# Methodological issues in forecasting: Examples from projects to support of ICT policy making

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# Outline

- Trend Analysis: Demand, technologies and architectures towards 2030
- Investment uptake towards 2030
- Business model of 4G networks
- Scenario methodology: Policy use

# Demand, Technology and Investment in Telecom Infrastructure towards 2030

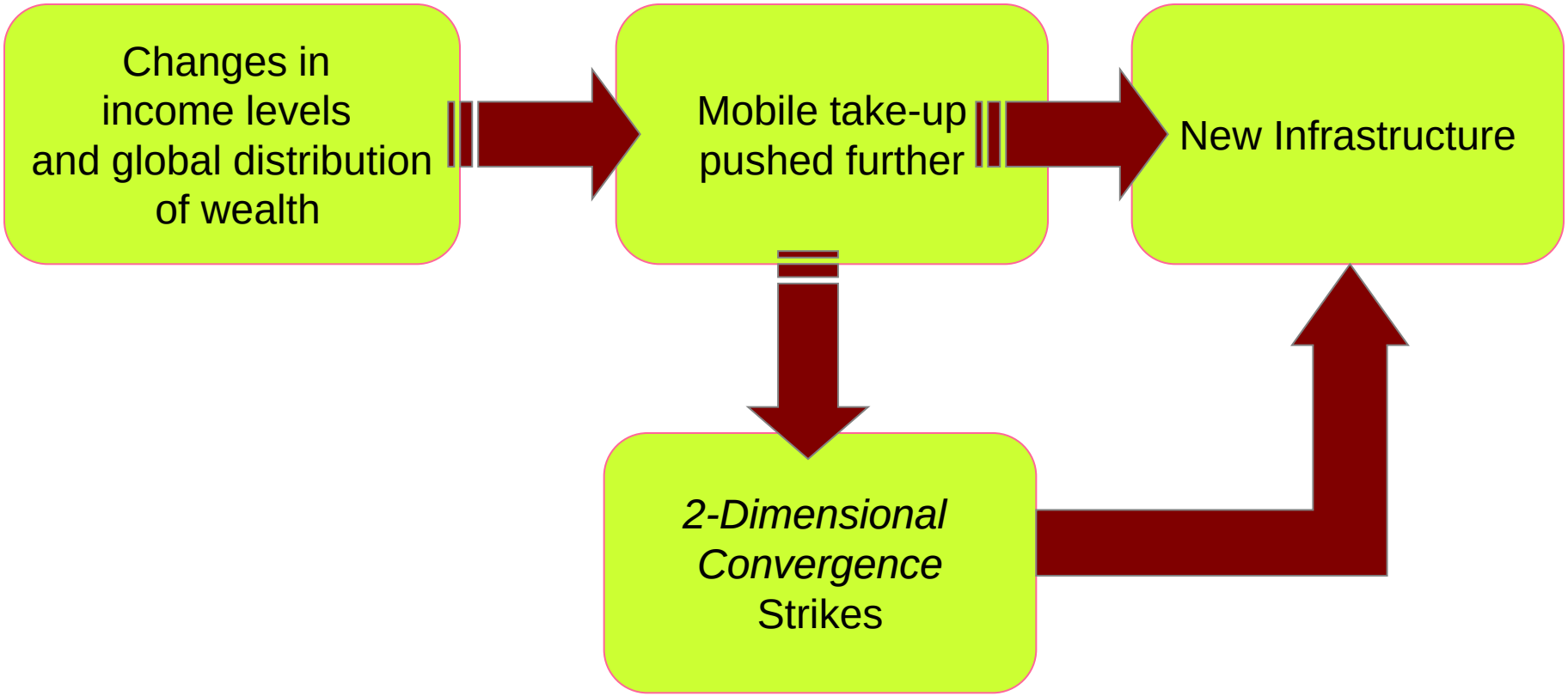
**A full paper has been published by the OECD in a book under the title:**

***Infrastructures to 2030 - Telecom, Land Transport, Water and Electricity*.**

# OUTLINE OF 2030 ANALYSIS

- The foundation – global demand
- Shape of network architecture to come - 2030
- Estimates of corresponding investment
- Global Impacts

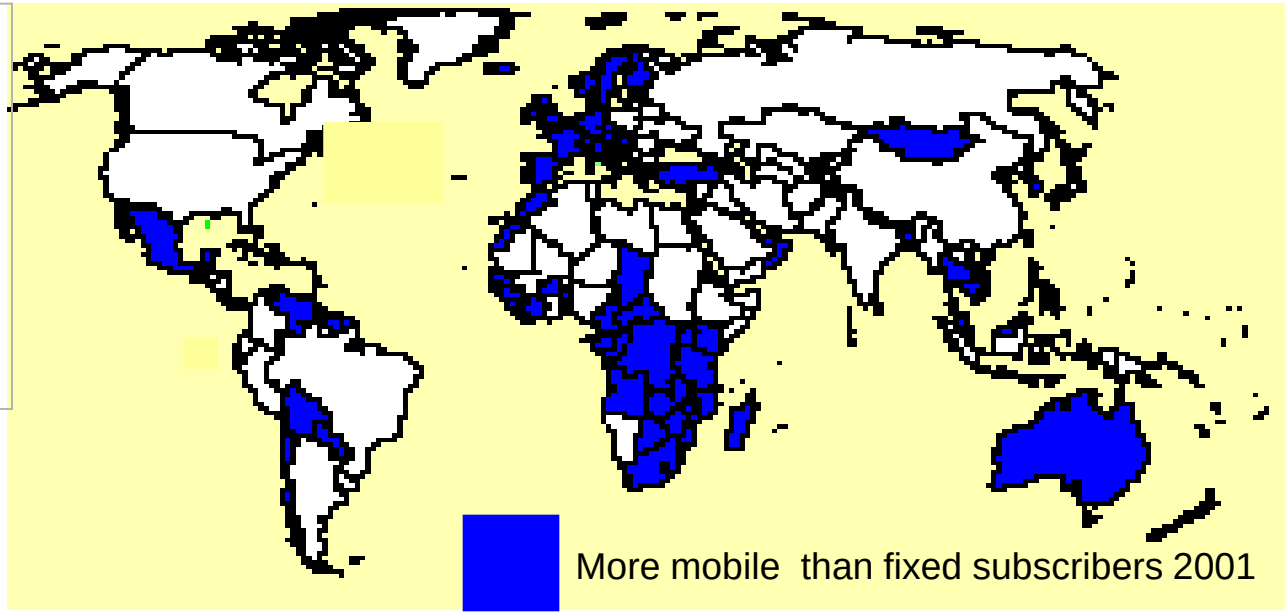
# A simple story for future telecommunications infrastructure -




**Note : by 2- Dimensional Convergence we imply the merging of;**
**( telecoms and media industries ) + ( fixed and mobile communications as one service )**

# The changeover is rapid and progressively becoming global -

Even in 2001, over 30 countries had more mobile than fixed subscribers, with the poorer countries leading




***Source*: ITU World Telecommunication Development Report, 2002; ITU World Telecommunication Indicators Database**

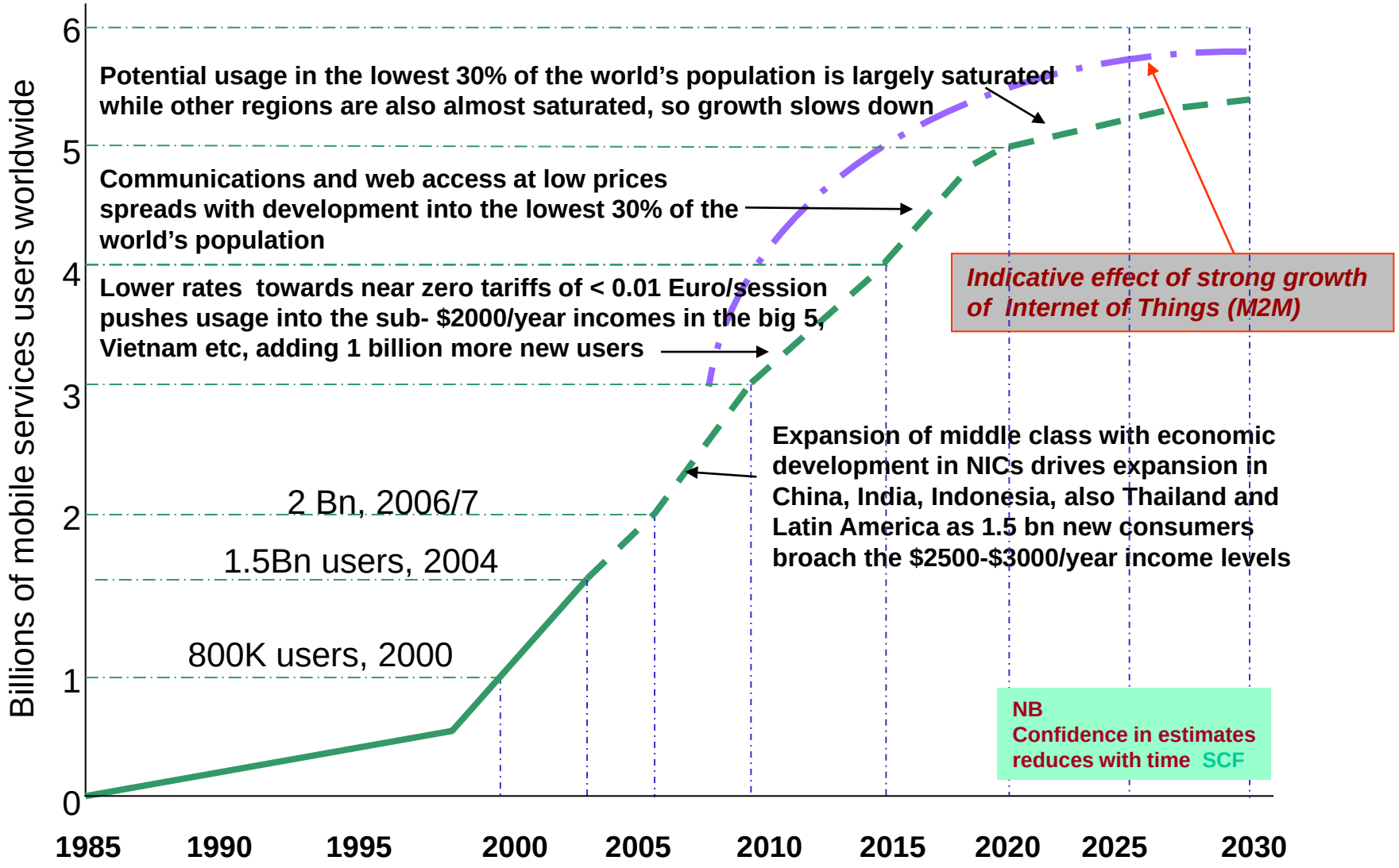
## GDP growth per capita is growing fastest in non-OECD countries

| **GDP/ capita GROWTH** | **1980s** | **1990s** | **2001-5** | **2006-15** |
|---|---|---|---|---|
| High income countries | 2.5 | 1.8 | 1.4 | 2.5 |
| Developing countries | 0.7 | 1.7 | 2.7 | 3.4 |
| World total weighted | 1.3 | 1.2 | 1.0 | 2.2 |

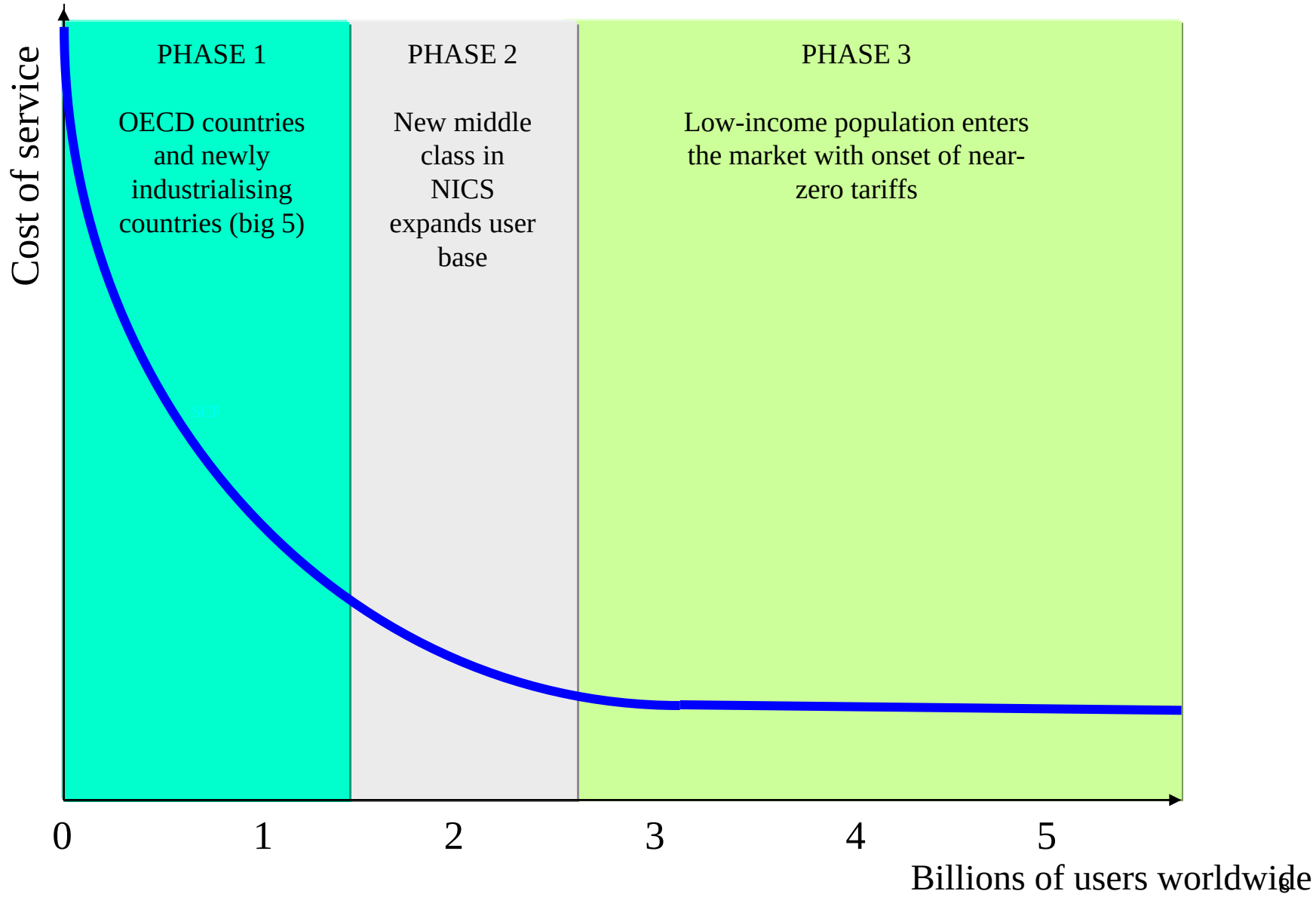
**Source World Bank 2005**

# Global user population growth

•With globalisation, OECD cost levels of services and handsets will slowly be rebalanced, being set by average world prices
•Saturation is set by affordable price for the majority of users – numbers which may reach 65% of a global population of over 8.2Bn by 2030 (US Census Bureau, 2005) if world usage goes towards average OECD levels of saturation today: 5.3Bn users

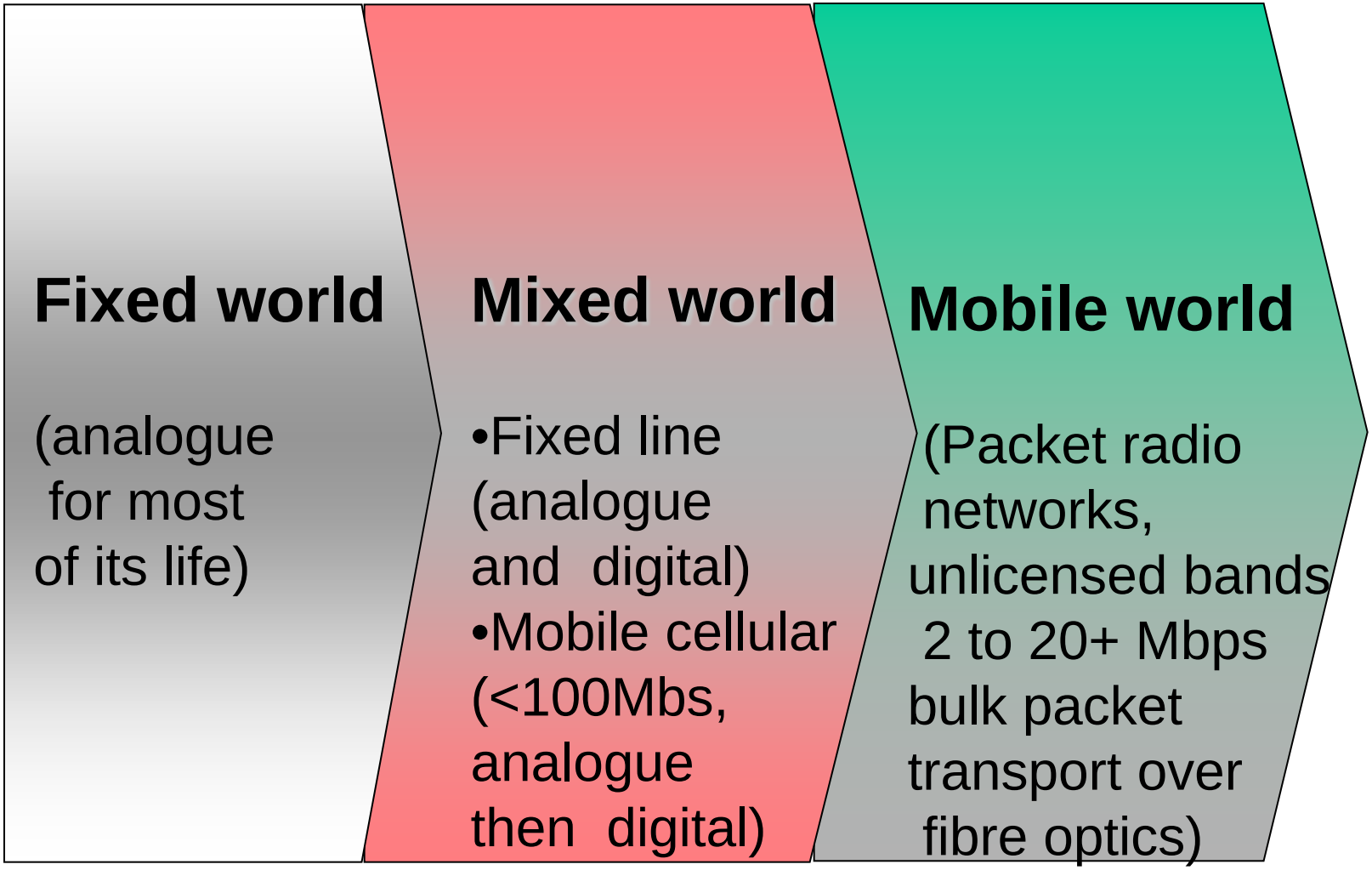


# User population numbers against base price trends – user population size is driven by costs of services

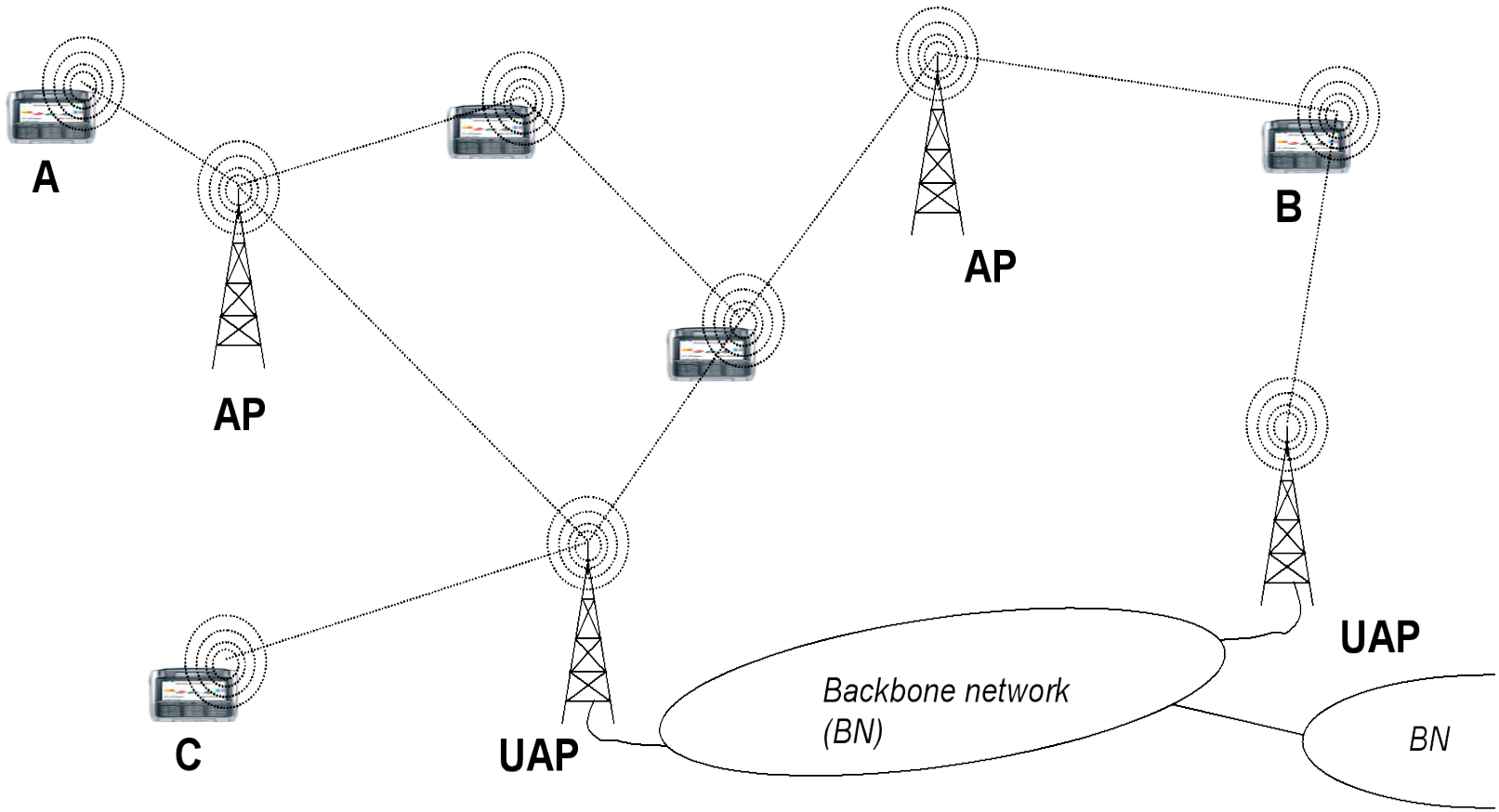


- The foundation – global demand
- ***Shape of network architecture to come - 2030***
- Estimates of corresponding investment
- Global Impacts

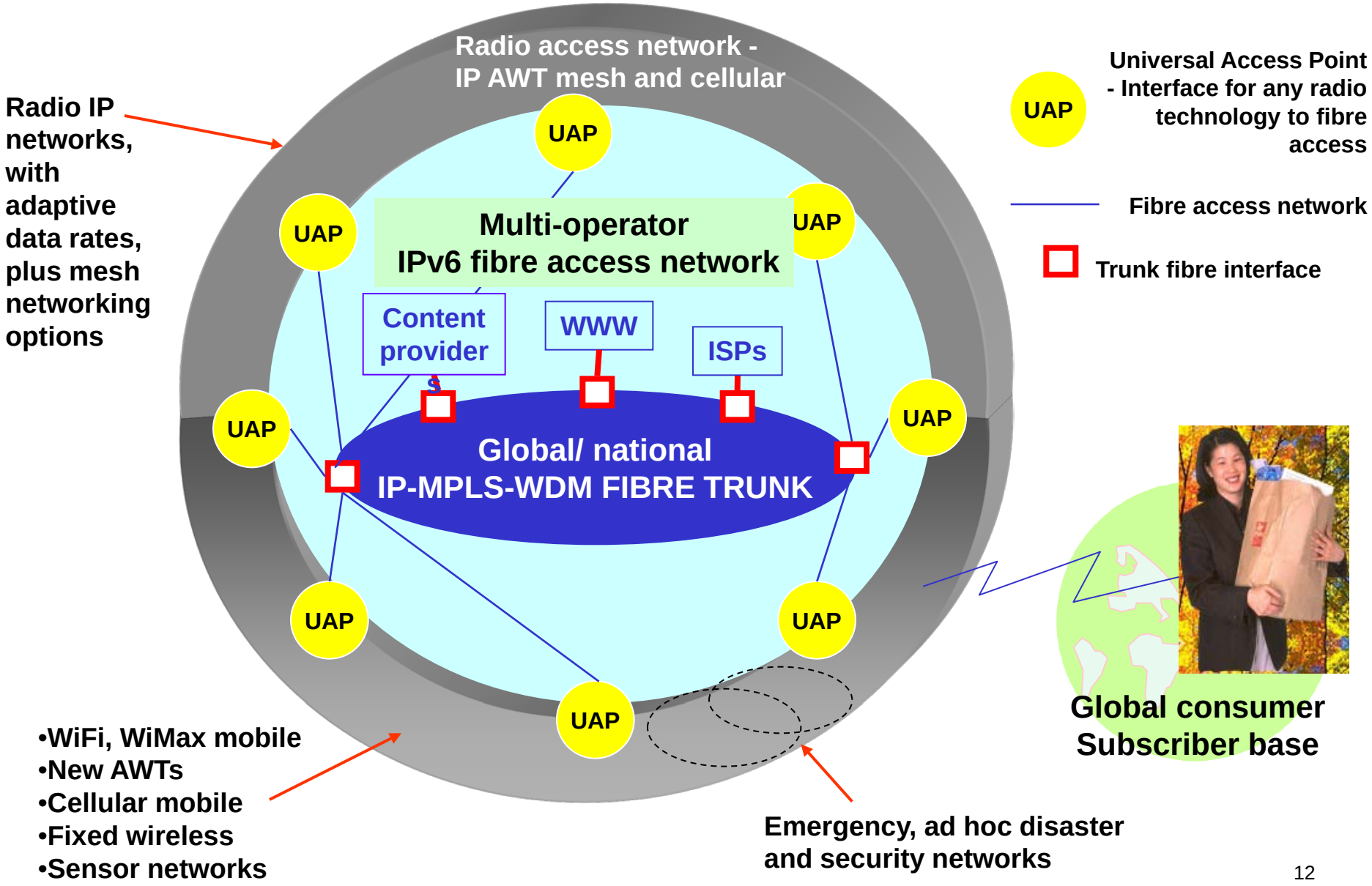
# Communications in the local loop will advance towards ubiquitous, pervasive services with new radio access techniques



# Towards a new infrastructure in mobile: relay antennas and terminals



# A simplified infrastructure beyond 2020 – a large mobile IP network - with a standard composite structure of optic fibre & radio



- The foundation – global demand
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- ***Estimates of corresponding investment***
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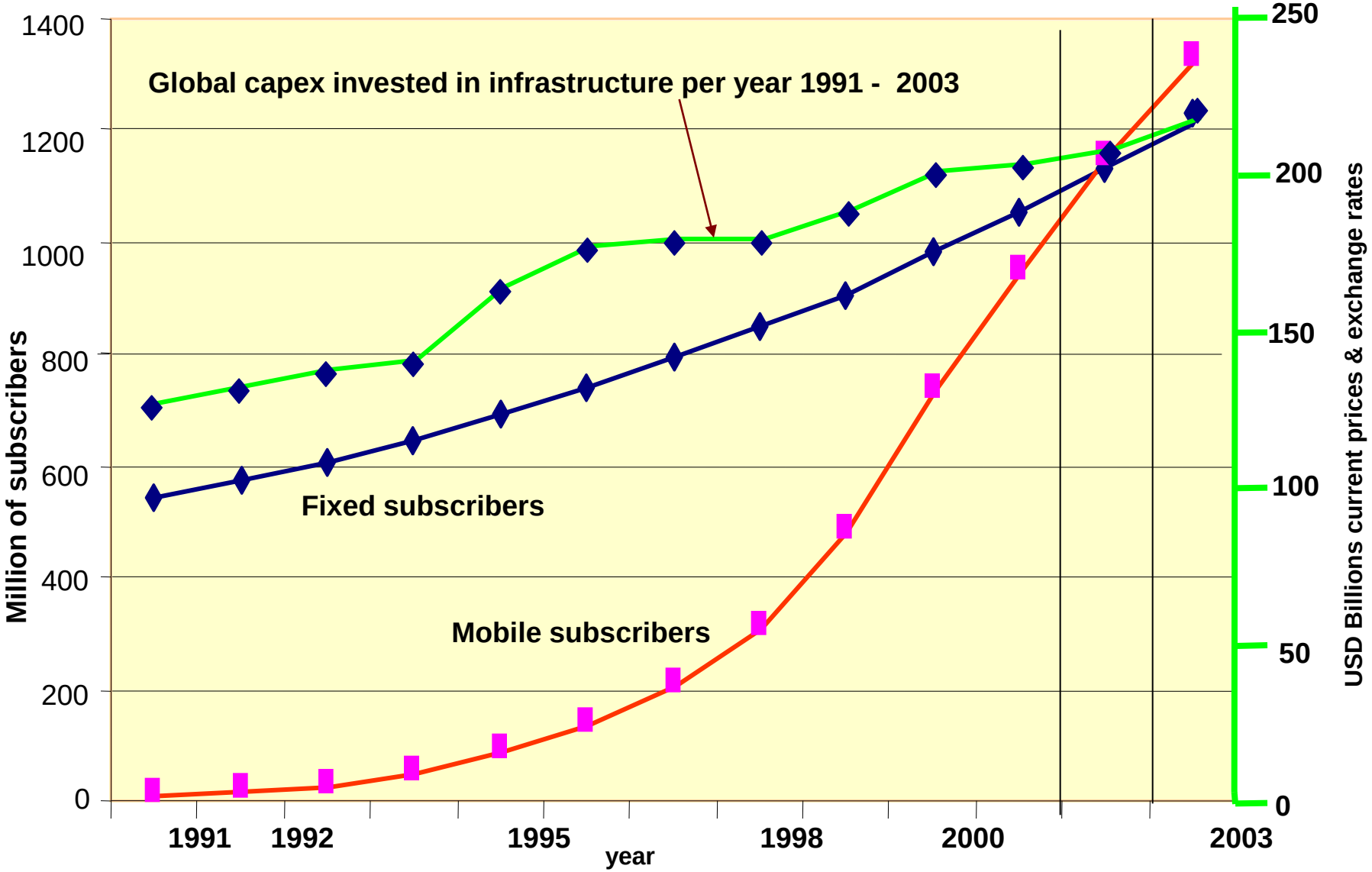
# Growth of subscribers worldwide 1991 - 2003 fixed and mobile against infrastructure investment (ITU) - the trend is for infrastructure spend to rise in absolute terms – but investment per user is *reducing* rapidly with time

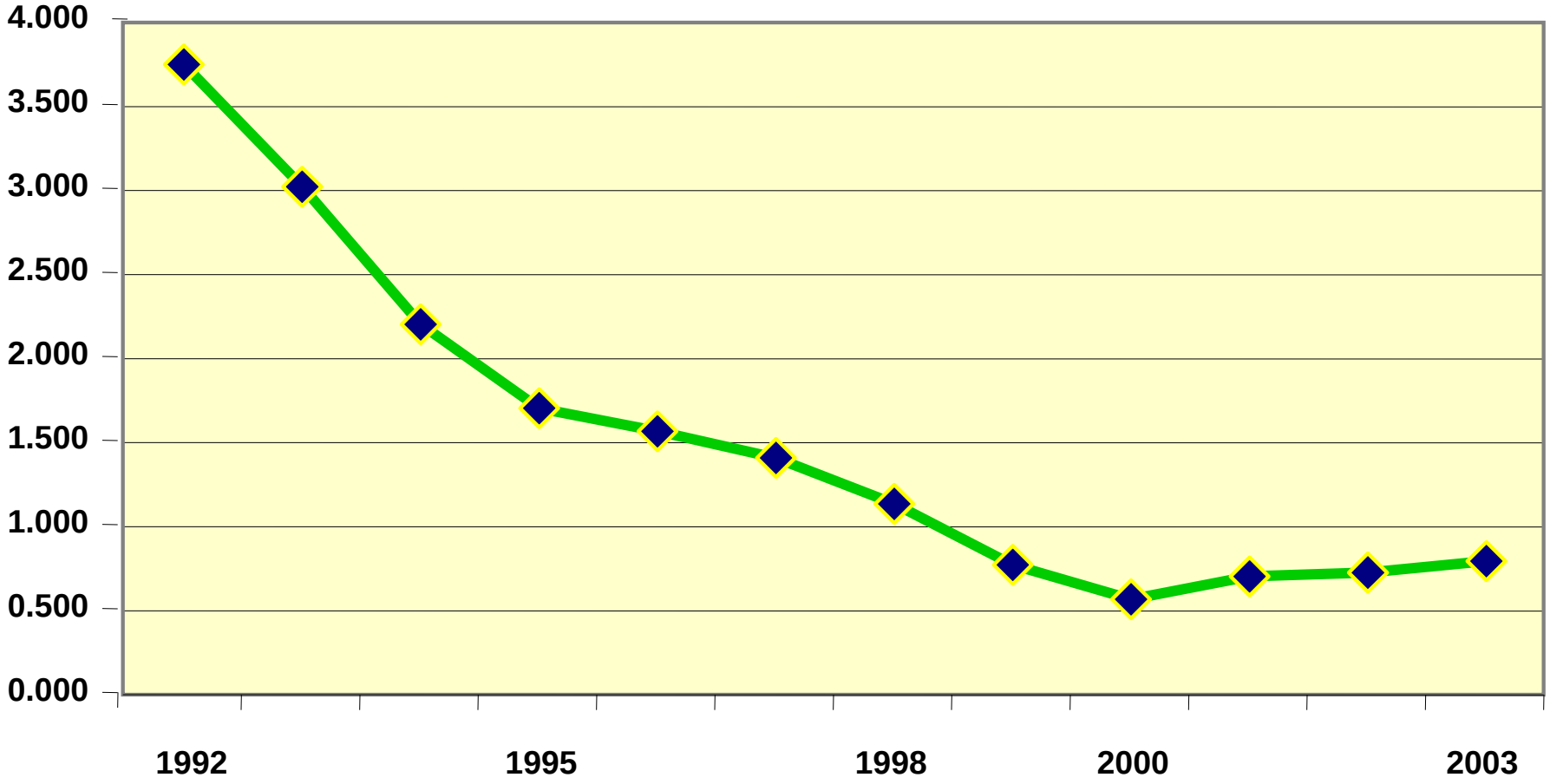



Source: ITU world telecommunications indicators database 2002

# The key trend is to cheaper infrastructures - capex per new subscriber* in kUSD 1992-2003

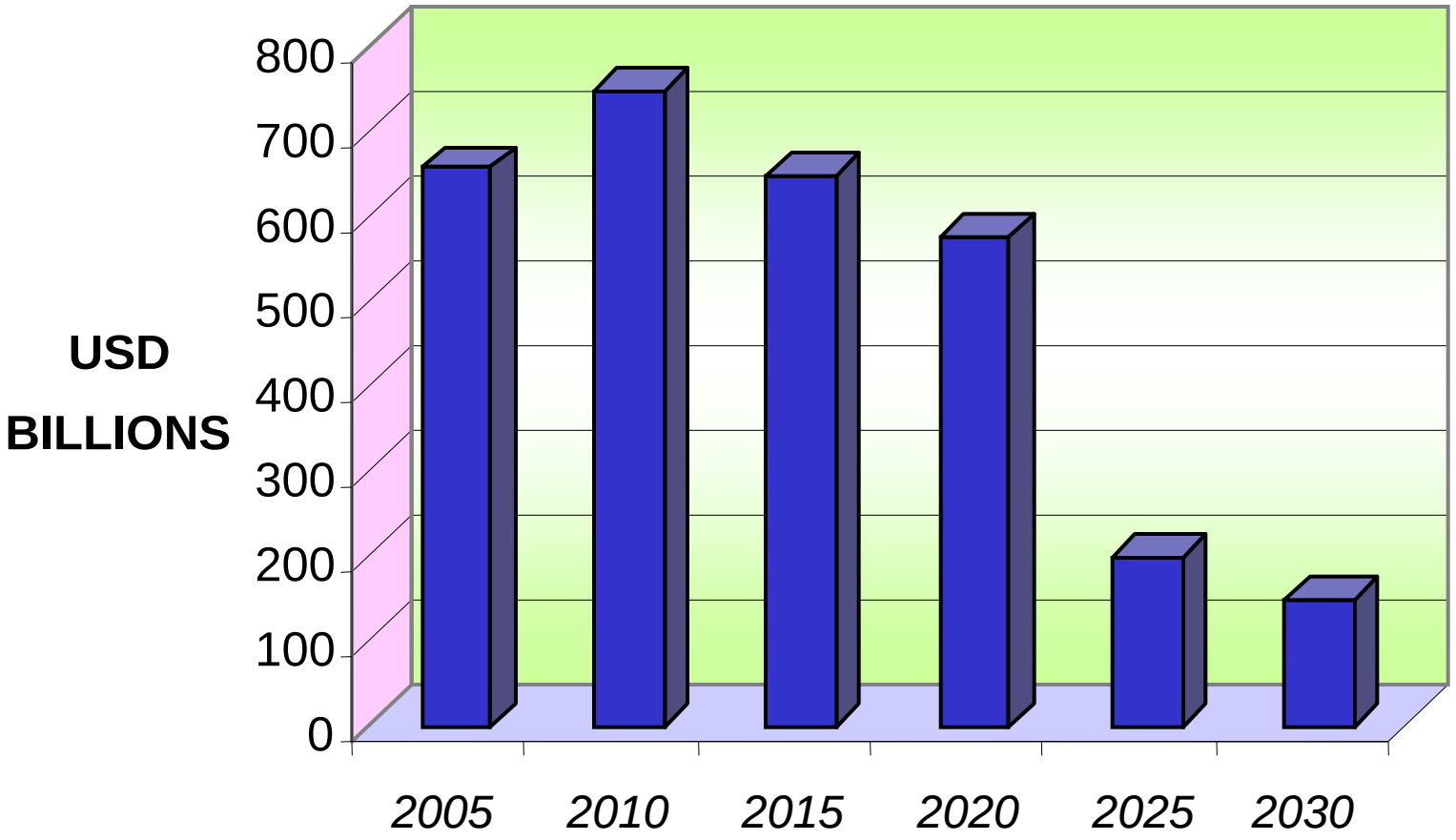
## - with technology advance, infrastructure cost/subscriber shrunk almost continuously 1992- 2003, as newer digital technology took hold, by some 70%

*** calculated as capex spend in previous year to create new subscribers in current year**



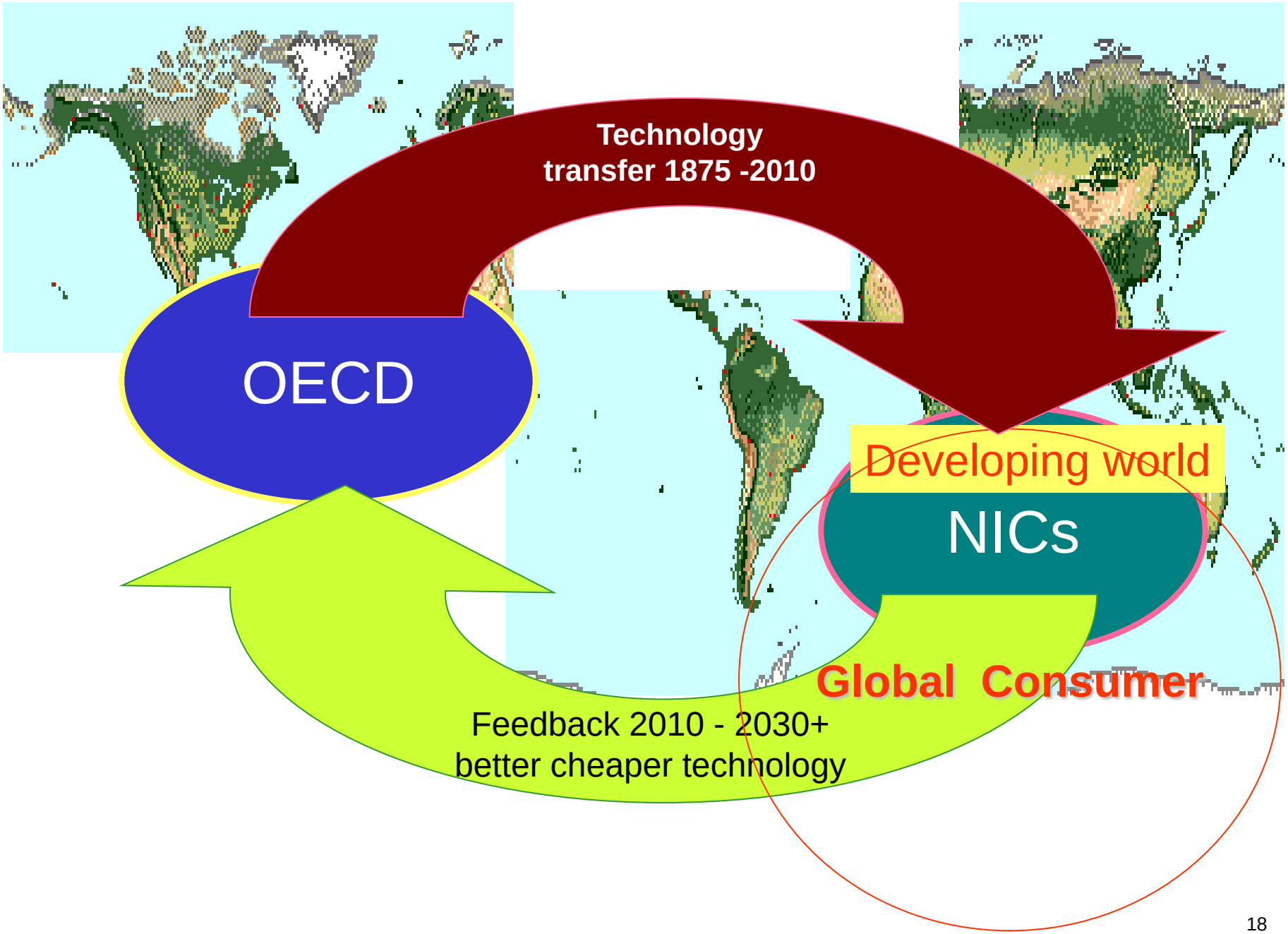

**Source: SCF Associates - derived from ITU World Telecommunications Indicators Database 2002**

# Infrastructure spend per year 2005 -2030 descends as technology advances to lower cost while global markets saturate




Model estimates

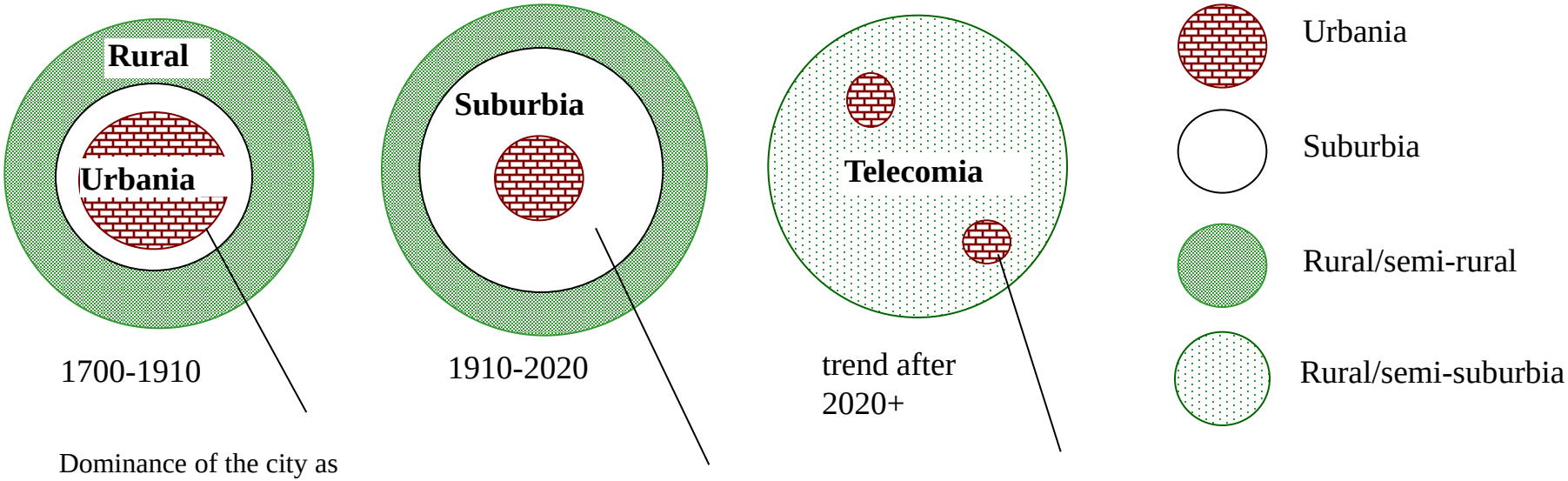
- The foundation – global demand
- Shape of network architecture to come - 2030
- Estimates of corresponding investment
- ***Global Impacts***


Technology
transfer 1875 -2010
OECD
Developing world
NICs
Global Consumer
Feedback 2010 - 2030+
better cheaper technology

# An infrastructure for the easiest commute of all?

- Is a new disposition of habitation – Telecomia - already appearing ?
  - Mesa Del Sol, Arizona – cheaper than Aspen, Los Angeles or San Francisco
  - Ideal climate
  - Far from everything
- 12 % of US workforce* is ‘distributed’ knowledge workers - i.e. ‘post-geographic’
- Lives in Telecomia ?

***Dispersion of residency and work places with teleworking and teleshopping -***




Dominance of the city as manufacturing and trade centre (largely in the OECD community)

Population migrates to the suburbs in many OECD countries

Cities shrink and tend to return to residential areas, with entertainment and hotel functions

* Business Week Europe 12/19 DEC. 2005 p. 80, Michelle Conlin *The easiest commute of all*/ C. Grantham Work Design Collaborative

# Business model

*Contribution builds upon results developed in the*

*EC/DG-JRC/IPTS Project*

*Future Mobile Services*
*(see http://fms.jrc.es)*

*and*

*EC FP6 SPORTVIEWS project*
*(see http://www.sportviews.org*

*The usual disclaimer apply - this contribution is of the authors, and does not necessarily reflect the view of the European Commission.*

# Aim & Contribution

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  - The aim is to provide a financial simulation of a *simplified* IMT-Advanced communications networks in order to provide a framework for understanding the impact of spectrum costs
  - Provide an interrelated set of technology, geography, costing and demand levels, based on scenarios and competition aspects, and sensitivity analyses

## Outline of business model presentation

1. Overview model
2. Main assumptions and results (incl. sensitivity analysis)
3. Questions for further elaboration

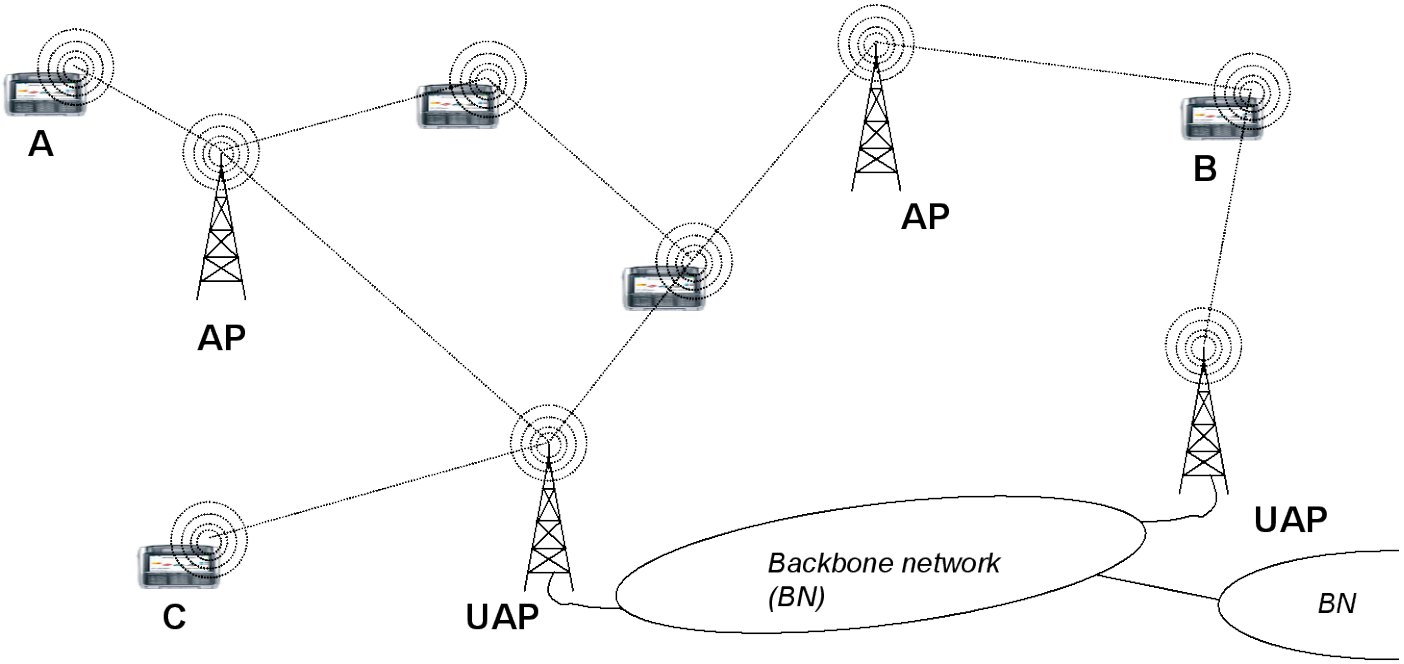
# What is IMT advanced?

**Important characteristics in our models:**

- Licensed AND unlicensed spectrum
- Increased data usage
- Multi technology usage
- Decreased cell sizes but also macro cell sizes
- Introduction of ad-hoc (mesh) network capabilities
  - Leading to reduced density of radio equipment
- Increased bit rates
- Increased importance of software (e.g. SDR)
- New pricing schemes
- In our models we have used two radio access points: APs (Access Points) and UAPs (Universal APs)
  - UAPs are defined to function as ordinary base stations with backhaul connections
  - APs are defined to function as repeaters and signal amplifiers, relaying radio signals to allow extensions of hops.

# Model characteristics – IMT advanced network overview

- An IMT-Advanced network elements have mesh capabilities
  - Multihop paths between handsets, APs and UAPs
- Redundant paths are often available

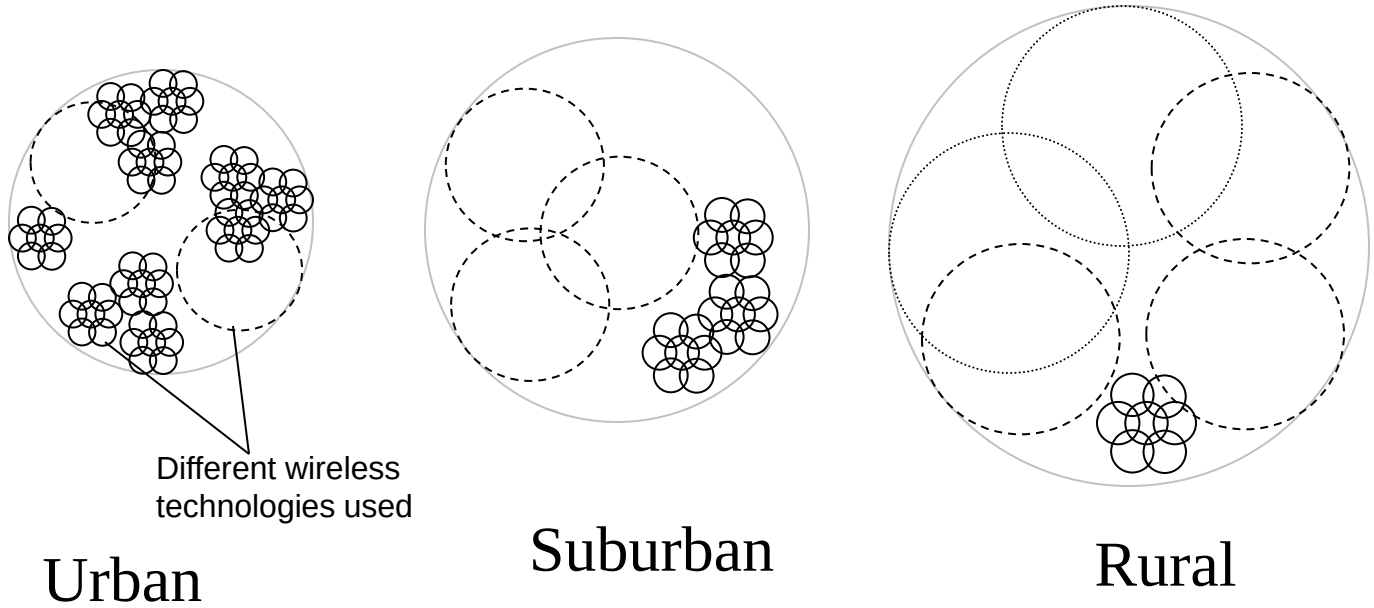



*BN*

# Model characteristics - overview

- The simulated IMT-Advanced network is divided into a number of corresponding ”network units”
  - Urban, suburban, and rural
- The ”network units” have distinctively different characteristics
  - E.g. Cell size, average distance between users, number of users in each network unit, etc.
- Each network unit is composed of a number of base stations, UAPs, etc., using various technologies
- The characteristics of each ”network unit” are defined regarding e.g. number of users coverage, average distance between users, number of users in each network unit, etc. leading to different investment costs
- By spreading the network units like a puzzle over the simulated geographical area, the investment costs can be approximated
  - e.g. 10 rural units, 16 suburban units, and 24 rural units to cover a certain area

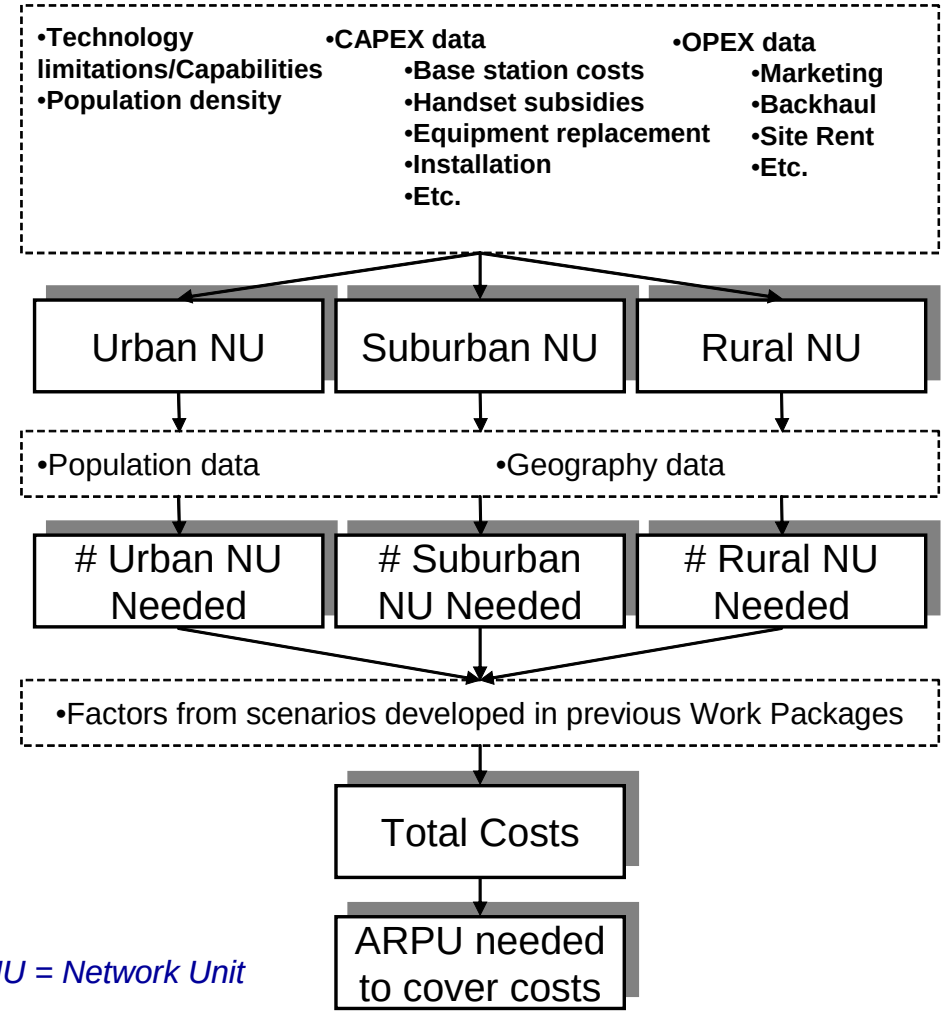
# Model unit - overview




- The network units differ in several ways, e.g.:
  - Size
  - Population density
  - Technology choices
  - Cost structures
  - Base station ranges

# Model characteristics - overview

- The model used is schematically presented to the right
- By using researched estimates for input data, reasonable cost structures can be approximated
- The aim is to evaluate IMT-Advanced business models by calculating ARPU levels needed to cover OPEX and CAPEX for the different socio/economic scenarios developed in the project




*NU = Network Unit*

# Overview of conclusions and sensitivity analysis

- Our simulation indicates **minimum ARPU levels of 15-19 € monthly** needed for the basic IMT-Advanced business case
  - Dependent on specific assumptions of diffusion levels, equipment cost developments, network architecture, etc
  - Excluding spectrum license costs

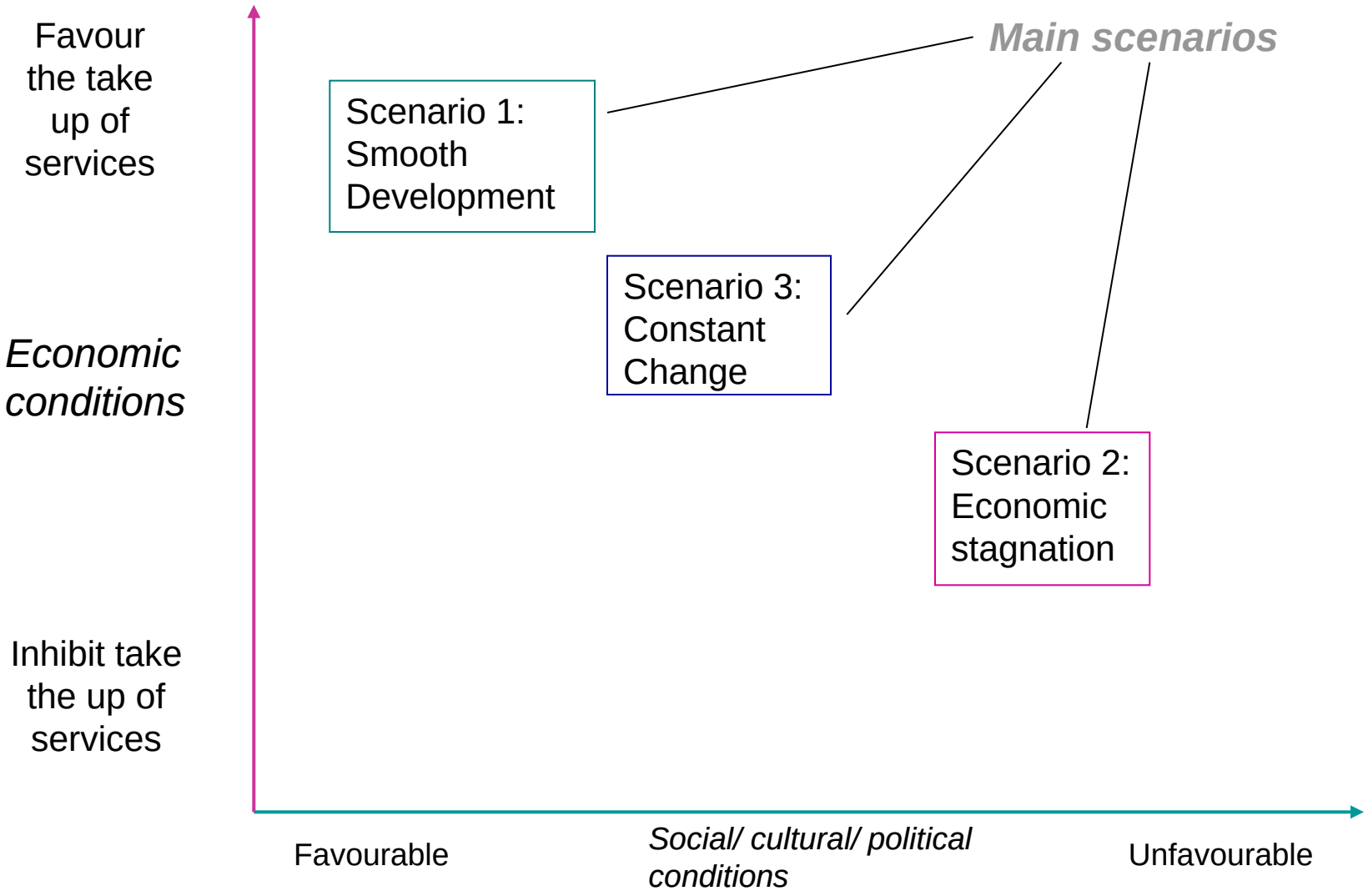
- Impact on IMT-Advanced business cases indicated by sensitivity analyses:

| | |
|---|---|
| Equipment cost development curves | Low |
| Site rentals | Low |
| Roll-out timing | Low |
| Replacement cycle | Low |
| The IMT-Advanced diffusion levels | Medium |
| Site construction costs | Medium to high |
| Competitive impacts | Medium to high |
| The cost of spectrum licences | High |

- The cost of spectrum is a major factor determining the business case of IMT-Advanced

- The diffusion of IMT-Advanced services would hugely benefit from all technologies and management methods allowing for low spectrum costs

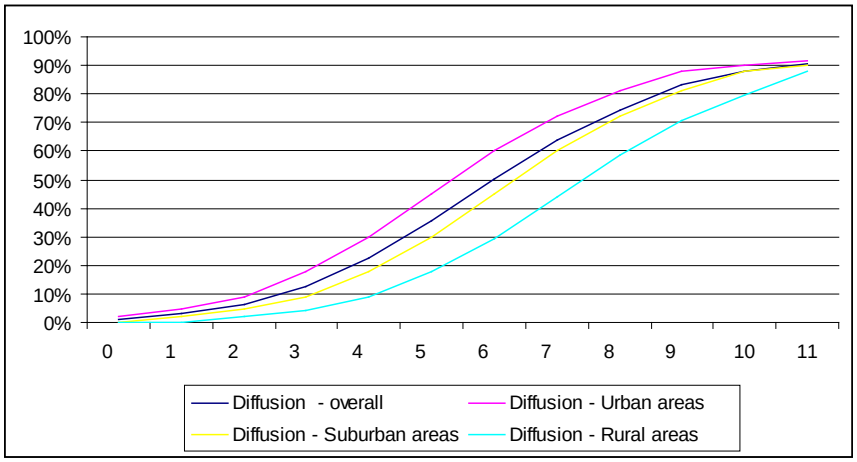
# Scenario assumptions - economic and sociological conditions



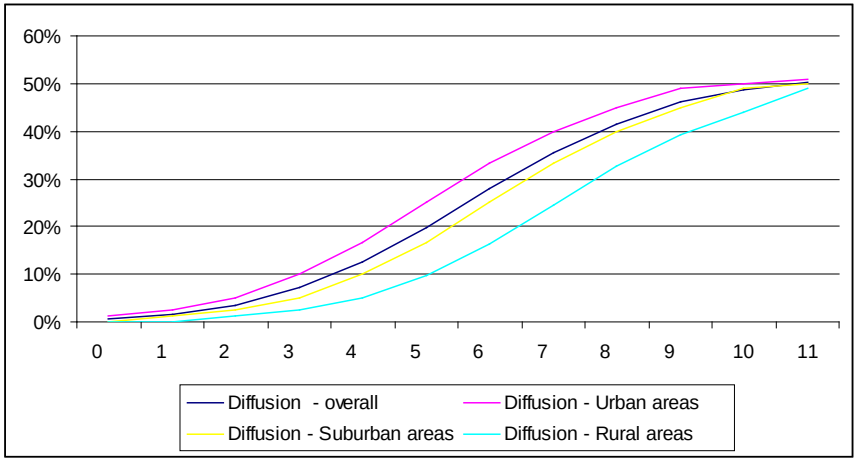
# Assumptions – scenario impact on subscriber diffusion

- Three scenarios –
  1. high growth (90% max)
  2. low growth (50% max)
  3. medium growth (75 % max)
- Same base year shown but different starting dates (2010, 2015, 2012 respectively)

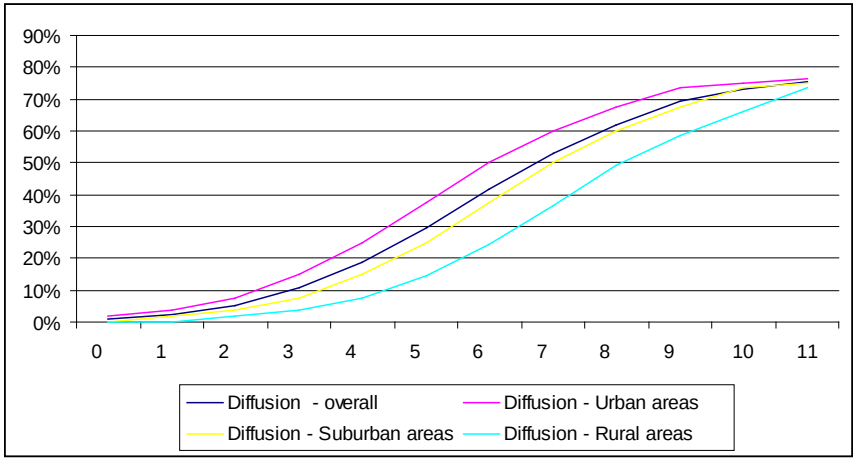
**Subscriber diffusion – Scenario 1**




**Subscriber diffusion – Scenario 2**



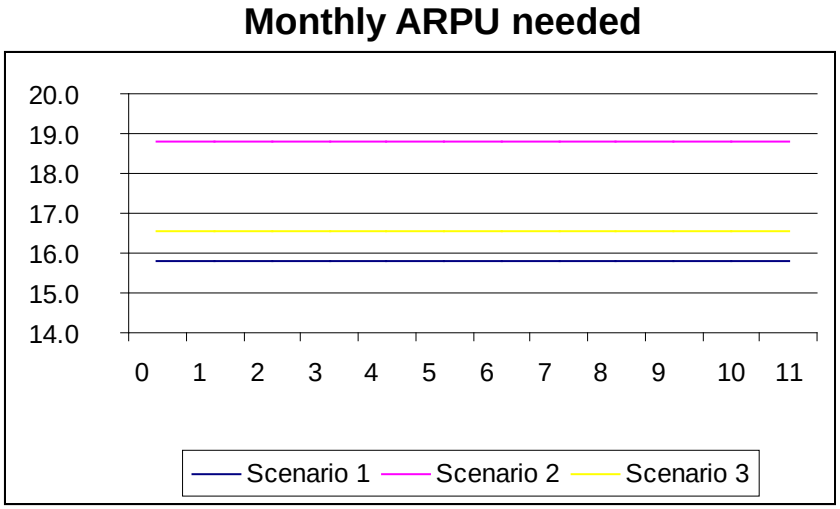

**Subscriber diffusion – Scenario 3**



# Results of base case for ARPU

- Interest rate used to discount figures: 12%
  - Interest rates are currently very low (Euroswap, STIBOR, etc. 2-3%)
  - A risk premium of 9-10% has been added
  - Both CAPEX and OPEX have been discounted to NPV
  - NPV has been annualized to calculate ARPU levels needed

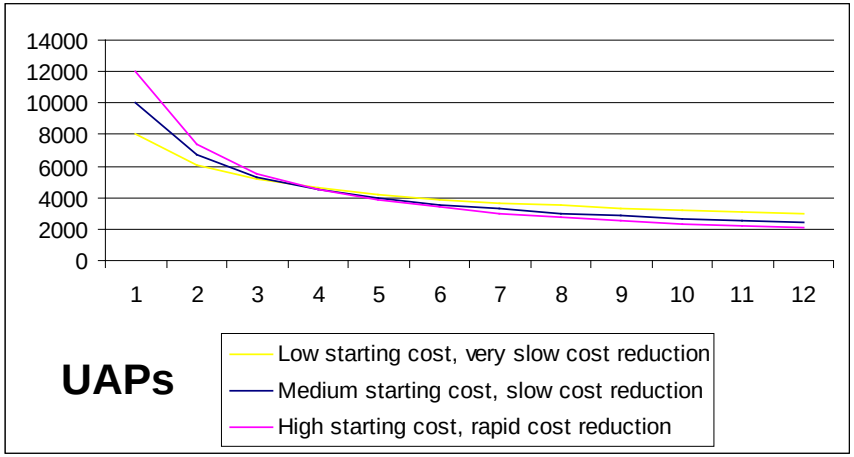
- Monthly ARPU needed to cover CAPEX+OPEX
  - 15.8€ in Scenario 1
  - 18.8€ in Scenario 2
  - 16.6€ in Scenario 3



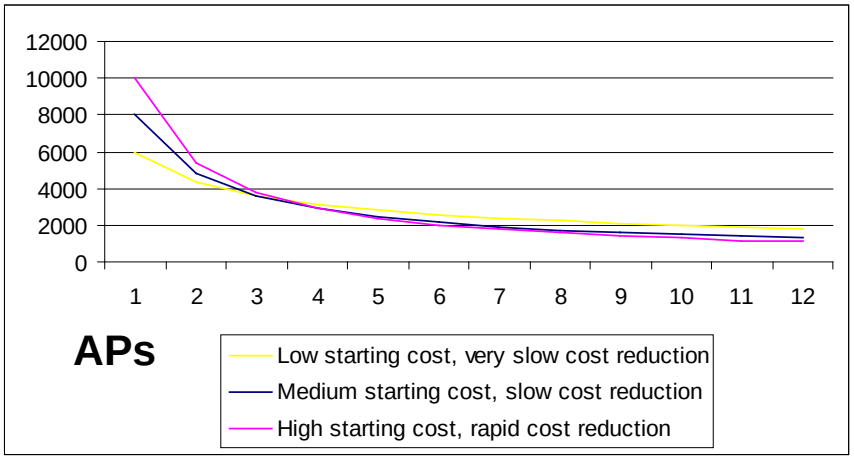
# Sensitivity analysis 1 – Different cost development scenarios

- Three different price scenarios have been simulated
  - Base scenario:
    **High starting cost, low cost reduction**
  - Sensitivity check scenarios:
    **Low starting cost, very slow cost reduction**
    **Medium starting costs, slow cost reduction**

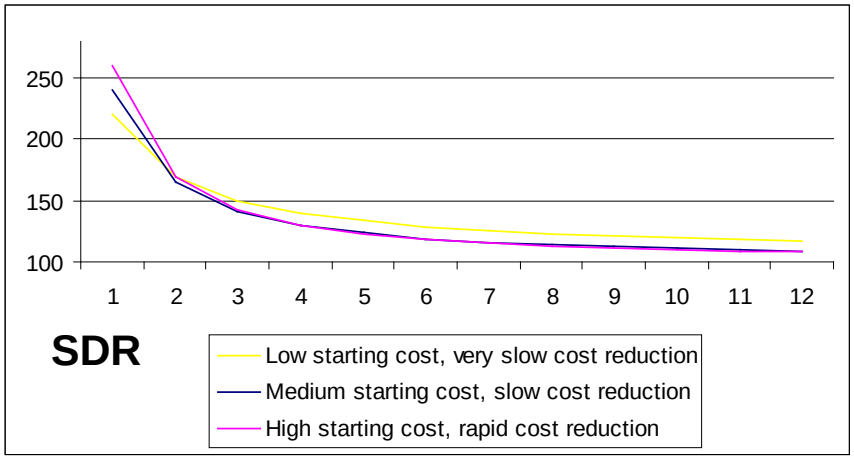
**UAPs – cost development curves**




**APs – cost development curves**



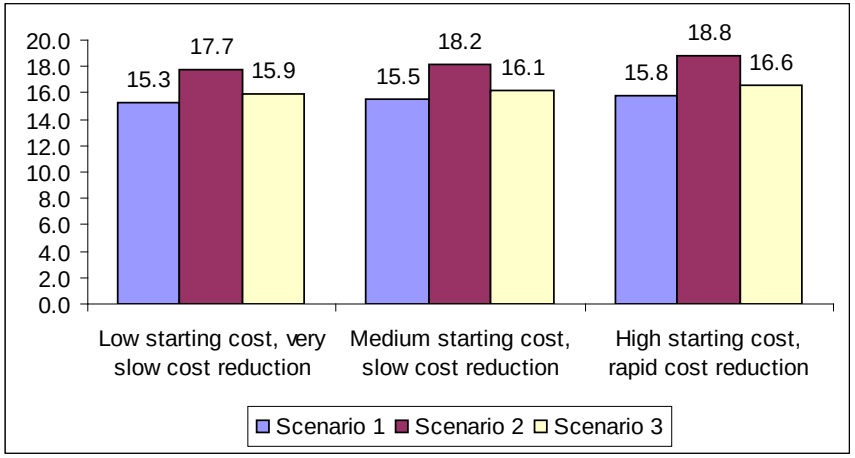

**SDR – cost development curves**



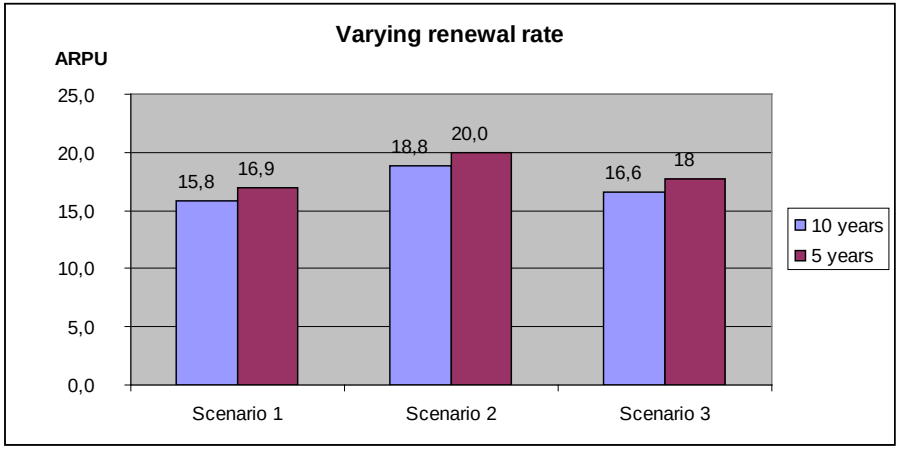
# Sensitivity analysis 2
# – Changed equipment cost and replacement rate

- Changed cost development patterns has small impact on monthly ARPU levels needed
  - Maximum of 1.1€ difference (Scenario 2)
- If considering both diffusion patterns and cost development patterns impact increases
  - Maximum of 3.5€ difference between lowest and highest ARPU needed (20% difference roughly)

**ARPU needed with different cost curves**




**ARPU impact of renewal timing**



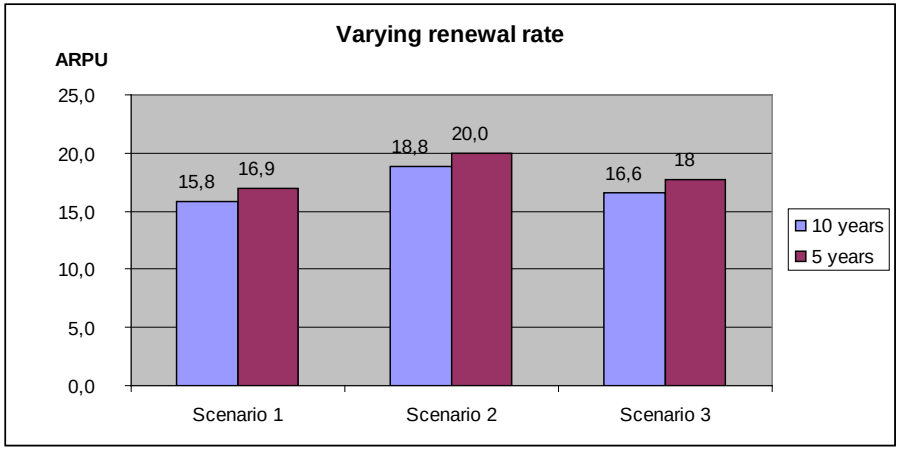

- Instead of having investment replacement horizon of 10 years, the figure shows a five year renewal (depreciation) horizon

- The ARPU impact is in the range of 10% increase

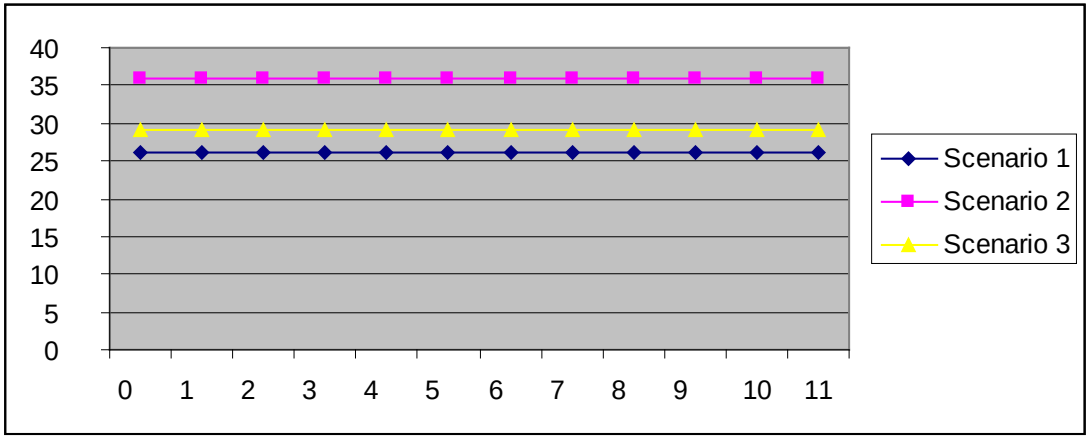
# Sensitivity analysis 3
# – Changed site rentals and site construction costs

- The site rental fees is here varied for the respective scenarios
- Even if the site rental is 4 times the base case, the effect on ARPU is not more than 25%

**ARPU impact of site rental variations**




**ARPU breakeven with site costs**

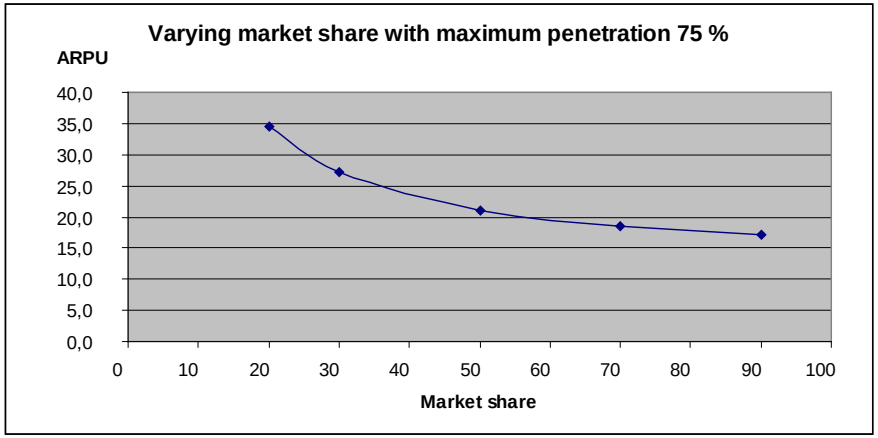



- 100,000 euro site construction cost for UAPs (similar to 3G sites)
- 10,000 euro (10%) for APs
- Assuming that 25% of the sites are new instead of rented
- ARPU break even impact is considerable

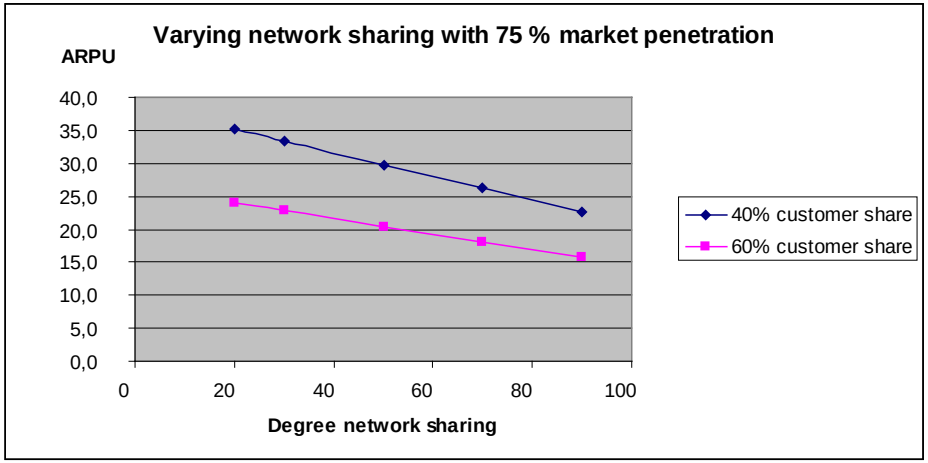
# Sensitivity analysis 4
# – Market share and network sharing impacts

- A rudimentary way to model competitive impacts is to provide a sensitivity analysis with the following assumptions:
  - The prospective operators constructs a nation-wide network
  - The market share is varied for all three scenarios (scenario 3 shown)
- The ARPU impact is substantial

**ARPU impact of varying market shares, scenario 3**




**ARPU impact of network sharing**

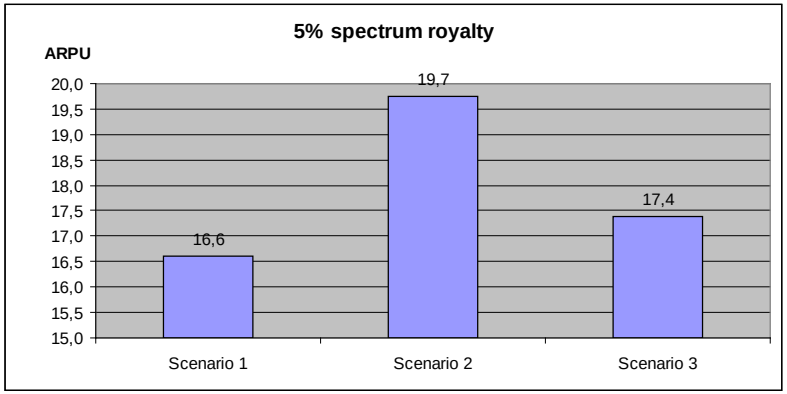



- Network sharing - the competitors have two separate networks with varying degree of collaboration.
- The two competitors have respectively 60% and 40% share.
- The two competitors may have captured only part of the total market. Here, is the impact of both players having combined 75% share of the total market share (corresponding to scenarios 3).
- ARPU impact is substantial

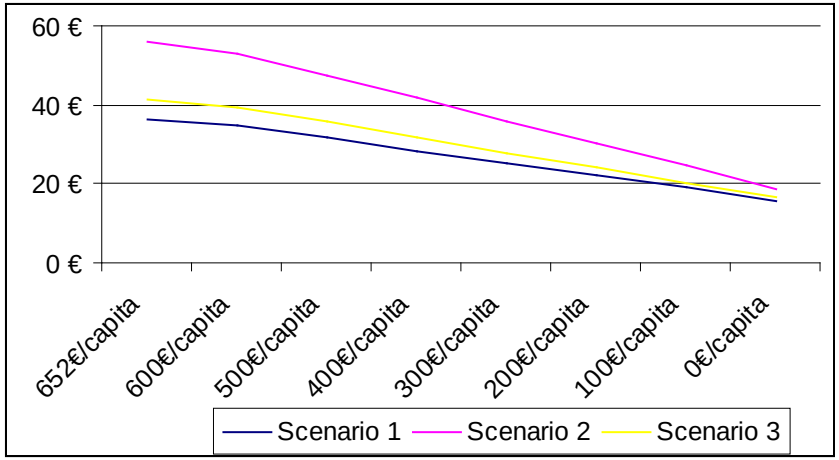
# Sensitivity analysis 5 – License fee (variable and fixed)

- To evaluate the impact on ARPU levels from variable spectrum fees, the example of Hong Kong's 3G licensing regime has been considered.
- In Hong Kong, a variable license fee of 5% on the turnover from year six was determined after an auction as well as a fixed fee for the first 5 years.
- Since a fixed fee is evaluated below we will use a 5% royalty for all years. This form of licensing entails a surcharge on the break even level of ARPU. ARPU impact is directly related to the magnitude and set-up of variable fees

**Spectrum royalty and ARPU impact**




**ARPU needed with added license fee***




- Adding a license fee has strong effects on ARPU levels needed
  - Impact depends on diffusion. strongest impact in scenario 2
- A license fee of 652€ per capita (3G license cost in the UK) increases the ARPU needed by
  - 130% in scenario 1
  - 200% in scenario 2
  - 150% in scenario 3

# Restatement of Business Model Conclusions

- Our simulation indicates **minimum ARPU levels of 15-19 € monthly** needed for the basic IMT-Advanced business case
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- Impact on IMT-Advanced business cases indicated by sensitivity analyses:

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- The diffusion of IMT-Advanced services would hugely benefit from all technologies and management methods allowing for low spectrum costs

# Scenario analysis

*Contribution builds upon results developed in the*

*EC/DG-JRC/IPTS Project*

*Future Mobile Services*

*(see http://fms.jrc.es)*

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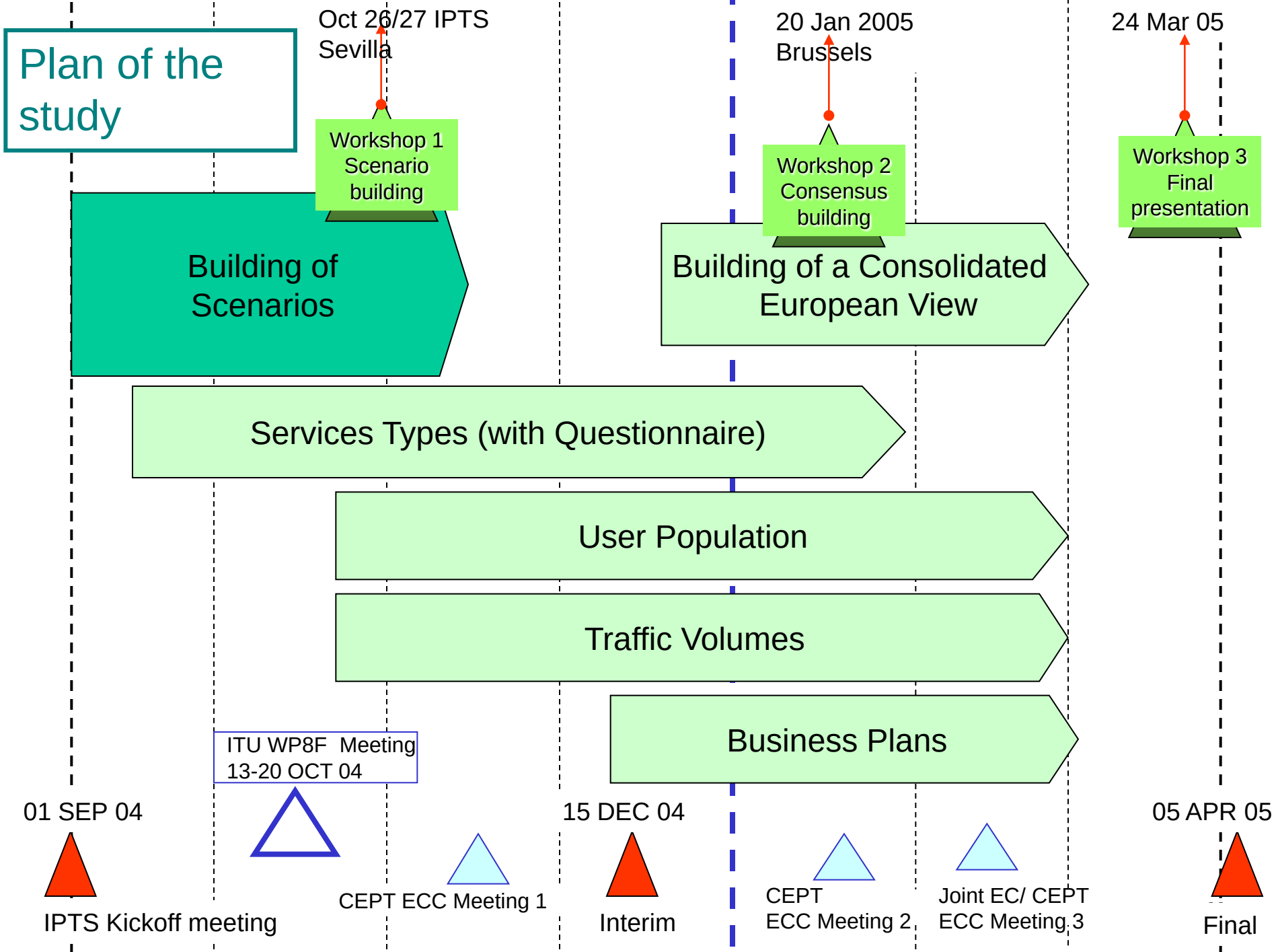
# Plan of the study



# Planning with scenarios

•Aim – to ask the right questions, not to answer them – by bringing useful future views of events, attitudes, surroundings, new forces and players

•Combine two worlds - a world of a future perception, usually centred on a theme or significant change - and the world of plain facts.

•Build several pictures of a specific domain of interest in which hypotheses can be set to obtain a range of future views - a small set of contrasting stories about the future - each scenario must be noticeably and fundamentally different in some explicit way to be valuable.

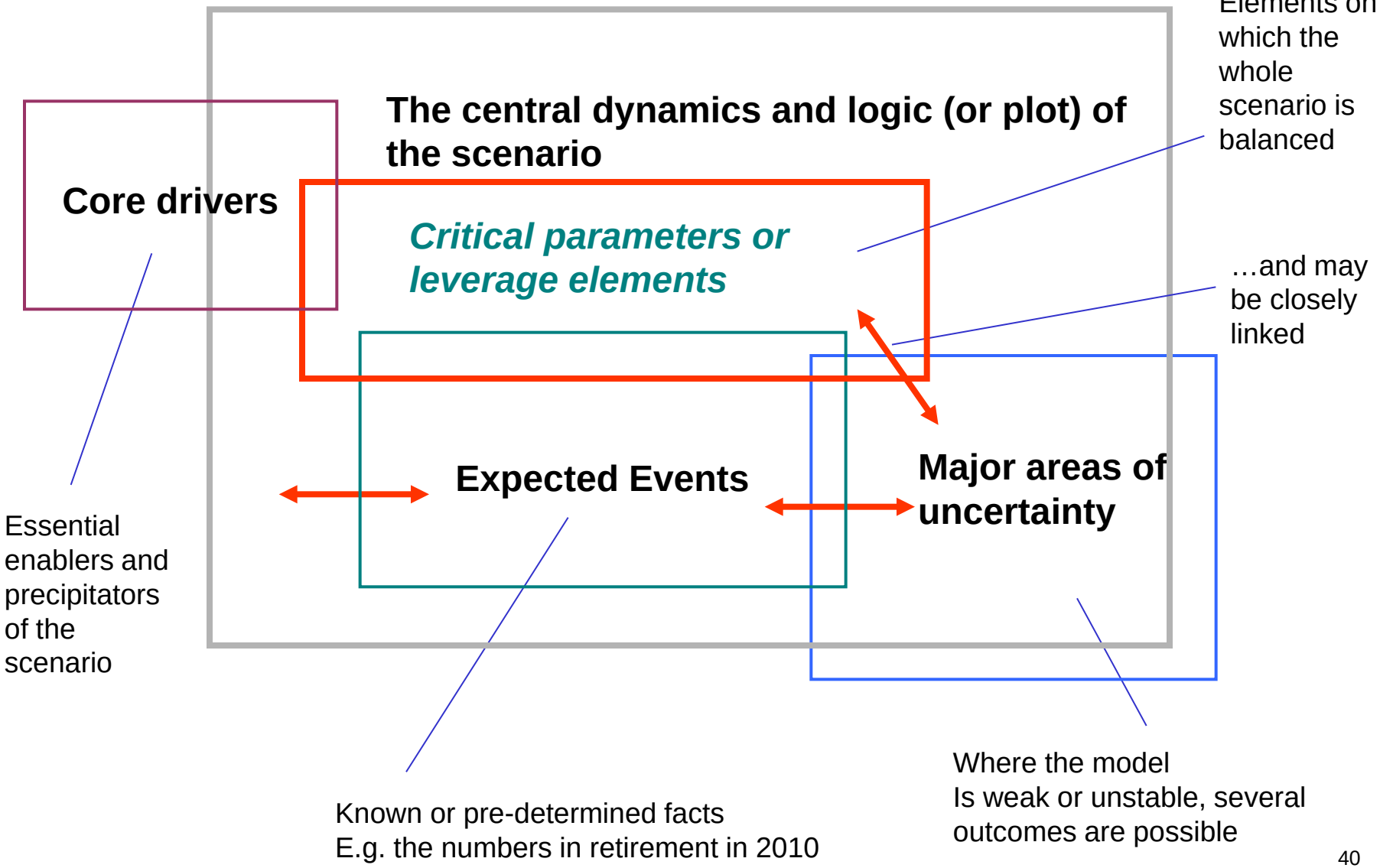
•Scenarios should be as convincing, yet as startling, as possible because the expected is often not reality, with all the chaos and complexity of the real world

•Involve all elements, as naturally as possible, to construct daily life at some or all of the three levels of personal, corporate and national/global environments.

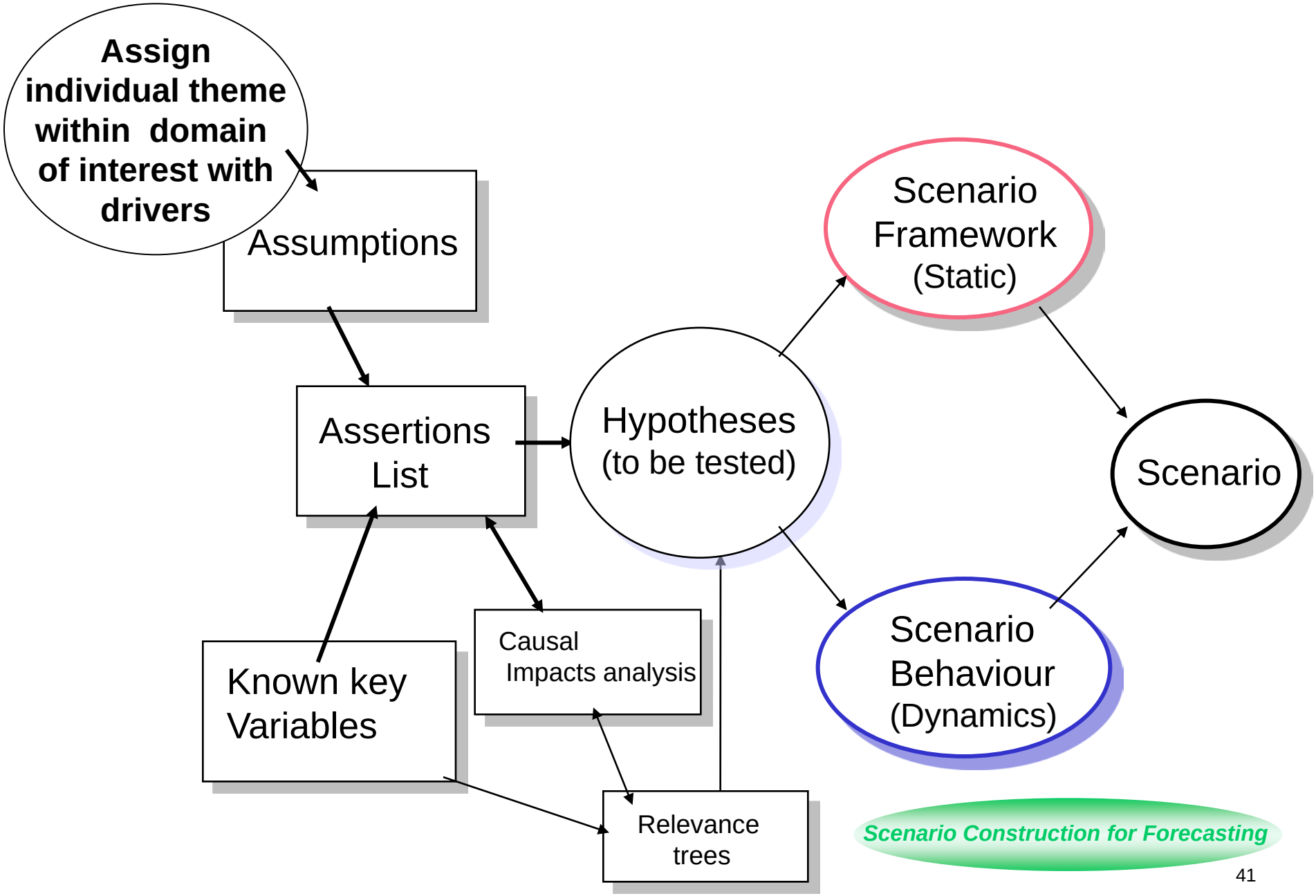
•Real forces of change must be identified – may be widespread and long term - increasing youth in the developing world (to be 40% soon); OECD populations will age faster ; rise of the NICs (newly industrialised countries).

# A scenario has several major building blocks

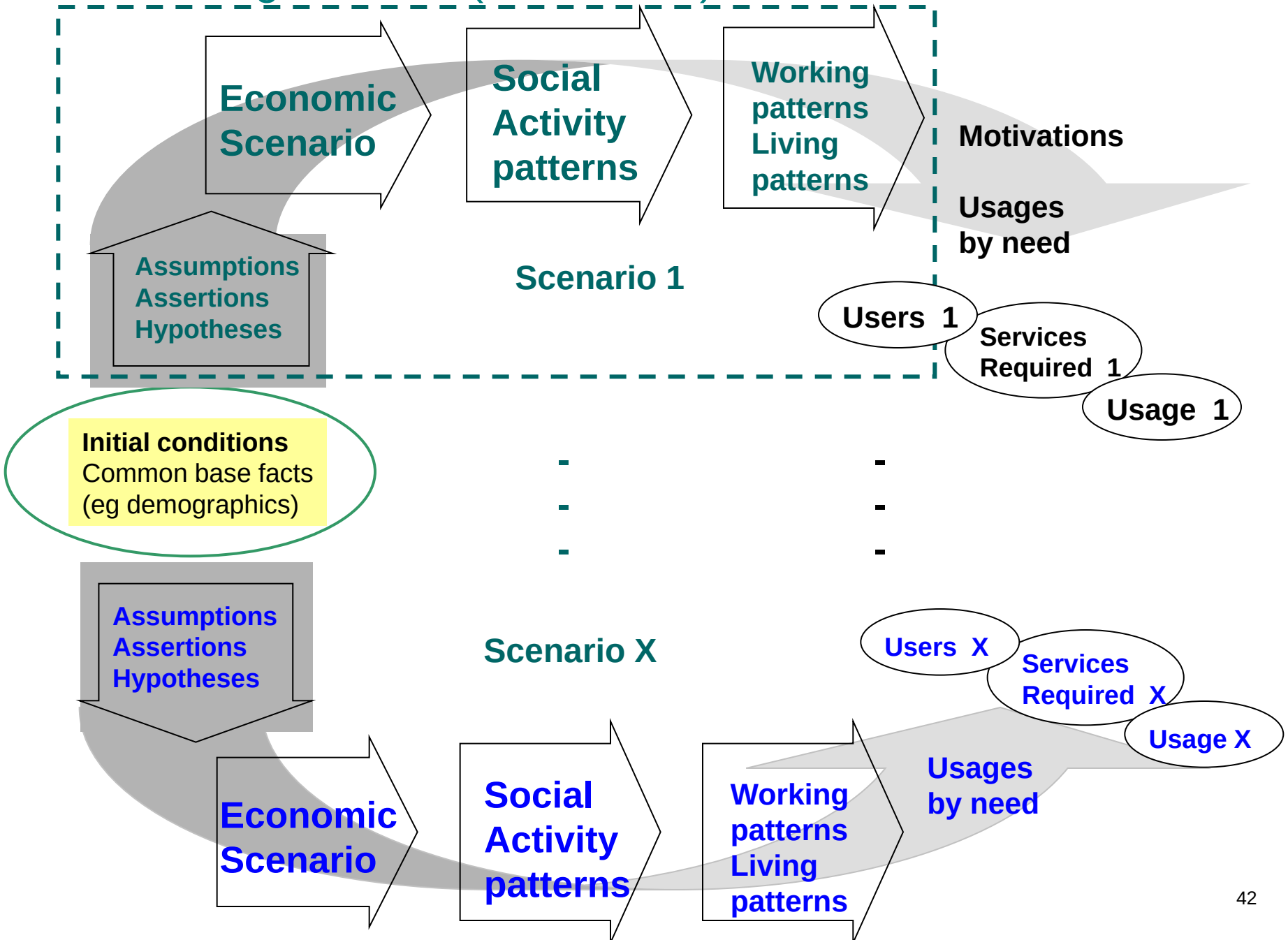
*Unfortunately they are not always clearly separable….*



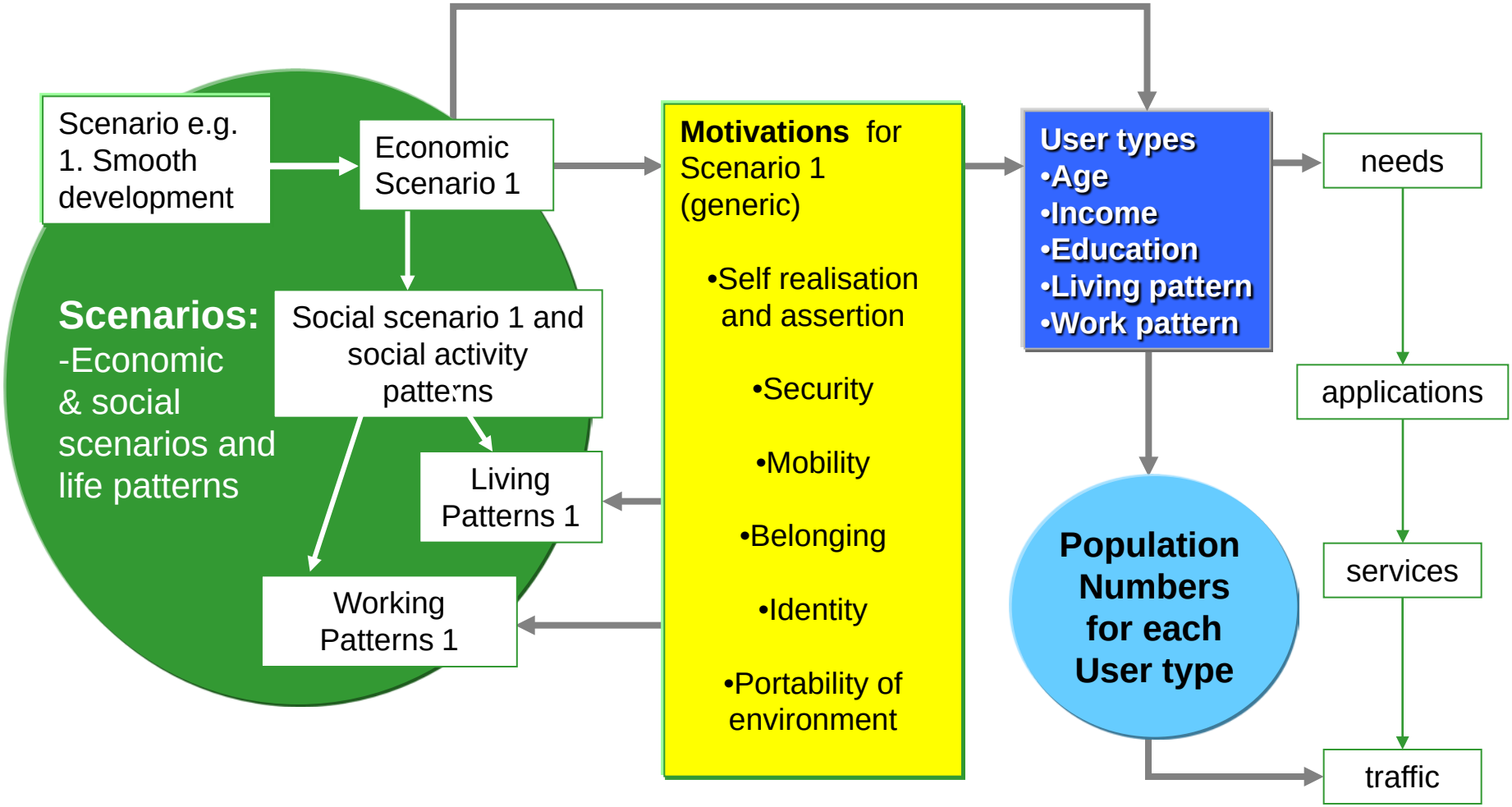
# Scenario Formulation



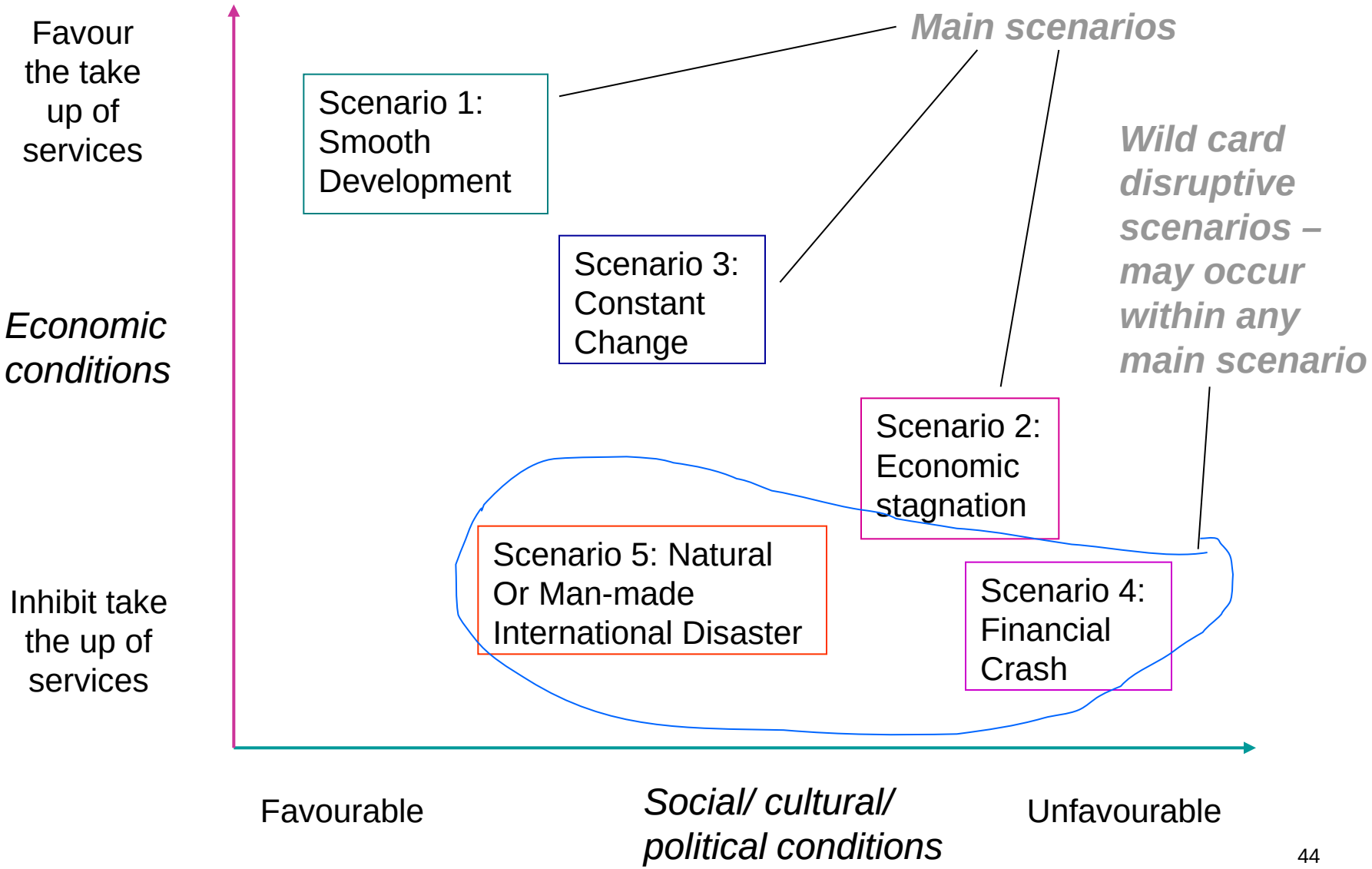
# Elucidating services (users want) from Scenarios



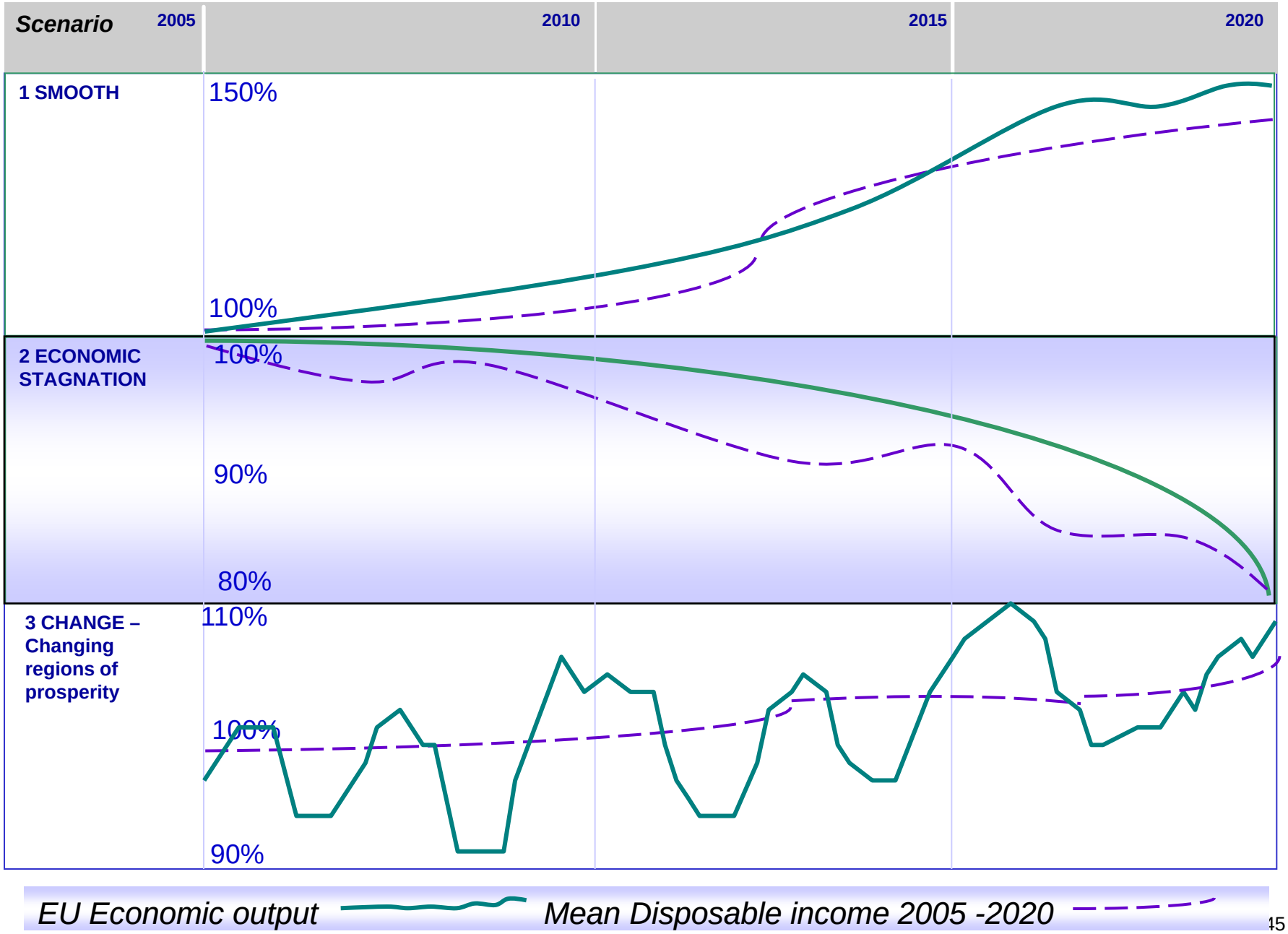
# In more detail, the FMS scenarios provide a basis for an economic/social/political environment to 2020, with consequent demands for mobile services



# Mapping scenarios - against the economic and sociological conditions

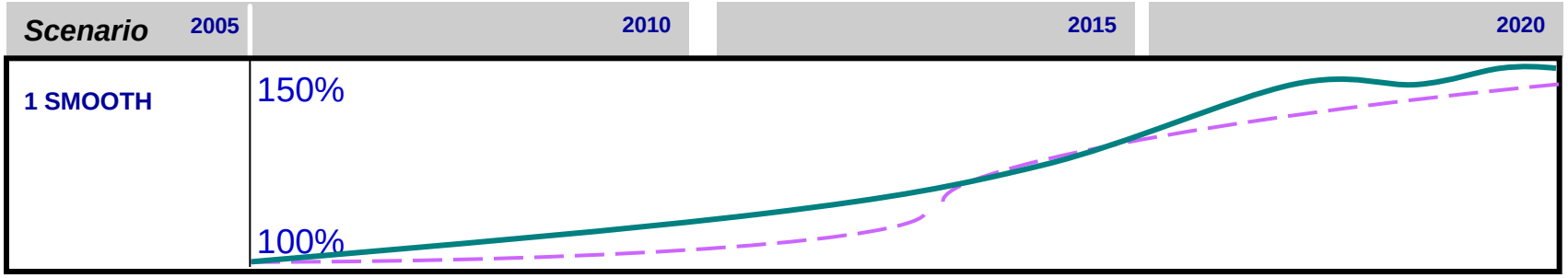


# Comparing development in the Main Socio-Economic Scenarios



# 1 Smooth development

– EU economy provides growth and positive progress in development, but in a fair and managed way that brings prosperity across all 25 members and any new accessions




| | | |
|---|---|---|
| Generating knowledge work through affordable re-training. Ubiquitous employment discovery, access and retraining. | Control of everyday life -ease of access to convenience services.<br>Support for extended family 'tribes'.<br>Ease of trade at low cost.<br>Expansion of business reach geographically. | Advanced support services at low cost for health, social requirements, education<br>International co-ordinated working across the EU / globally |

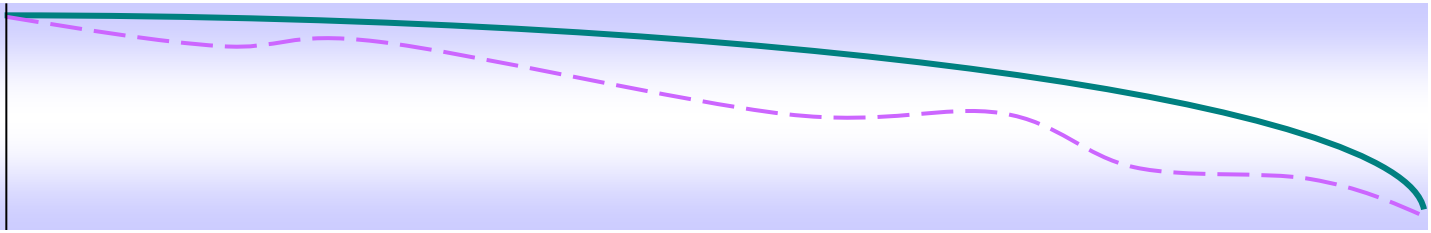
*EU Economic output* — *Mean Disposable income 2005 -2020*

# 2 Stagnation

## – economic stagnation with progressive deflation as in Japan from late 1980s, continuing to 2004, with enormous overhang of loans on assets, especially in private housing

| *Scenario* 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|

**2 DECLINE – economic stagnation**

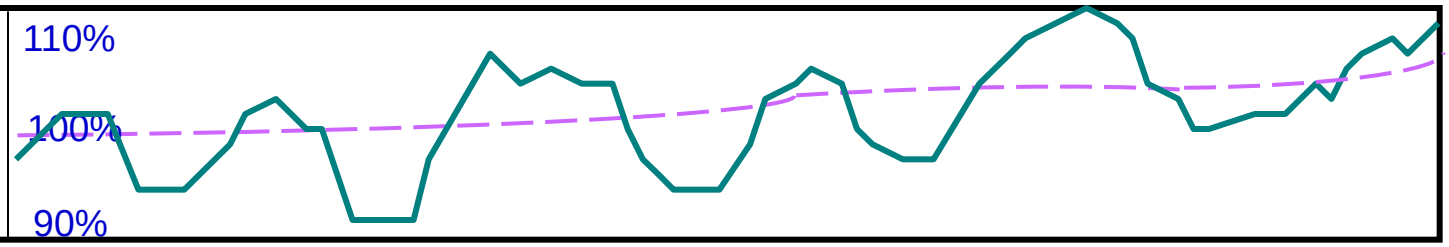



| | | |
|---|---|---|
| Belts tighten in the family and the firm. Disposable income and consumption restricted.<br>Search for lower costs of doing business .<br>Simple SME support.<br>Seek security. | Reducing outlays. Seeking employment either in conventional or in underground economies.<br>Operating business at very low cost.<br>Simple business services.<br>Support for rural communities at low cost | Simple lifestyle at minimal cost. Opting out.<br>Support for trading and bartering in a non-enterprise based economy.<br>Support for migrant workers overseas outside the EU including financial remittances. |

*EU Economic output* — *Mean Disposable income 2005 -2020*

# 3 Change

## – Constant changes, up and down with ad hoc growth and recession, often in parallel in different geographic markets, but moderately positive overall –with geographic and sector pockets of stability, and some of failure, all randomly distributed

| ***Scenario*** 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|
| **3 CHANGE – Changing regions of prosperity** |  | | |
| | Access employment<br>- find<br>- retrain as required<br>Simpler infrastructure and laws for SMEs | Support to (re)build life in new regions<br>Support for clustered communities of SMEs<br>Conserve cash to live through downturn | Build remote environment – through constant contact with remote family, perhaps remote work and training<br>Distributed business operations across EU |



*EU Economic output* *Mean Disposable income 2005 -2020*

# Needs from each scenario as it develops

| Scenario | 2010 | 2015 | 2020 |
|---|---|---|---|
| 1. SMOOTH | Generating knowledge work through affordable re-training.<br>Ubiquitous employment discovery, access and retraining. | Control of everyday life -<br>ease of access to convenience services.<br>Support for extended family 'tribes'.<br>Ease of trade at low cost.<br>Expansion of business reach geographically. | Advanced support services at low cost for health, social requirements, education<br>International co-ordinated working across the EU / globally |
| 2. ECONOMIC STAGNATION | Belts tighten in the family an the firm. Disposable income and consumption restricted.<br>Search for lower costs of doing business. | Reducing outlays. Seeking employment either in conventional or in underground economies.<br>Operating business at low cost.<br>Simple business services.<br>Support for rural communities at low cost | Simple lifestyle at minimal cost.<br>Support for trading and bartering in a non-enterprise based economy.<br>Support for migrant workers overseas including financial remittances. |
| 3. CHANGE | Access employment<br>-find<br>-retrain<br>Simpler infrastructure and laws for SMEs | Support to (re)build life in new regions<br>Support for clustered communities of SMEs<br>Conserve cash to live through downturn | Build remote environment – through constant contact with remote family, perhaps remote work and training<br>Distributed business operations across EU |

**Credibility from Questionnaires so far**

**Low**

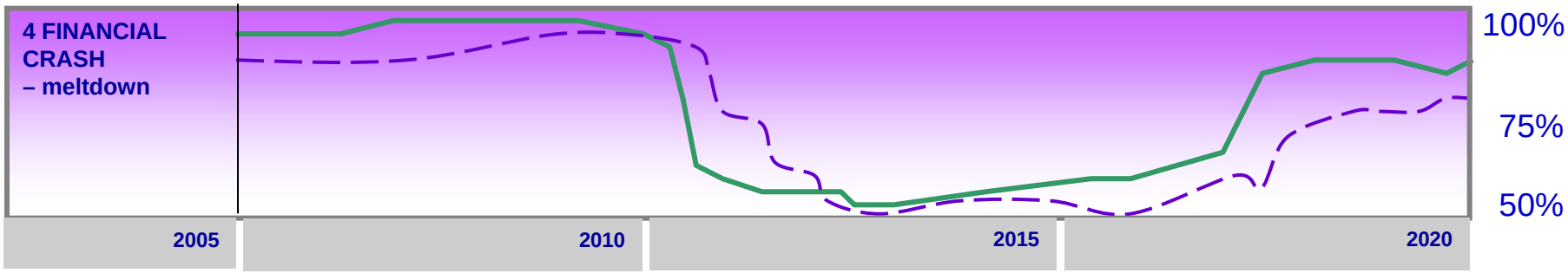
**High**

**High**

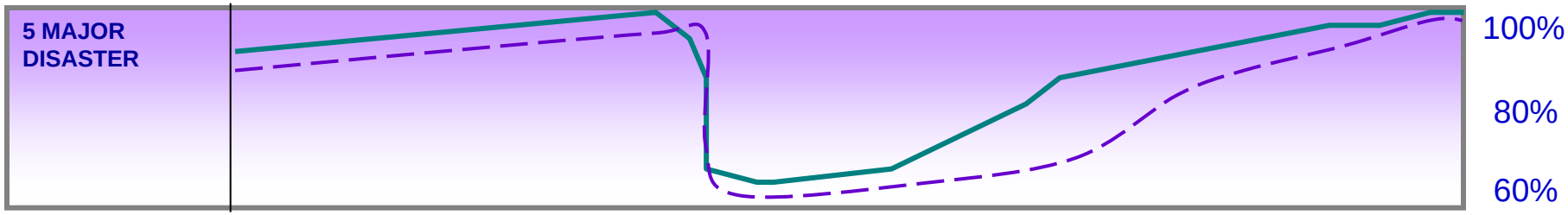
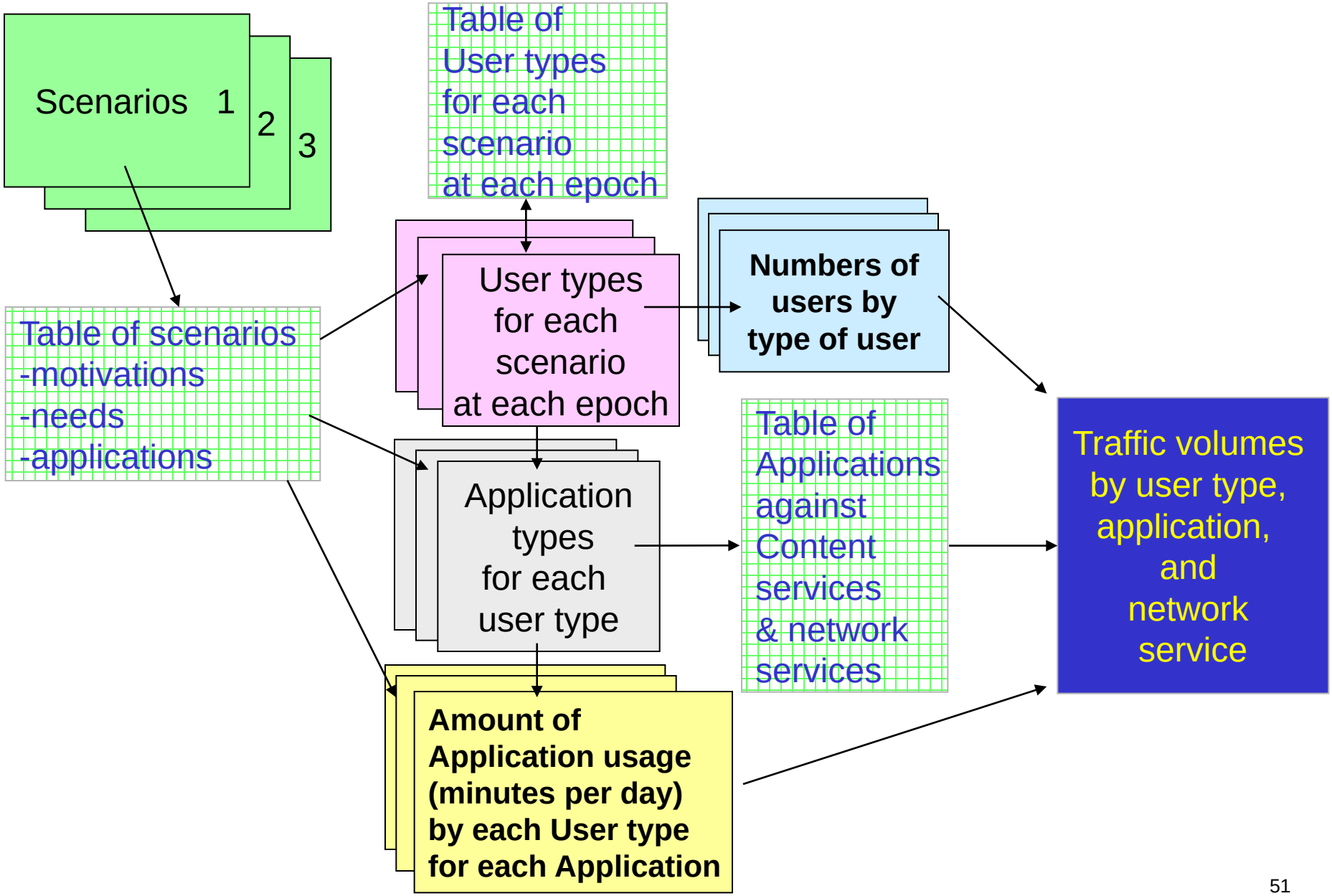
# The Discontinuity Scenarios

•May occur within any other scenario

•Financial crash – the impacts of a major reduction in disposable income, followed by a slow recovery




•Disaster – natural or attack – use of technology (especially mobile and wireless) to survive and recover - new vocations, social organisation and applications



# The Methodology to calculate Traffic volumes from User types and Services, in outline