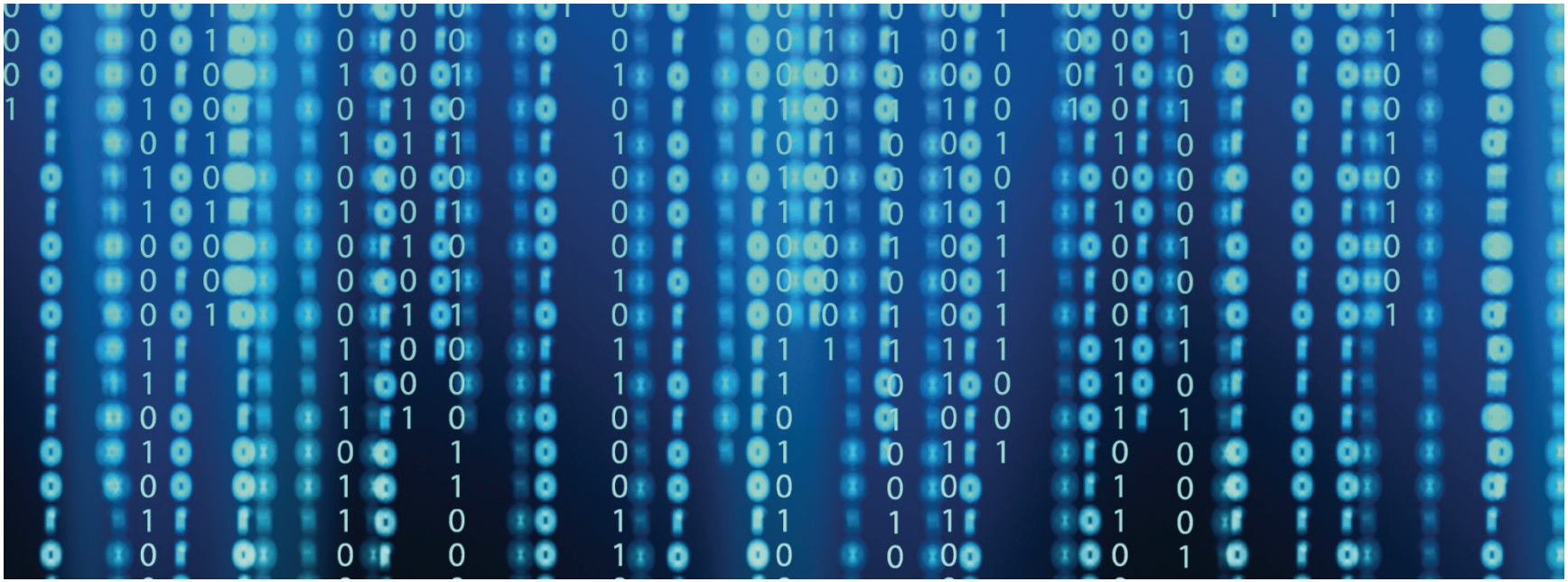
DEVELOPMENT OF IMPACT MEASURES FOR E-INFRASTRUCTURES

Dissemination Workshop

Brussels, February 20th 2012



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Agenda

Arrival and welcome coffee	10:00
Opening and welcome (European Commission)	10:30
Introduction to the Study	10.45
Session I: Presentation of results and findings of the study	
Presentation of the results of the evaluation	11:00
Presentation of monitoring system	11:45
Discussion	12:00
Lunch break	12:30
Session II: Discussion of results and implications	
Statement 1 (including discussion): A. Manieri, ERINA+	13:30
Statement 2 (including discussion): J. Sanchez, eNventory	14:00
Statement 3 (including discussion): S. Andreozzi, EGI	14:30
Statement 4 (including discussion): Mickael Pero, RIFI	15:00
Final discussion and concluding remarks	15:30
Closing	16:00

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Introduction to the study

Structure of the presentation

- Study objectives and methodology
- Results of the empirical research
- Evalution Framework

Introduction

- diffusion of ICT leads to new kinds of knowledge creation and representation within research and innovation
  - co-evolution of application in business and sciences
  - affecting scientific work and output → e-Sciences
  - e-Infrastructures major brick stone for the shift towards e-Sciences
- defined as networked tools, data, instruments and resources that support virtual and heterogeneous communities of researchers and their co-operation partners, covering the whole R&D value chain
- Europe achieved leading role in the last decades, but to continue the way continuously review is necessary
- Requires understanding of the effects, impacts and success factors of the e-Infrastructures program as well as lessons learned from ongoing projects.

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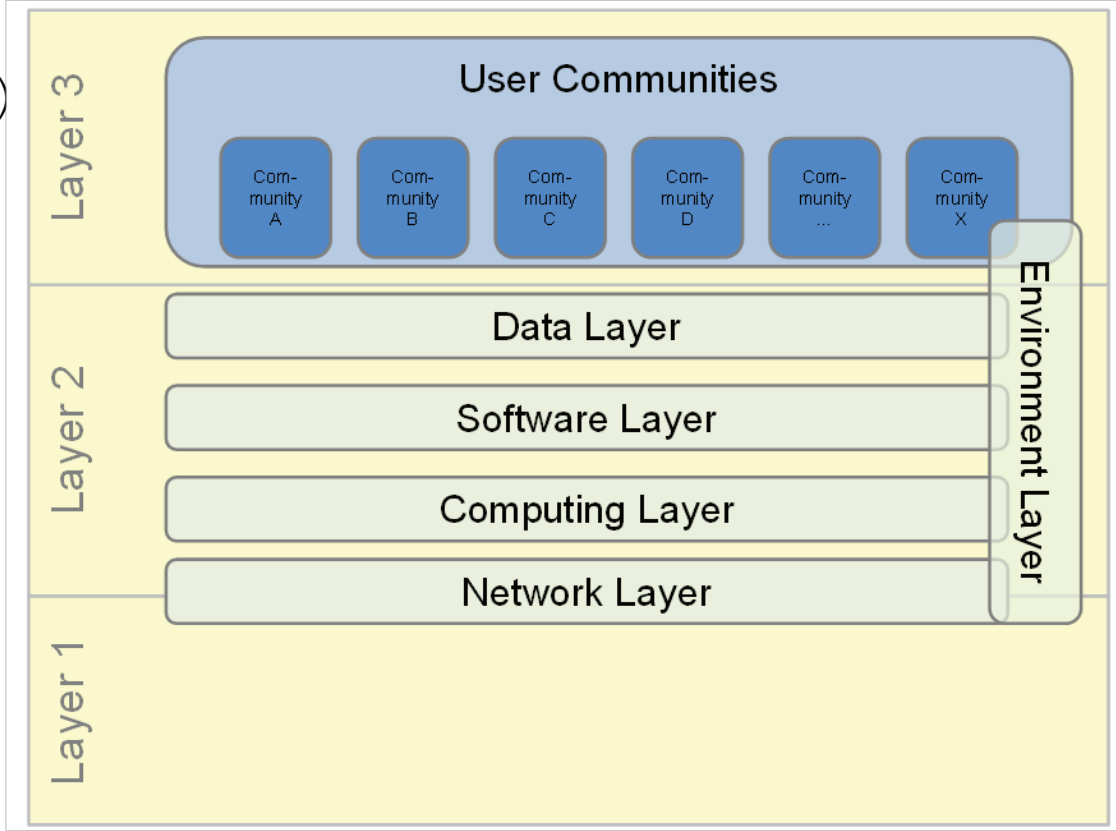
E-Infrastructures –Importance, Definitions and Goals

- growing importance of e-Infrastructures → nearly doubled budget from FP6 to FP7, programs in the US, many European countries etc.
- first basic definition of cyberinfrastructure (layer2) by Atkins et al. 2003 → mostly in concordance with EU definitions
- 5 technical layers/domains inside e-Infrastructure
- diversity of type of inputs, projects etc.
- forming challenges for assessment



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Study objectives and methodologies

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Objectives and key research questions

Objectives

- developing and testing a robust framework for monitoring and evaluation based on information obtainable by the projects themselves.
- analysing socio-economic impact of e-Infrastructures and contributions to EU policy aims based on the results of the test with a selected number of projects.
- recommend a set of concrete actions to be taken at the European and Member States level to implement the resulting monitoring and evaluation system

Key research questions

- Did the program achieve its goal of enabling e-Science as defined in the program's objectives?
- Are there any wider socio-economic impacts in relation to the goals?
- Are there any unintended impacts or effects?

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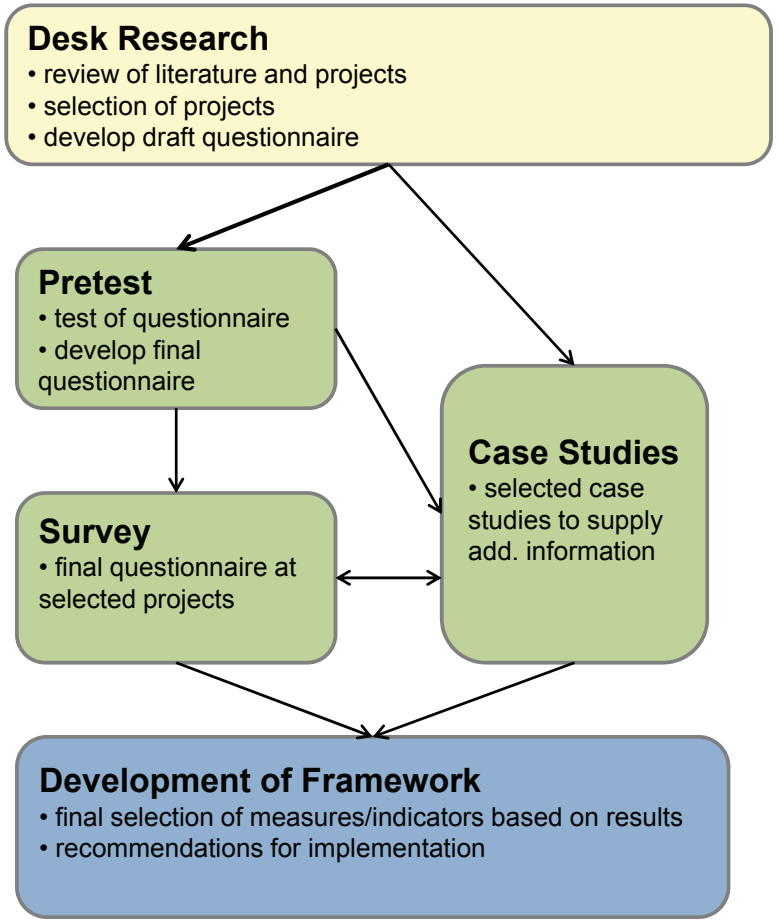
Methodology – Structure of pilot study

- Desk research
  - review of existing literature and programs
- Pretest
  - test of questionnaire → Finalization
- Survey
  - questionnaire at selected projects
- Case studies
  - based on survey results and research
  - aimed at supporting the analysis
- Framework Development
  - based on the results of survey
  - selecting promising measures



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Methodology - Challenges

- **Heterogeneity of projects**
  - addressed by the development of a typology of e-Infrastructure projects and their clustering in a multi-criteria matrix.
- **Problem of data availability**
  - addressed by a survey and by access to project proposals and any kinds of documents provided by the project coordinators and/or the Commission.
- **Measuring indirect impacts**
  - tackled by consolidation of existing impact assessment approaches and an intervention logic chart for the relations between objectives, input, output and outcome of the program.
- **Lack of conceptual framework**
  - Addressed by extensive feasibility and test studies

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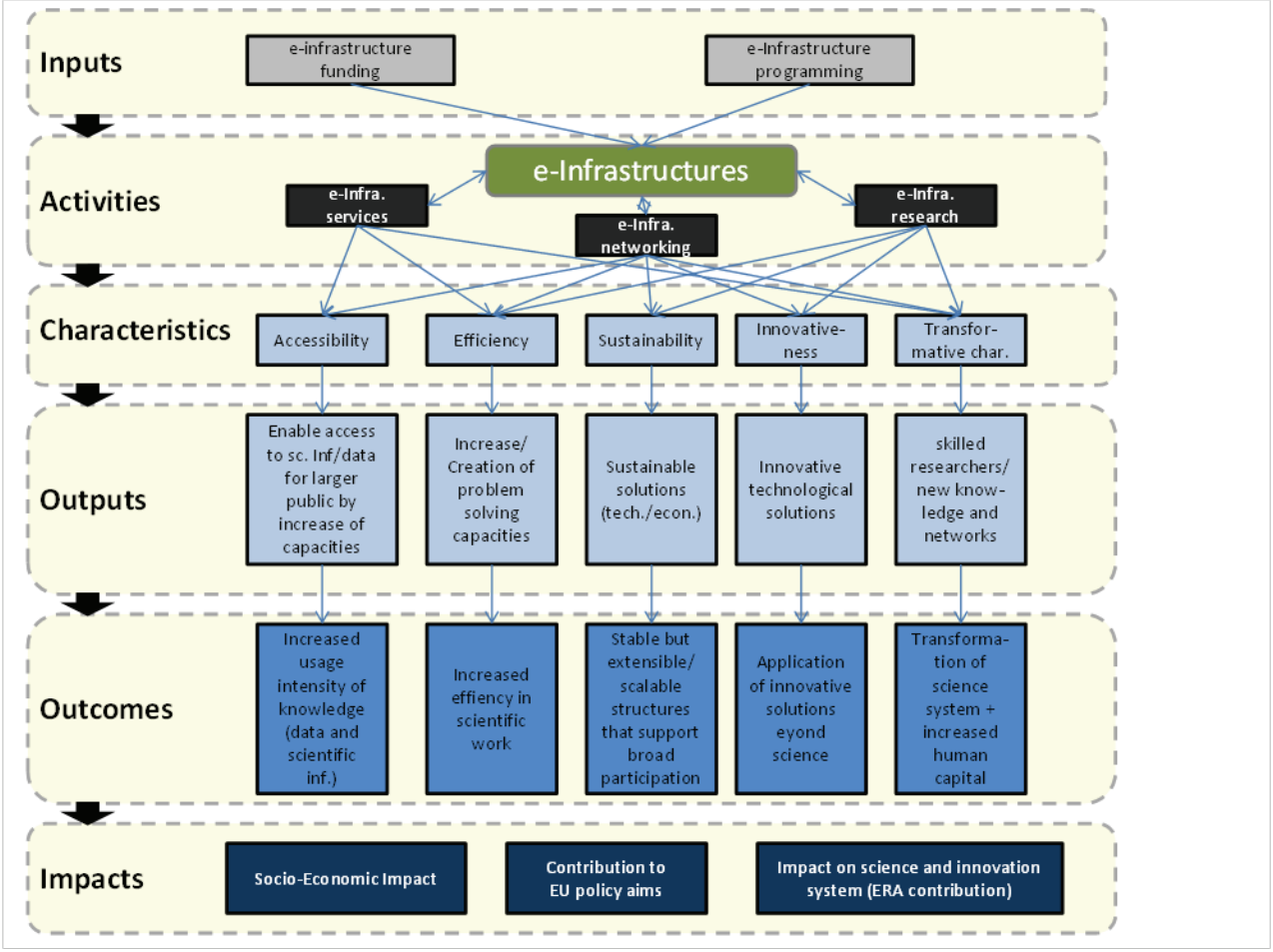
Logic Analysis

First step towards framework

- in-depth analysis of the program goals and structure
- aimed at understanding the intervention logic

- Reflect the overall goals of the e-Infrastructure:
  - Respond to the change in the way research is done;
  - Enable new fields of research to emerge;
  - Serve as test-beds for innovation in ICT;
  - Enable easier access to information;
  - Enable global collaborations.

Intervention Logic



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Results of the empirical research

Overview

- Project selection
- Development of questionnaire
- Questionnaire structure
- Results

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Project selection - Overview

- multi-criteria selection process in order to select representative set of projects
- ensuring framework will be applicable to the program as a whole
- 21 out of 29 projects responded
- dimensions of selection
  - domain (implicit) → 4-5 per domain
  - Status → ongoing, nearly finished
  - type of activities → mostly three, all at least two
  - discipline orientation → strong inter- and multidisciplinary focus
  - size (in financial terms)
  - geographical focus → most consortia consit at least of 5 EU partners, several EU-Non EU
  - Access → mostly open, application based
  - type of actors → orientation towards research institutions, few private companies

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Questionnaire development

- Survey as the basic tool for collecting data from projects → Basis for measuring the outcomes
- development in several loops and close coordination with Commission
- extensive pre-test with seven projects
  - Géant, EGI, NeXpres, PRACE, EUDAT, OpenAire, i4Life

- Aims of the pre-test
  - to demonstrate the appropriateness and feasibility of the survey questions
  - To test appropriateness and feasibility of the output indicators for the monitoring system
  - To identify the best output measures in terms of usefulness for impact assessment and contribution to policy aims

- formed valuable input for the final questionnaire deployed

Structure of the questionnaire

- Measurement of direct results of the projects in the different dimensions
- Each dimensions reflects goals of intervention logic
- Accessibility
  - ***to be easily accessible to the public and to provide large enough capacities***
- Efficiency
  - ***to offer sufficient problem solving capacities***
- Sustainability
  - ***to develop sustainable activities and infrastructure solutions***
- Innovativeness
  - ***to develop Innovative technological solutions***
- Transformative character
  - ***to produce skilled researchers and new knowledge and networks***
- Additional set of questions with complementing in

Output Analysis: Accessibility Indicators

- focus on several criteria describing the access to the infrastructure and its facilities in general, includes
  - user base and its growth
  - geographical and sectoral origin of the users
  - the scientific disciplines users stem from
  - size and reliability of the infrastructure
- Collecting all this information enables us to observe the increase in e-Infrastructure capacities for users and to picture the usage intensity of available knowledge
- revealed that the projects reach a broad variety of users from different countries and backgrounds
- provide a broad basis of available resources (scientific information as well as problem solving capacity) depended on size and scope

Output Analysis: Efficiency Indicators

- reflect the creation of problem solving capacities as well as the recent level of efficiency in scientific work
  - increase of problem solving tools like, e. g. software packages upscaled or the development and introduction of problem specific algorithms and services
  - support of projects achieving meaningful results earlier
  - publications linked
  - self-efficiency
- level of available services increased significantly since funding
- high level of projects benefiting from e-Infrastructures
  - new projects and publications enabled
  - Earlier achieved meaningful results
- high level of utilization across all covered domains

Output Analysis: Sustainability Indicators

- focus on the long lasting sustainability of and the participation in e-Infrastructure projects
- Survey covers:
  - follow-up financing
  - institutions carrying on the project work after its end
  - the need for special investments and replacements in order to keep the infrastructure running for several additional years
  - operational costs
  - international cooperation
- strong need for replacements due to technological development
- many projects are intended to carry on after current funding
- variety of # of cooperation reflects the heterogeneity of the projects

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Output Analysis: Innovativeness Indicators

- addresses innovative technical solutions and the application of these possibly not only in, but also beyond science.
  - related survey items picturing
  - announcement of patents,
  - user-reported innovations or
  - potential innovations based on the work or results e-Infrastructures projects
  - the type of affiliation of the consortium members
- 1/3 say that users have reported innovations or patents linked to the project
- majority has started to contact new types of users
- Strong orientation towards user in universities or research centres (mainly natural sciences), only very few are governmental institutions or private firms
- High level of potential for future innovations, also for industry (as user or supplier) and public authorities

Output Analysis: Indicators for transformative character

- Reflect contribution to increasing the skills of researchers or creating new knowledge and networks thereby transforming the science system in general
- Related survey items:
  - participation of universities/research institutions
  - knowledge dissemination in terms of project result used for teaching, PhD- or Master-Theses supervised
  - disciplines tackled
  - collaborations
- clear focus on knowledge dissemination (projects results used for teaching, supervision of thesis etc.)
- strong support of users in addressing research questions not solvable without infrastructure (2/3 of projects)
- high level of collaboration with projects in same domain as well as other domains
- strong orientation towards tackling multiple research disciplines

Case studies analysis

- additional case studies to supplement quantitative oriented survey analysis
- Aims: more detailed, qualitative picture and understanding of the selected projects and their specific context in order
  - to gain better understanding of the interrelations of domains, criteria, user needs and indicators
  - (if possible) determine unintended impacts
- Based on 5 cases are
  - GÉANT3 (high speed Infrastructures), EGI-Inspire (e-science grids), NEXPReS (e-science environments), OpenAIRE (Data infrastructures for e-Science), and MMM@HPC (High performance computing).
- Conclusions:
  - helped to better understand and explain the responses as well as specific interrelations
  - BUT: assessment of single cases complex due to the variety in scope, size etc.
  - BUT: no unintended impacts determined → but there could be some!

Assessment of questions

- Two-folded approach to assess the questions and related outputs for further use

- 1.Step meaningfulness
  - Low rate of responses
  - Implicitness of answer
  - Diversity of answer
- 2. Step: usability for further steps
  - Main question: usable for outcome, impact or policy contribution analysis → loop-process
- Conclusions:
  - results of the first step influenced the approach for further analysis, in particular for outcome analysis
  - selection of methodology for outcome analysis had influence on selection

Evaluation framework

Overview

- Outcome analysis
- Identification and assessment of wider socio-economic impacts
- Identification and assessment of contributions to EU policy aims
- General conclusions and recommendations

Outcome Analysis (Methodology)

Principle Component Analysis:

- transformation to convert a set of observations of possibly correlated variables into a set of uncorrelated variables
- shows which variables are most important for indicator
- **But:** unable to specify components for single characteristics; proposes to aggregate variables which do not match; unable to handle domains

Composite Indicators:

- Innovation Union Scoreboard (2010) - slightly adapted to our survey
- standardized non weighted sum of results of selected variables
- Composite indicator formed for each characteristic

Outcome Analysis (Accessibility)

Composite Indicator for Accessibility 0.78

- Increase of Userbase (domain specific):
  - Acceptance rate of proposals (HPC, GVRC)
  - Requests accepted (Data Infrastructures)
  - Increase of traffic (HSN)
- Increase of Available Resources (domain specific):
  - Increase of available information (GVRC, Data Infrastructures)
  - Level of utilisation (HPC, E-Grids)
- Access Beyond Science and private Users:
  - Project results used in education / avaliable for public
  - Users of private industry and govermental institutions

Outcome Analysis (Efficiency)

Composite Indicator for Efficiency: 0.94

- Improved Problem Solving Capacities (domain specific):
  - Increase in upscaled software packages (HPC)
  - Increase in offered services (Data Infrastructures)
  - Increase in problem solving tools (E-Grids)

- Research Projects Benefited from Infrastructure or Reached Meaningful Results Earlier (domain specific):
  - For the domains: HPC, GVRC, Data Infrastructures, E-Grids

- Efficiency Self-Assessment:
  - At least better than most other facilities or best in field

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Outcome Analysis (Sustainability)

Composite Indicator for Sustainability: 0.52

- Continued Work:
  - Institution carries on project work
- Cooperation:
  - With project in same domain
  - With project in different domain

Outcome Analysis (Innovation)

Composite Indicator for Innovation: 0.51

- Patents and Innovations:
  - Patents announced
  - User reported Innovations
  - Potential for future Innovations

- Origin of Users and Consortium (Pool of Knowledge):
  - Any private firms member of consortium
  - Any public bodies member of consortium
  - Users from private industry
  - Users from governmental institutions
  - Users from universities / research centres

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Outcome Analysis (Transformative Character)

Composite Indicator for Transformative Character: 0.77

- Increase of Knowledge Base:
  - Results used in teaching
  - Training for projects participants and outside researchers
  - PhD/Master-Theses supervised

- Transformation of Science
  - New science degree obtainable
  - Addressing previously unsolvable research questions
  - Project work tackles multiple research disciplines
  - New research standards developed

Outcome Analysis (Limitations)

Potential Limitations:

- Needs sufficient number of observations
- Some component items based on few responses
- Large projects could drive results
- Values need to be treated with care
- Indicator sensible to results

Solutions:

- Repeating the study frequently
- Building composite indicators over several years
- Control for large projects or projects in starting phase

Impact Analysis (1)

Impact Areas:

- Research Excellence and Innovation:
  - Research quality; dissemination of research results; preservation of scientific knowledge; innovation performance
- Human Capital:
  - Opportunities for training, lifelong learning, skills; achievements/improvements of the educational system
- Economy:
  - Productivity; competition; employment; growth
- Public Authorities:
  - Performance of public authorities; exploitation of public data
- Third Countries and International Relations

Assessment:

- Impacts analysed based on composite indicator
- Results of composite indicator related to expectations

Impact Analysis (2)

Research Excellence and Innovation:

- *Quality of Research:*
  - Collaboration and utilisation of knowledge easier
  - quality of science increased as accurate results obtained faster
- *Dissemination of Research Results:*
  - Results available for public or used in education
  - Cooperation and collaboration with universities and other institutions
- *Preservation of Knowledge:*
  - Depending on storage capacities (up-to-date, need to frequent improvement)
  - Knowledge easily accessible

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Impact Analysis (3)

Research Excellence and Innovation:

- *Innovation Performance:*
  - Spillovers between particapating parties
  - "pool of knowledge": scientific, governmental, industrial knowledge
  - Innovations, patents, research standards inside and outside the boundaries of e-Infrastructures

- *Results:*
  - Driving characteristics: access, efficiency, transformative character, innovation, sustainability
  - Assessment: positive impact

Impact Analysis (4)

Economy:

- *Productivity:*
  - Innovations, quality of work
  - Access to high-speed facilities, availability of high qualified specialists

- *Competition:*
  - Knowledge spillovers and easy access to knowledge
  - realised innovations, open standards

- *Economic Growth:*
  - Access to high-speed facilities, efficient scientific work,
  - productivity, innovations

Impact Analysis (5)

Economy:

- *Employment:*
  - Opportunities in technology and research
  - Economic growth, productivity, innovations
  - Stimulation of demand for highly qualified personnel

- *Results:*
  - Difficult to assess (no direct reporting, long-run)
  - Driving Characteristics: access, efficiency, innovation, transformative character
  - Assessment: positive impact

Impact Analysis (6)

Human Capital:

- *Lifelong Learning:*
  - Access and circulation of knowledge
  - new knowledge and results shape learning process
  - Scientific disciplines and new research fields influenced

- *Training and Increase of Skills:*
  - Inhouse training or training for "outsiders"
  - New knowledge and training broadens skills

Impact Analysis (7)

Human Capital:

- *Improvements of the Educational System:*
  - Dissemination of results
  - Awareness of the public
  - PhD-/Master-Thesis supervised

- *Results:*
  - Improvements in learning behavior and education (only long-run)
  - Driving Characteristics: tranformative character, access, innovation
  - Assessment: positive impact

Impact Analysis (8)

Public Authorities:

- *Performance:*
  - Innovations, knowledge, experience, results spill over to public
  - But: diffusion of innovations in public sector not yet completely explored

- *Exploitation of Public Data:*
  - Increased efficiency in scientific work
  - Facilitated handling of large databases

- *Results:*
  - Driving Characteristics: access, efficiency, transformative character, innovations
  - Assessment: positive impact

Impact Analysis (9)

International relations:

- *Third Countries and Cooperation:*
  - Users from several different geographical areas and sectors
  - Spill-overs to and increase of scientific work in acessing countries

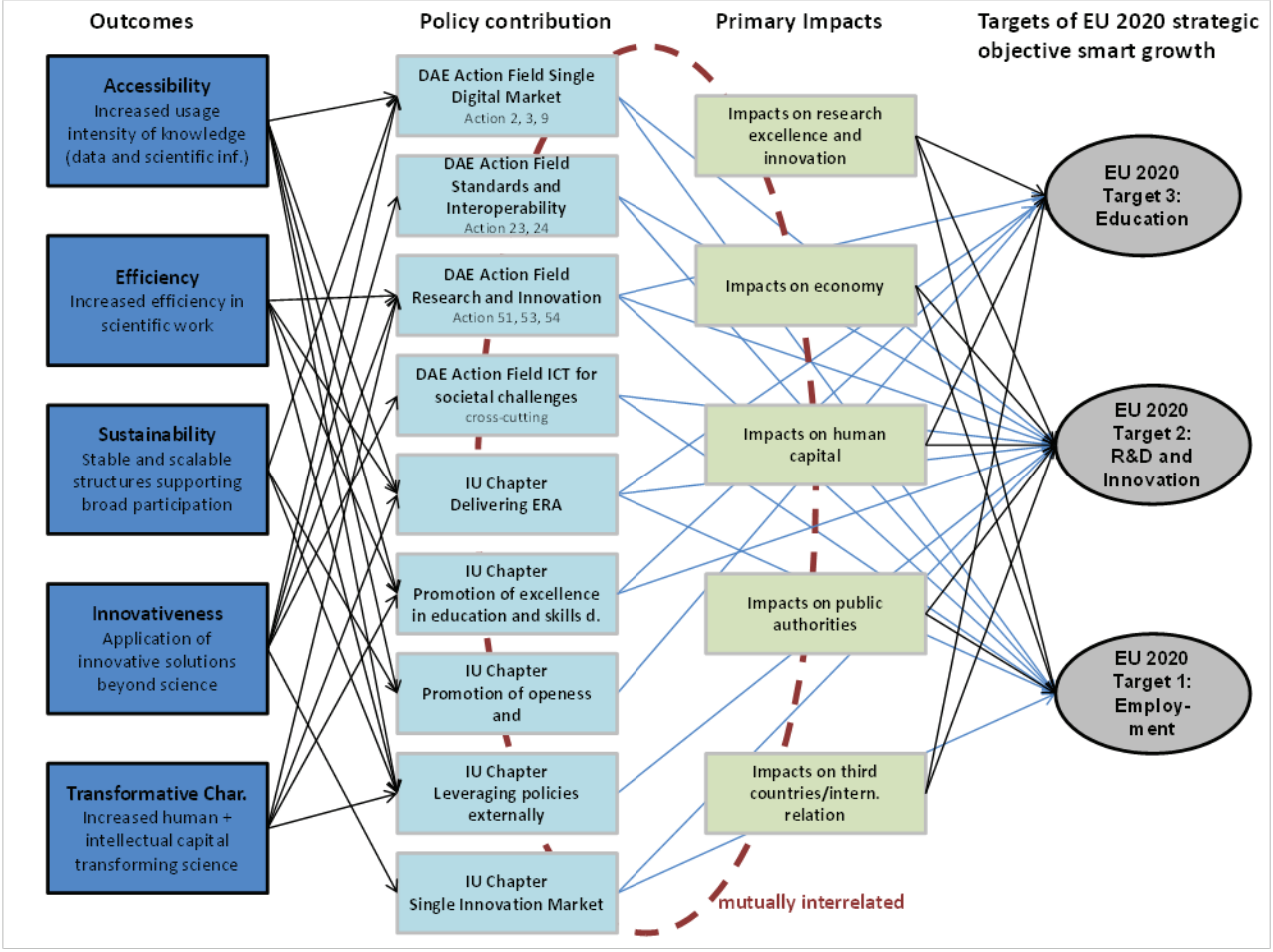
- *Results:*
  - Driving Characteristics: access, sustainability
  - Assessment: moderate impact

Contribution to Policy Aims
EU 2020 strategy

- EU 2020 strategy has 4 strategic objectives
  - smart growth
  - sustainable growth
  - inclusive growth
  - (economic governance)
- 5 targets assigned and 7 flagship initiatives are launched to achieve them

- most relevant is smart growth with its flagship initiatives Digital Agenda, Innovation Union and Youth on Move
- assigned targets:
  - Employment: 75% of the 20-64 year-olds to be employed;
  - R&D / innovation: 3% of the EU's GDP (public and private combined) to be invested in R&D/innovation;
  - Education: Reducing school drop-out rates below 10% and at least 40% of 30-34–year-olds completing third level education

Contribution to Policy Aims
EU 2020 strategy - Overview



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Contribution to Policy Aims
Digital Agenda for Europe - Overview

7 Pilars or Action Fields with 101 specific actions, most relevant are:

- Action Area 1 – Digital Single Market
  - Actions 2, 3, and 9
- Action Area 2 – Standards and Interoperability
  - Actions 23 and 24
- Action Area 5 Research and Innovation
  - Actions 51, 53, and 54
- Action Area 7 – ICT for societal challenges
  - no specific actions, but many projects support research in fields of societal challenges

Contribution to Policy Aims
Digital Agenda for Europe - Highlights

- Action Area 5 – Research and Innovation
  - Action 51: reinforce the coordination and pooling of resources → high level of collaboration expressed in sustainability and transformative character; programming of the e-infrastructure program leading to examples like Geant, EGI or PRACE
  - Action 53: financially support joint ICT research infrastructures and innovation clusters → overall impact by e-infrastructure program achieving
  - Action 54: develop a new generation of web-based applications and services → innovativeness (support of new web based services and solutions)

- Action Area 1 – Digital Single Market
  - Action 2 – preservation of cultural work → accessibility, sustainability
  - Action 3 – Access to PSI → accessibility, innovativeness
  - Action 9 – eCommerce directive → innovativeness

Contribution to Policy Aims
Innovation Union (including ERA) - Overview

Innovation Union names overall 13 chapters addressing challenges in the European science and innovation system of which are 5 relevant

- Delivering ERA
  - Completing the European science and innovation System
- Promotion of excellence in education and skills development
  - Attractive environment for researcher in Europe
- Initiative on the promotion of openness and capitalising Europe's creative potential
  - Open Access to research
- Leveraging our policies externally addresses
  - Attracting external research
- Initiative on a single innovation market
  - European market for innovations

Contribution to Policy Aims
Innovation Union (including ERA) - Highlight

Delivering ERA (European Research Area)

- encompass all research and innovation activities in Europe
- effectively enable researchers, institutions and businesses to circulate, compete and cooperate even across borders with the aim of giving them access to an EU wide open knowledge and technology space
- Strategic agenda 2020 contains three goals:
  - Fifth freedom (free circulation of knowledge, researchers etc.) → positive contribution through high level of accessibility
  - Attractive conditions for research and innovation → influenced by the availability of resources (high level of accessibility) and effective and excellent research conditions (high level of efficiency and transformative character)
  - Healthy competition and appropriate level of collaboration → influenced by high level of efficiency and of transformative character
- positive contribution to these strategic aims indicate overall positive contribution

Contribution to Policy Aims
Overall Assessment

Contribution to the three assigned strategic targets:

- Mutually interrelations between policy contribution and impacts

- **Employment:** impacts in growth and employment, research and innovation, productivity and competitiveness; contribution to Digital Single Market, Single Innovation Market → creation of jobs in multiple ways
- **R&D (spending):** impacts on research and innovation, human capital formation, growth and employment, contributions research and innovation, ERA, innovation market → more investments through attractiveness, competitiveness
- **Education:** impacts on socio-cultural aspects, human capital formation, contributions to ERA, education and skill development

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General Conclusions

Conclusions regarding key research questions:

- Applied methodology is suitable to indicate the program achievement in relation to its goals
- suitable to determine and assess socio-economic impacts and contributions to EU policy aims
- there are limitations
  - due to the lack of time series and benchmarks (negative, positive)
  - unintended impacts are not covered
  - any interventions should not be aimed at optimizing single indicators → mutual interrelations of indicators with other aspects

- Based on that we suggest:
  - Implementation of a monitoring system
  - development of tool box for further analysis

Recommendation
Overall Approach

- Goal of the study (ToR): recommend a monitoring system and concrete measure for implementations
- based on the results of the study and experiences made during study time
- Balance between additional burden and needs for monitoring and assessment
- two-fold approach:
  - survey in regular intervals for monitoring based on the developed composite indicator
  - survey in non-regular intervals for additional purpose of analysing impacts and policy contribution

Recommendation
Monitoring system - Survey

- Regular monitoring system based on the composite indicator of the pilot study:
  - 5 areas: Accessibility, Efficiency, Sustainability, Innovativeness, Transformative
  - only slight changes in each according to the results of study, this includes
    - adjustment/integration of missing items for domain-specific items in accessibility and efficiency, changes in sustainability to
    - Require special focus on communication with user
  - Implementation as part of the annual reporting → calculable for projects
- Complementing survey in non-regular intervals
  - some data not used for the composite indicator still valuable for the discussion and analysis of impacts and policy contribution
  - implementation within the final reporting of the projects

Recommendation
Monitoring System

- further development and coordination
  - require regular review due to the "moving target" e-Infrastructure
  - Establishment of working group in the context of ESFRI/E-IRG
  - Integration of stakeholders (projects as well as users)
  - offers potential to agreement between EU and Member States on comparable monitoring system all over Europe

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Recommendation
Tool Box

- experiences during the study confirm results of the review of existing approaches (f. e. UK e-Science program, NSF cyberinfrastructure program) as well as of existing literature → no one size fits all solution
- Exploitation of the experiences of the different studies in order to develop tool box for e-Infrastructure monitoring and assessments
- Additional instruments could be for example:
  - Inventory (siehe eNventory) supported by general surveys (examples: Survey of Science and Engineering Research Facilities) → coordination required
  - User surveys: integrating needs and challenges of users to understand impact on their work
  - Bibliometricl support: enable to measure research excellence
- To be considered:
  - Not only tools, also how and when to use
  - concertation required → understanding intersections between EU and national level f.e.

Thank you

Questions and discussion?

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