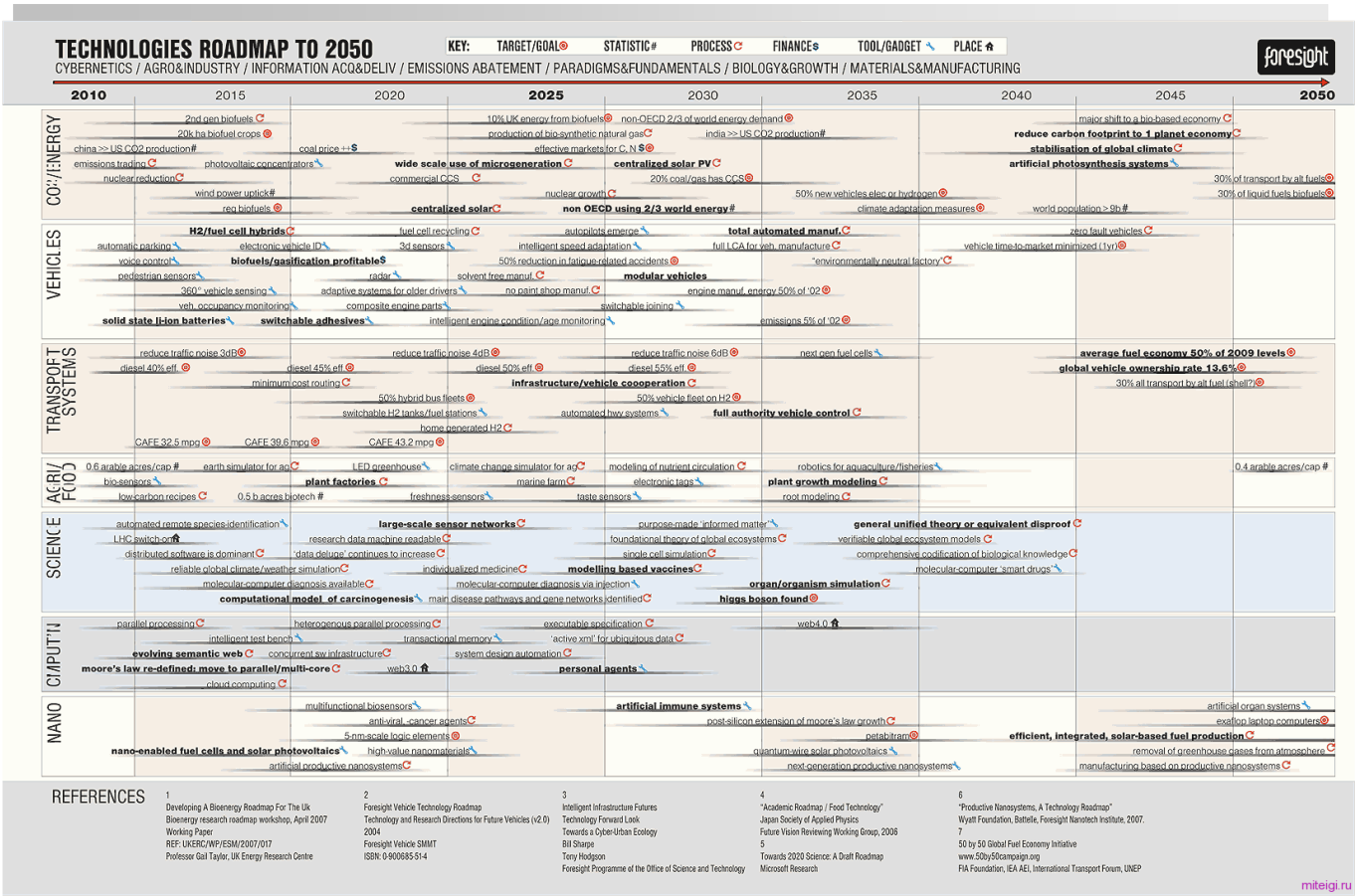
How does a roadmap look like?



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How does a roadmap look like?

S Short—Less than 3 years
M Medium—3 to 10 years
L Long—More than 10 years

MARKET TRANSFORMATION

STRATEGY 1—Develop clear definitions and standards for lighting quality

Activity	Timeframe
✔ Develop a uniform set of performance specifications for lighting systems.	S M
✔ Create industry-standard formats for energy and economics data for use across the many available software packages.	M
• Increase enforcement of ASHRAE/IESNA Standard 90.1-1989 and adoption of ASHRAE/IESNA Standard 90.1-1999.	S
• Determine objective definitions and metrics of lighting quality.	S M
• Support and conduct third-party evaluation of integrated lighting system design and application.	S M
• Incorporate requirements for environmental sensitivity for lighting systems (such as daylight use) into the existing code structure.	M

Note: Checkmarks indicate the activities that ranked #1 in their respective category from the internet voting. For detailed voting results for all categories, visit the Lighting Roadmap Web site.

MARKET TRANSFORMATION

STRATEGY 2—Increase demand for high-quality lighting solutions by quantifying, demonstrating, and promoting life-cycle benefits to broad audiences

Activity	Timeframe
✔ Increase scientific knowledge of how lighting parameters impact human psychology, health, and productivity.	M
✔ Maintain nonpartisan lighting centers and laboratories around the country where innovative lighting technologies can be demonstrated.	M
✔ Conduct educational forums for end users about the effects of lighting on people and their activities.	S
• Identify real customer needs through needs assessments and focus groups.	S
• Determine unique lighting characteristics and needs for specific environments (e.g., hospital, retail, office, restaurant).	M
• Use work performance research to help make the marketing of quality lighting more effective, as with ergonomic furniture.	M
• Conduct regional light fairs/expositions to showcase innovative lighting technologies.	S
• Develop a marketing campaign promoting quality lighting to the general public.	S
• Increase use of government buildings to demonstrate innovative technologies.	S M
• Increase publicity on the results of collaborative design and construction projects.	S M

MARKET TRANSFORMATION

STRATEGY 3—Strengthen industry education and credential lighting professionals

Activity	Timeframe
✔ Create educational programs on the design, installation, and use of lighting controls.	S
✔ Improved education on daylighting, including simple rules of thumb for architects.	S
• Provide training to product sales and distribution professionals about life-cycle cost analysis and the effects of lighting on people.	S
• Increase incorporation of NCQLP and CLMC certification requirements into Request for Proposal and Request for Quote language for building construction projects and energy-saving performance contracts.	S
• Establish design assistance teams to teach others how to better integrate lighting into overall building design and how to maximize daylighting.	S M
• Increase use of the Internet to provide information on research, demonstration, and regulatory activities.	S

Vision 2020
The lighting technology roadmap
www.nrel.gov/docs/fy00osti/27996.pdf

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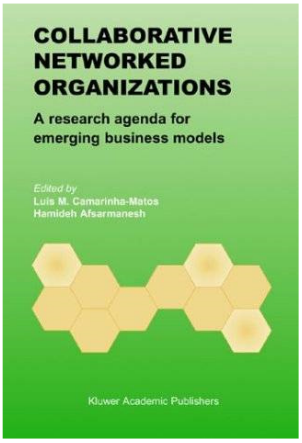
Further reading



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. www.researchgate.net/publication/226937637_A_Roadmapping_Methodology_for_Strategic_Research_on_VO

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. www.researchgate.net/publication/226527248_A_Strategic_Roadmap_for_Advanced_Virtual_Organizations

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

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

James Parnitzke (2011), How to build a Roadmap http://pragmaticarchitect.wordpress.com/2011/03/05/how-to-build-a-roadmap/

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