Information Society Technologies

Enterprise Interoperability

Research Roadmap

Annex I – Indicative Research Challenges

Final Version
(Version 4.0)

31 July 2006

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1. Introduction

The present document is Annex I to the Enterprise Interoperability Research Roadmap[1]. This Roadmap aims at laying out the goals (ideas) of the research in Enterprise Interoperability (what is to be accomplished) rather than the technology/methodology used to achieve these goals (how to achieve it). The Roadmap identifies a vision for Enterprise Interoperability research and four Grand Challenges. Its strategic view permits flexibility towards new technological approaches, particularly considering the long time-span of the research framework. It is also consistent with the principle of giving proposals for research projects the flexibility to suggest their own technological approaches to realise the stated goals.

The aim of the indicative research challenges in this annex is to propose explicit research ideas as specific research issues within the Grand Challenges established in the Roadmap. They are not meant to be prescriptive or comprehensive, i.e. specific project proposals may very well fall outside the scope of the research challenges listed in this annex. These research challenges mostly originate from version V1.0 of the Roadmap[2].

The editors have put considerable effort into tightening up the wording and, more importantly, the ideas presented in the Roadmap. Concerning the indicative Research Challenges in this annex, it should however be noted that they originate from "bottom-up" contributions; the research challenges are grass-root submissions. As such, the editors very much relied on the original submitters as regards the contents and the formulation, and applied a "light-touch" approach in processing the submitted texts on these research challenges. The editors have only made changes to the research challenges of version V1.0 of the Roadmap and now in this annex, where they felt there were substantial issues/problems in the text that needed to be corrected. Some of the research challenges with open issues were also removed from the annex, although the headings of these challenges are still in the text. Most other descriptions of the research challenges from version V1.0 of the roadmap remain in their original form in Annex I.

The structure of this annex follows the original structure of V1.0 of the Roadmap. The indicative research challenges are split in three categories, namely Policy (P), Business-Economic (B), and Technical (T). The technical category is again split in five categories, namely Enterprise (business/knowledge) (T1), ICT systems and Architecture & Platform (T2), Methodology (T3), Semantics and Ontology (T4), and Generic Modelling (T5).

Each of the chapters starts with a short introduction. The introductions include figures that position the research challenges in that chapter in a 2006-2010 timeline, indicating the time frame in which the research challenge should be addressed. Research challenges that were deleted from this annex are still represented in the figures with dashed lines and in italic font. Research challenges that were added after publication of V1.0 are not shown in the figures. The timelines indicated in the figures for the research challenges are based on the estimates of the original V1.0 authors.

[1] ftp://ftp.cordis.europa.eu/pub/ist/docs/directorate_d/ebusiness/ei-roadmap-final_en.pdf
[2] ftp://ftp.cordis.europa.eu/pub/ist/docs/directorate_d/ebusiness/20051221_roadmap_v10.pdf

2. POLICY Challenges (P)

The role of policy and regulation in this context is to minimise any negative impacts of the new technologies, while also maximising the positive benefits of the technological change. It is common that the regulations that enterprises consider as barriers to technological change to be the very regulations that individuals consider as to minimise any negative impacts of the new technologies upon them. Consequently a consideration of all stakeholders' interests is required before policy proposals are implemented.

The main challenges to policy makers from the interoperability vision and roadmap presented here are common to many other visions and roadmaps, requiring the encouragement of the adoption of open standards to support both interoperability between the products from different manufacturers, and a competitive marketplace to drive down costs. Secondly, the technologies must build on security and privacy measures from the outset.

A key change resulting from inter-enterprise interoperability (e.g. through Web services or the Grid) will be the establishment of trusted service providers, probably acting on a global scale and disrupting the current supply chains and regulatory environments. The policy challenges identified here must be met to support such trusted international interoperability.

A second change is that systems become more dynamic and responsive to change themselves by managing and executing policies across complex distributed systems, rather than executing low level instructions from operators. Therefore, as with the semantic modelling of the data and systems, the level of human responsibility is raised from direct actions, to the definition of "policies" (not to be confused with the legal and regulatory policies which are the topic of this section). The expert system boom of the 1980's partly collapsed because the regulations of professions and companies would not allow humans to delegate actions and low level decisions to machines that ran in policies whose definition was the lowest level of human involvement. The reward, status, governance, performance monitoring, liability and penalty systems of professions and companies will have to be modified along with the culture which people build on them in order for policy level management to be assimilated into future working practices.

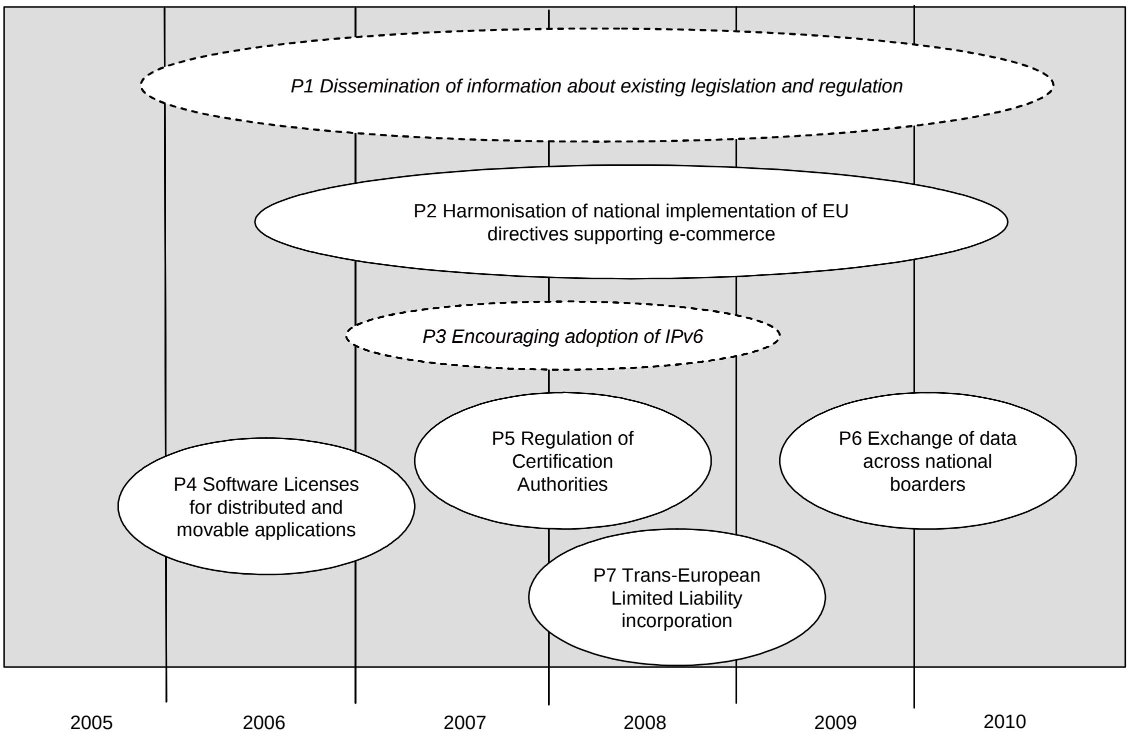

Figure 1 Policy area challenges
(See Chapter 1 for an explanation of the figure)

Interoperability between devices is one of the four main challenges identified in the i2010 strategic framework to produce a single European Information Space. To meet this challenge, i2010 proposes a comprehensive approach to effective and interoperable digital rights management (2006/7), a strategy for a Secure Information Society (2006), to define e-business policies aiming to remove technological, organisational and legal barriers to ICT adoption as well as where needed, mandatory instruments. The policy challenges addressed here are those required to facilitate interoperability within an enterprise which complement those proposed in i2010, and may constitute candidates for the mandatory instruments that i2010 allows for.

2.1. Dissemination of information about existing legislation and regulation (P1)

Deleted due to not being referred to by the Grand Challenges.

2.2. Harmonisation of national implementation of EU directives supporting e-commerce (P2)

Research challenge	Harmonisation of national implementation of EU directives supporting e-commerce
Description	The implementation by member countries of various EU directives designed to support e-commerce differ either in legislation or in practice. The consequence is that international e-commerce within the EU is blocked.
State-of-the-art	A major barrier to adoption of e-commerce is the lack of full harmonisation of e-business legislation and the resulting divergences between national legislations. In particular this problem of a lack of harmonisation applies to: • Distance Selling Directive • Data Protection Directive • e-invoicing • e-signatures Directive – despite the European Electronic Signatures Standardisation Initiative • e-privacy Directive
Research Activity	EU member states must be shown the problems resulting from the lack of harmonisation, and encouraged to harmonise their implementation of directives to allow international e-commerce within the EU.

2.3. Encouraging adoption of IPv6 (P3)

Deleted due to not being referred to by the Grand Challenges.

2.4. Software Licenses for distributed and movable applications (P4)

Research challenge	Software Licenses for distributed and movable applications
Description	Software license models are ill adapted to run in grid environments that can quickly scale up or down depending on demand. If a software license is based on any of CPU usage, number of CPU, number of cores, number of users, number of members of an organisation, for example, costs can quickly escalate as more processors are called into service. If the license is limited to use by a single organisation, then its use in a technologically mediated VO is questionable.
State-of-the-art	Everybody in the community knows the problem and is waiting for the first company to jump to a new solution and see if they get market advantage, or

	drown in legal fees.
Research Activity	Vendors should develop and use a new form of license based on on-demand computing usage which is compatible with the practical needs of distributed VOs.

2.5. Regulation of Trusted Certification Authorities (P5)

Research challenge	Regulation of Trusted Certification Authorities
Description	Certification Authorities grant certificates by many different criteria, and are relying on the market to resolve the appropriate one for different roles. A consequence is that most user businesses do not know which CA to trust or use, and what is being certified.
State-of-the-art	Several countries (e.g. Germany, Singapore) have implemented some form of licensing, but not all, and they are not harmonized.
Research Activity	Introduce regulations for CA that give them benefit by limiting liability in return for clear criteria for audit of grounds for issuing certificates, record keeping, and confidentiality.

2.6. Exchange of data across national borders (P6)

Research challenge	Exchange of data across national borders
Description	Global companies find barriers in several countries to shipping information obtained within that country across national boundaries. This presents a significant barrier to international e-commerce with those countries.
State-of-the-art	Nothing is known on this issue.
Research Activity	It is unclear what solution could be applied across countries outside the EU.

2.7. Trans-European Limited Liability incorporation (P7)

Research challenge	Trans-European Limited Liability incorporation
Description	There is no legal entity available to specifically support organisations when operating as a VO.
State-of-the-art	EEIG and European Society are both candidates with flaws for the role. The ALIVE (http://www.vive-ig.net/projects/alive/) and LEGAL-IST (http://www.legal-ist.org/) projects have both advocated changes in this area from a legal perspective.
Research Activity	The establishment in the laws of EU member states following an EU Directive of a limited liability entity capable of supporting e-commerce activities between existing legal entities.

3. BUSINESS – ECONOMIC Research Challenges (B)

In general business personnel outside the ICT industry are unlikely to think that interoperability is an issue for them, as opposed to their technical colleagues. The consequence of this sentiment is significant and manifold. It impacts on issues ranging from the transfer of research results to industry, to those concerning investments into research, particularly for the private sector. Business personnel are also likely to be confused by the many market (or marketing) signals coming from the supply side of IT, software and related services, as well as from the increasing circles of standards and specifications producing organisations. Furthermore, they may recall investments made in the previous generation(s) of technologies, now termed "legacy". Finally, investment – or risk – capital typically rewards proprietary solutions with their lock-in effect and captive markets.

There is an increasing opinion from both public and private sectors that research for research sake is an insufficient justification for financing. Research needs to be relevant for industry. ICT research needs to show that it has impact and especially benefits beyond the ICT community itself ("mainstreaming of ICT research"). The large volume of research and statistics correlating ICT deployment with productivity growth is an example of responding to such issues. At the same time, however, other studies and predictions point to continually massive outsourcing of manufacturing, and increasingly services and high tech too, from the developed world – which has enjoyed ICT-induced productivity growth – to less developed regions. A conclusion could be that productivity growth could not alone be the measure of value creation.

The 2nd Pillar of the i2010 strategy explicitly links innovation with investment in ICT research. An over-riding focus is the management of innovation and creation of value in the full cycle of ICT research, from ideas generation to shipment of R&D results to the market. In respect of the present Roadmap, therefore, what is strategically important is: 1) what does innovation mean for enterprises? 2) what value does enterprise interoperability bring in business, economic and the broader societal terms? 3) what innovation can enterprise interoperability bring to businesses? and 4) what is the business-economic context needed to make it happen?.

In formal terms, enterprises are legal constructs and are governed by particular laws and regulations of a jurisdiction, which themselves evolve (see previous chapter on policy challenges). But enterprises first and foremost live or die depending on meeting market demand, now and in future. It is important to focus business-economic research in enterprise interoperability through the lens of the *demand* for enterprise interoperability. Here, the general history of ICT interoperability has already shown that the state-of-the-art of the markets is not the same as the state-of-the-art of the technologies. Three examples would suffice: the market-winning technology for the video recorder (Betamax vs. VHS), the astonishing growth of SMS as a main application of the mobile phone, and the rapid metamorphosis of "google" from a company name into a common verb across the world.

Accordingly, the salutary lesson is not to attempt to devise business-economic research challenges in order to "out-think" the market. Rather, the business and research challenges are meant to provide a frame of reference to the future in order to address enterprise interoperability in a way that is meaningful and understandable to the business world and individual enterprises. Enterprise interoperability in this sense is an intersection of business, economic and technology developments, embedded within a legal and regulatory environment. And the state-of-the-arts of the markets are shaped collectively by these different aspects.

Moreover, such markets (note the plural) cannot be ring-fenced: they are context dependent; some are even indeterminate in relation to what they really are and become provisionally labelled in relation to a technology-enabled business model (e.g. "Web 2.0", "Nano-Bio-Info Convergent Supply Chains", "Open Source Market"). It may be argued that this is in sharp contrast to "classical" industry sectors, where the problems are well known and the solution space well defined, and which the business-economic research challenges must address in order to be relevant. However, enterprise interoperability may spawn surprises and new business developments even for the mature – and much-studied – sectors like automotive and retail. Well-documented value chains are not immutable. From a broader perspective, market convergence and consolidation is also likely, as economy of scales, global sourcing, competitive labour costs, competitive tax regimes etc render established business models untenable. The future company may also become hard to label in terms of the traditional model of inputs/outputs (e.g. Nike, Levis). The research question here is how enterprise interoperability may contribute to such developments.

Particularly for the subject area of enterprise interoperability, therefore, the markets are fluid constructs, for which there is no single source of decision-making and no “Invisible Hand” (Adam Smith, 18xx) to guide or orchestrate certain “desirable” outcomes, including for the incumbent. Betting on a set of target industries for enterprise interoperability – or for ICT for that matter – in terms of research funding may turn out to be short-sighted. Moreover, empirical data and research studies consistently show that SMEs are the lever of “creative destruction” and the enduring source for a renewed momentum of disruptive innovations and ICT-based business models.

Accordingly, a clear description of the seminal domain of business-economic research challenges is needed, especially in the current climate of profound transformation of the IT, software and related services industries (which some commentators presaged as a strategic aspect of the emergent “Service Economy”). Well-defined business-economic challenges, which attract the support and buy-in of particularly the business community, will help shape future developments of the markets.

Furthermore, emerging scientific concepts and disciplines – such as “network sciences”, “meta technologies” and “digital business ecosystems”, just to name a few – may have far-reaching impact on enterprise interoperability over time. In due course, they may transform both theoretical and practical approaches to businesses and economics, such as the “knowledge worker” and “knowledge management” before.

At present, twelve enterprise interoperability business-economic research challenges have been provisionally defined. They could be grouped under four overall headings, in relation to the context of addressing the research challenges (with a few of these challenges relating to more than one or even all headings):

Enterprises and Sectors: B.1, B.2, B.4, B.6, B.7, B.9, B.12

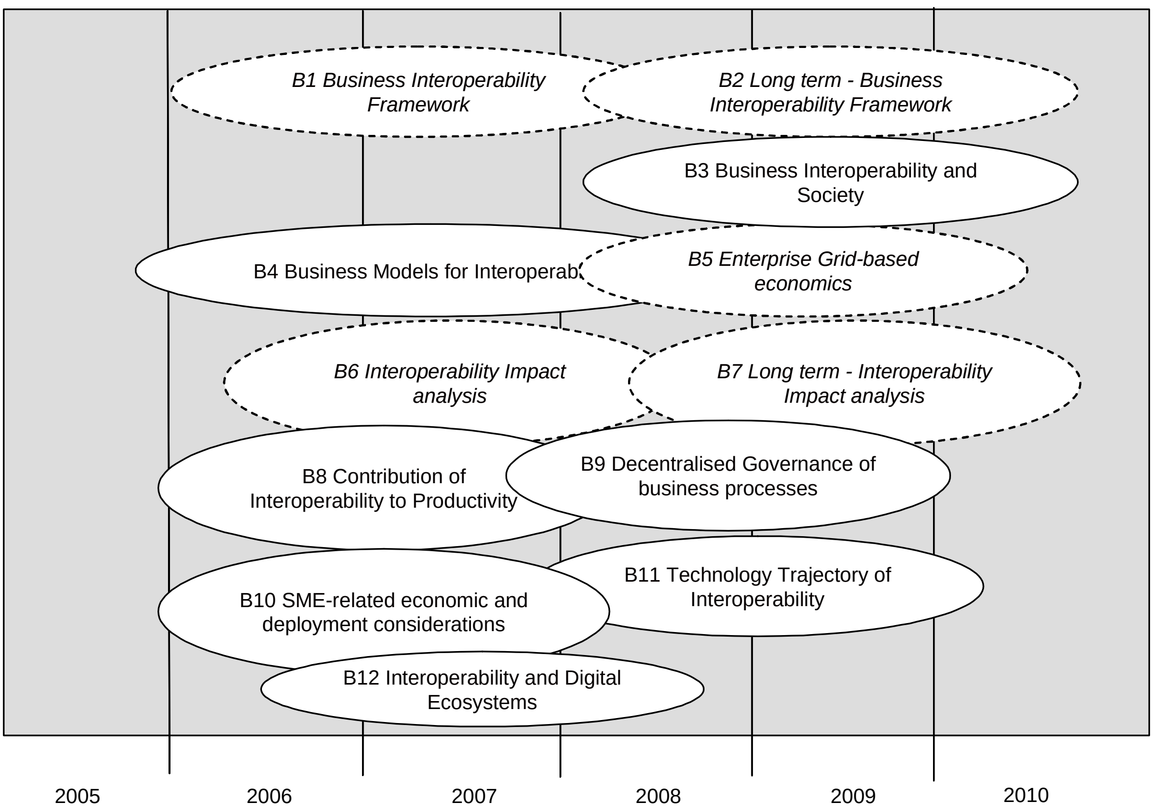

Figure 2 Business – economic area research challenges
(See Chapter 1 for an explanation of the figure)

Macro Business and Economics: B.4, B.5, B.8, B.10, B.12

Business and Economics Paradigms: B.11, B.12

Business Interoperability & Society: B.3, B.12

3.1. Business Interoperability Framework (B1)

Deleted due to ongoing work.

3.2. Business Interoperability Framework – Long term (B2)

Deleted due to ongoing work.

3.3. Business Interoperability and Society (B3)

Research challenge	Business Interoperability and Society
Description	Problem statement: • *How does interoperability contribute towards solving societal issues?* This research challenge is about developing long term and multi-disciplinary research into interoperability from the perspective of how interoperability relates to and contributes towards macro, societal issues. This research aims to lay the foundation for a new and holistic discipline in business interoperability research. It will do so by applying established socio-economic theories to interoperability in order to analyze the impact of interoperability on economic value creation and societal effects. Research areas will include the following theories and related practices: • Networked Organisations Theories / Practices • Economic Theories / Practices • Socio Theories / Practices • Community Theories / Practices • Institutional Theories / Practices • Business Management Theories / Practices By way of example, networked organisation research has shown that transparency and open book policy is not always favoured by enterprises in a network. Some community theories on the other hand suggest a "positive sum game" in increased cooperation and public availability of resources. Yet some economic research - notably that relating to the resource based view - indicates that economic performance is not optimised by simply optimising the performance of each productive resource, on its own. How do these insights from different disciplines contribute towards determining the contribution of interoperability to societal issues such as market coordination, innovation and inclusiveness? Another example concerns European economic, social, and cultural diversity. This European specificity is embedded into a broad range of citizen, business, cross-national economic and social activities. Interoperability of enterprises needs to be concerned with the needs of businesses stemming from those diversities in relation to, e.g. information access and resource sharing. This research challenge is a direct contribution towards the specific research challenges identified for the Policy area.
State-of-the-art	Networked Organisations Theories / Practices Much relevant research has been conducted in this area with studies issued, e.g.

	ATHENA Activity B3 "Assessment of networked organisations and value models" (available from www.athena-ip.org) Economic Theories / Practices Study on economic theories for interoperability being finalised in ATHENA Activity B3 Socio Theories / Practices None relating to interoperability Community Theories / Practices Examples include research into open source community, standardisation and other consortia, information "commons", … Institutional Theories / Practices None relating to interoperability Business Management Theories / Practices None relating to interoperability Finally, there is no known ongoing research in **consolidating the above different disciplines and aspects** in addressing interoperability.
Research Activity	The research activity will consist in providing a **holistic picture of interoperability in a socio-economic context**, linking interoperability research to societal issues and challenges, including: • Open and competitive markets • Strengthening innovation and investment in ICT • Inclusive eBusiness • European diversity • Etc.

3.4. Business Models for Interoperability (B4)

Research challenge	Business Models for Interoperability
Description	Problem statement: • *Does interoperability bring about the commoditisation of products and services?* • *What is the balance of interest in interoperable products and services between the supply and demand sides of the industry?* • *Is there a business case for interoperable products and services?* The research work is of relevance in that it seeks to clearly • Define what is meant by "interoperable products and services". • Explore business models for interoperability on the supply side of ICT • Explore business models for interoperability on the demand side of ICT • Consolidate supply and demand analyses in defining business requirements for interoperable products and services by stakeholders, answering questions such as: Has IT become a commodity; and if so, does it matter? • Analyse profit and loss responsibilities in relation to the structure of the firm and the associated governance issues
State-of-the-art	Ongoing activity of the Cluster on Enterprise Interoperability. See also supplementary material below.
Research Activity	The research activity will consist in providing an **overall framework** for identifying and describing business models, business cases, and business values for interoperable products and services, including: • Identification of motivations for market actors to invest in R&D in interoperable products and services. • Value proposition for and valuation of business models related to advancing interoperability. • Closing the gap between R&D, innovation and investment in IT.

	• Etc. Note: technical issues such as business ontology will be explored in the Semantics research challenges in the technical section.

3.5. Enterprise Grid-based economics (B5)

Deleted due to not being referred to by the Grand Challenges.

3.6. Interoperability Impact analysis (B6)

Deleted due to ongoing work.

3.7. Interoperability Impact analysis - Long term (B7)

Deleted due to ongoing work.

3.8. Contribution of Interoperability to Productivity (B8)

Research challenge	Contribution of Interoperability to Productivity
Description	Problem statement: *How does interoperability contribute to the productivity of an economy?* ICT impact on productivity growth could arise from a number of channels, such as: • The effect of rapid technical process in the ICT producing industry on total factor productivity growth • The effect of ICT investment on labour productivity growth through capital increase of substitution • The effect of economy-wide use of ICT on total productivity growth through creating knowledge spillovers However, some economists have argued that such impact is based on broad indicators that do not reflect the true impact of ICT (conform the "productivity paradox" of using indicators to measure ICT innovations, which could only be measured indirectly particularly in the services industries). Against this background, the impact of interoperability on productivity is an even more intractable issue. It is also linked to various research challenges identified in this section, in particular B3, B4 and B11. The research will aim to contribute to the above issues from the specific context of enterprise interoperability, based on the work also on other research challenges in the business-economic area. The subject area is potentially vast and wide ranging from product market flexibility to labour market flexibility to infrastructures and R&D spending.
State-of-the-art	There is a vast volume of research work on the contribution of ICT to productivity as well as published data and league tables for countries and regions. But none of these specifically address interoperability.
Research Activity	Many studies have shown that ICT has made a significant contribution to productivity and growth of an economy. This is among the key arguments for increasing investment in ICT, from research to deployment. However, it is not clear whether increase in interoperability would contribute to increase in productivity. This is also linked to the question of how the benefits of interoperability would accrue at the firm, value chain, sector and macro economic

	level, and how the benefits are to be distributed across the different levels. It has been suggested that in order to demonstrate the benefits of interoperability, a "simplified" microeconomic approach to infer the contribution of Enterprise Interoperability to the firm's capital and labour productivity is needed. This could be based on the firm's production and cost theories, by analysing the impact of interoperability on the firm's access to new markets. The research will seek to answer: what are the **casual relationships**, if any, that could be established between interoperability performance and the productivity of an economy. Both micro- and macro-economic aspects, as well as short- and long-term impacts, need to be identified/addressed.

3.9. Decentralised Governance of business processes (B9)

Research challenge	Decentralised Governance of business processes
Description	Problem statement: How to manage: • Decentralised Responsibilities, Targets and Decisions • Decentralised Resources • Laws, Rules, Policies, Accreditation … • Multiple supply chains competing for local resources causing conflicts and perturbations in individual supply Chains And how to support their diversity within the business processes. Relevance: For instance: Different rules, laws and policies for the same business process in different countries and industrial sectors. Different policies/constraints for negotiations with national public administrations. Local decisions and its relevance and impact across organisations
State-of-the-art	• Harmonisation efforts within the EC • Harmonisation efforts/standardisation in electronic commerce such as CEN/ISSS, • Projects such as eGovernment, • "Business Dynamics" John Stearman / 2000 • DBE-IP Digital business ecosystems
Research Activity	This research activity will analyse and develop features in terms of services within a digital business ecosystem environment to manage the gap between decentralised assets, targets and constraints.

3.10. SME-related economic and deployment considerations (B10)

Research challenge	SME-related economic and deployment considerations
Description	Problem statement: *How to increase the participation of SMEs in e-business, from R&D to deployment?* SMEs represent over 99% of all enterprises in the EU, generate over 40% of the overall economic activity and contribute to over 60% of industrial employment. Moreover, studies also show that they are the main source of innovation in ICT. Increasing the participation of SMEs in eBusiness is therefore not just an economic necessity. It is also essential for achieving the vision of i2010 in bringing the benefits of ICT to all in a more inclusive society. Considerable progress has been achieved over recent years in the adoption of ICT and e-business practices by large European organisations. However,

	numerous market surveys confirm that SMEs are still lagging behind. They are constrained by: • a lack of the necessary technical and management skills needed to capitalise on the new technologies • inefficient utilisation of existing information • geographical environment • a lack of human and financial resources • a lack of standardised, compatible and appropriate ICT solutions Past initiatives also suggest that piecemeal initiatives targeting SMEs do not have the expected results.
State-of-the-art	There is a vast volume of research work on SMEs, e-business and technology deployment. The interoperability aspects are being researched by INTEROP and ATHENA.
Research Activity	In contrast to numerous previous research studies, this research activity will seek to identify and recommend the kind of **preconditions** that are needed in improving SME participation in e-business. Specific research issues will range from SME competency to investments to methodologies that would assist SMEs in deployment. Specifically the research will investigate the issues of SME participation at a **systematic level**, and to ascertain the kind of **structural obstacles** for SMEs in relation to their contribution to interoperability and the benefits that they derive from interoperability. One approach could be to look at particular attractors and business drivers for SME involvement in networks and the possibilities for a gradual (or even viral) progress to interoperability. For example, an SME is persuaded of the benefits of X1, but the technology providing that also provides a Y2 capability that makes it easier (or even unavoidable) to move to X2 in the future. An example might be low cost access to VPN over P2P, which also implies implicit acceptance of some other things, e.g. standards and ways of working. This “stair-case” kind of approach is linked to the concept of “designed-in” interoperability.

3.11. Technology Trajectory of Interoperability (B11)

Research challenge	Technology Trajectory of Interoperability
Description	Problem statement: *Is there a technology trajectory of interoperability?* Neo classical economics from Adam Smith onwards is based on assumptions about economic cycles, which have been variously applied in recent decades in defining “technology cycles”. The shape and timeframe of technology trajectory is closely linked to the emergence of “breakthrough technologies” and the various technology “laws” that have been defined for technological developments (e.g. Moore's Law, Metcalf's Law, Gilder's Law, Negroponte’s Law, Lessig’s Law, Conway’s Law). These are in turn linked to a systems view of how technology evolves and becomes adopted over time, an exponent of which is Fisher’s “fundamental theorem” of systems in evolutionary motion. The availability or otherwise of a technology trajectory of interoperability has immense implications for 1) predicting the development of specific (groupings of) technology; 2) investments in technology by both supply and demand sides of the market, by both public and private sectors; 3) adequacy of the market mechanisms in fostering innovation; 4) the kind of “intervention” that may be needed or not from an institutional perspective; 5) the “optimal” distribution of financial capitals and production capitals in the development of technologies; 6) the “first comer” / “later comer” advantage in technology adoption.
State-of-the-art	• Various theories of economic cycles, e.g. Smith, Marshall, Samuelson,

	Nelsen, Winter • Gartner: hype curve • Schumpeter: creative destruction (monopoly) • Carlota Perez: turning point / recessive interval ("techno-economic paradigm") • Etc.
Research Activity	The research activity will consist in establishing whether past and present research and insights on technology trajectory could contribute to developing a specific **technology trajectory of interoperability**. Assuming that there is indeed a **technology trajectory** of interoperability, then the research question is: what is it? A secondary issue is whether the technology trajectory has a complementary **engagement trajectory** in relation to those technologies, such as take-up, timing relative to the trajectory, and timing of the technology. Relevant issues could include: • Phasing of the likely take-up by the technology development community at large • How individual firms may progress from one level of technological capability to another The regional dimension, social and other types of networks, addressing issues such as localisation costs, regional impact, danger of lock-out.

3.12. Interoperability and Digital Ecosystems (B12)

Research challenge	Interoperability and Digital Ecosystems
Description	Problem statement: *How can interoperability enable and sustain digital ecosystems?* Digital ecosystems are ICT-based communities of organizations pursuing common long-lasting objectives like, e.g., promoting a technology, developing a market or a region, establishing regulatory frameworks. Compared to traditional forms of enterprises aggregation, like industrial districts, digital ecosystems take advantage of ICT as the main conduit for business transactions and knowledge sharing. This allows cooperation across regional and sectorial boundaries, a fundamental advantage for SMEs. Interoperability has been highlighted as a primary requirement for digital ecosystems, but past research has mostly focused on the technical aspects, e.g., on open standards and infrastructures to be deployed in these new organisational forms. From a Business-Economic perspective, the main questions to be answered are: • What business strategy underpins the creation of interoperable digital ecosystems? Who are the stakeholders and which values do they pursue? How can these different value systems be combined and integrated? • What business model should be pursued to provide ecosystem-level interoperability? Who are the actors involved (e.g. government, industry representatives, enterprises, individuals) and what role do they play?
State-of-the-art	• EU projects in the Digital Ecosystem cluster (in particular DBE). • "Virtual Organisations Breeding Environment", promoted by the ECOLEAD IP, where the ecosystem is seen as a larger networked organization originating several Virtual Enterprises. • Digital ecosystem initiatives undertaken by industry leaders (e.g. Amazon, eBay, Google, and vendors such as SAP).
Research Activity	The research will start by analysing relevant ecosystem examples from a business perspective, in order to gather the interoperability-related reasons behind an ecosystem creation and its sustainability. Systematisation of this knowledge should lead to an extension of Business

	Interoperability concepts. The final objective is to define an “ecosystem layer” as a foundation for the development of particular business interoperability frameworks and impact assessment models developed at the company and the value chain level. Note that the validity of these frameworks and models is dependent upon the properties and characteristics of specific ecosystems.

3.13. Decentralized Quality Management of Business Processes (B13)

See Annex II, Issue 131.

Research challenge	Decentralized Quality Management of Business Processes
Description	Problem statement: Does Interoperability influence Quality of Business (Product/Processes)? How ensure that interoperating business processes have the same quality (process and product quality) as an internal established business process. It is a question how to manage: - Decentralized Quality Management Policies/Targets - Decentralized Quality Management Requirements/Standards - Decentralized Quality Management Organisational Structures - Decentralized Quality Measurement System/Rules/Constraints - Decentralized Quality Management Responsibilities - etc., and how to support their diversity within business processes and how to represent quality aspect within Enterprise (Business/Knowledge) Model
State-of-the-art	Quality management methods and procedures for internal business processes; ISO 9001:2002; ISO TS 16949
Research Activity	This research activity will analyse and develop criteria and features in terms of methods and services (e.g. flexible QM-Modules) to manage the gap between decentralized Quality management Targets, Constraints, Structures, Standards, Rules, Responsibilities within digital business ecosystem environment

4. ENTERPRISE (BUSINESS/KNOWLEDGE) Research Challenges (T1)

Industry and especially SMEs in Europe are under great pressures due to the increasing competition from the global market. Large companies can react in setting-up subsidiaries around the world. However, SMEs have to concentrate on setting-up cooperation and collaborations within the global market. Increasingly global supply chains are being established. Industry engaged in this cross regional supply have to handle costs, quality, trust, transactions etc. in efficient way to be competitive and at the same time be attractive for possible collaboration partners. Consequently, collaboration methods and tools have to be developed and adapted for Enterprise demands to reduce the costs for, and to handle, the worldwide collaboration processes supporting knowledge availability, persistence and sharing focusing on reducing interoperability costs in the Enterprise and collaborative business processes.

An important challenge is to understand each other on different levels. This is difficult using the same language and within one culture but it becomes extremely critical between very different cultures, languages, industrial traditions, tools, laws and business rules. This constrains possible fruitful co-operations between organisations.

Enterprise modelling is used today mainly by large enterprises to clarify, analyse and implement business processes. Enterprise modelling is intended to achieve a common understanding across stakeholders. It enhances the stakeholder understanding of the co-operation however, the EM delivery need enhancing, perhaps with advanced conferencing technologies.

The availability of natural resources becomes more and more critical for the future of an enterprise, and the whole product life cycle becomes more and more the focus of interest. So interoperability is not only required in the workflow between companies during the production, but it also is a prerequisite for the whole Product Life Cycle Support (PLCS) between the various enterprises involved.

The technical support of business will be realised by smart agents/services creating the required connection between enterprises. The connections are built to meet business demands. Knowledge about, and of, enterprises will be used to facilitate interoperability dynamically during cooperation (might be temporary) e.g. a knowledge profile of an enterprises might be provided in a standard way describing which knowledge services are available as well as the conditions to access these services. The overall picture will be provided by visual, easy understandable enterprise models, bridging the gaps between stakeholders and knowledge domains and providing the prerequisites for interoperability between organisations. The research challenges are grouped from the overview across the enterprise stakeholders, the analysis of the different business facets and the configuration of the business processes by enterprise models taken into account non-functional aspects of contracting to the bridging of culture borders (see below):

- T1.1 Interoperability of Enterprise models
- T1.2 Usability of enterprise models
- T1.3 Cross organisational business processes
- T1.4 Agreements and Contracting
- T1.5 SME Situation Challenges
- T1.6 Interoperability aspects of intercultural cooperation

Following a summary of each of the points are given followed by the detailed challenges:

Interoperability of Enterprise models

Interoperability requires a consolidated and consistent understanding across all stakeholders, which is gathered from unstructured and incomplete views. The application of enterprise modelling promotes the common understanding of the enterprise business processes within the company and across companies. The company is supported to succeed in reducing the throughput times, improving the process quality, reducing costs and therefore improving the customer satisfaction and competitiveness. To assure a correct cooperation between two or more entities it is mandatory to build an appropriate model of them. This can lead to a stronger amplification of all the cross-interface activities and constraints between the entities. Enterprise models illustrate the organisational business aspects as a prerequisite for the successful technical integration of IT systems or their configurations. If an IT system is not accepted by staff members, because its usefulness or is not transparent, then it quickly loses its value due to erroneous or incomplete input and insufficient maintenance. This at the end results in investment losses.

The enterprise models cover the knowledge of the internal processes and between organisations as well as the demand on IT support. The challenge description exemplifies the strengths, values, limitations and gaps of the application of enterprise modelling to achieve and to support interoperability between companies and illustrates the required research topics.

- Interoperability driven by enterprise business models,
- Generic rules & services for model derived service environments,
- Interoperability of distributed enterprise models.

Usability of models

The knowledge expressed in models has to be integrated into the configuration of workflows, simulation and application products. To realise the integration between the models and the executed business processes, an interoperating middleware between them and the applications, the workflow and simulations is required. This will allow a real time reaction to business changes.

The evolution of legacy systems and the need to migrate to or co-exist with other applications cause the requirement for a new environment of applications, information sources etc. Issues with interoperability demand that ontologies are automatically produced from several independent unstructured information bases that can be used to carry out mappings and allow information merging or application interoperability.

Currently there are some methods being investigated but the resources and computational power needed would appear to be excessive and not practical to use in an operational scenario. An interactive enterprise to enterprise interoperation of business must be realised.

Cross organisational business processes:

This group is concerned with modelling and execution of cross-organizational business processes, i.e. business processes that cross multiple organisations. Modelling and execution of business processes have demonstrated their applicability within the boundaries of the enterprise. This concept could provide a significant opportunity in the cross-organisational context as well. It considers interoperability of enterprise systems at the business process level.

Agreements and Contracting

Interoperating systems within an organisation can occur without any form of governing agreement, but usually they require some form of Service Level Agreement (SLA) between departments, divisions or some form of organisational unit which states metrics for charging, and quality of service. When systems interoperate across organisations, contracts or Agreements are usually made containing some form of penalty clauses, or action to be taken when the contracted service is not provided – these may be supplemented by SLA providing the detail of the service quality agreed. Middleware mediated interoperability employing Web Services or the Grid which includes a management function can provide a mechanism to monitor SLA and enforce the contractual clauses to be applied when they are breached. Automatic monitoring of SLA and enforcement of contracts throughout a supply chain provides a rapid response to breaches of agreements which in turn fosters trust between organisations as well as identifying potential financial losses. Complete enforcement of all the terms and conditions in a contract is, as yet, infeasible, since it would require a machine understanding of legal obligations and legal interpretation which are not yet available. However, there may be a level of monitoring and enforcement which provides benefit in excess of the cost of implementing these management processes. The technical issues of representing and enforcing such SLA and contract conditions need to be resolved, to the level of methodologies for use, so that analyses can be made of the costs and benefits for different business situations to determine where the application of the technology is beneficial.

SME Situation Challenges

A main challenge regarding SMEs is to change the actual situation for interoperability of SME which is based on the force of the demand of large companies. In most cases, SMEs tackle interoperability only if they are “commercially motivated” by large customers. Therefore, it is just a reaction of a market situation and lags behind the technical evolution of the large market players. This has to be changed into proactive acting providing interoperability actively to many customers. Two main aspects are relevant for SMEs:

- Interoperability enabling cooperation between SMEs on demand (support of networking between SMEs) and
- Interoperability provided as market prerequisite for the cooperation with large companies (concurrent plug-in to different cooperation configurations).

Interoperability aspects of intercultural cooperation

Culture diversities are a barrier between organisations and national regions to become interoperable on the enterprise level. Industry has already bilateral business links and supply chains but the effort of making systems communicate with each other on an interregional and intercontinental level is all on the shoulders of these individual enterprises. The research agenda is somehow a bit behind in the aspect of supporting these supply and value chains.

Enterprises are confronted with cultural diversity when these enterprises become internationally active. Disregarding the cultural component in a situation of intercultural cooperation can and will lead to mistakes due to misunderstandings which are the result of differences in working practices, language and customs. Because of these cultural and national differences, an information system that

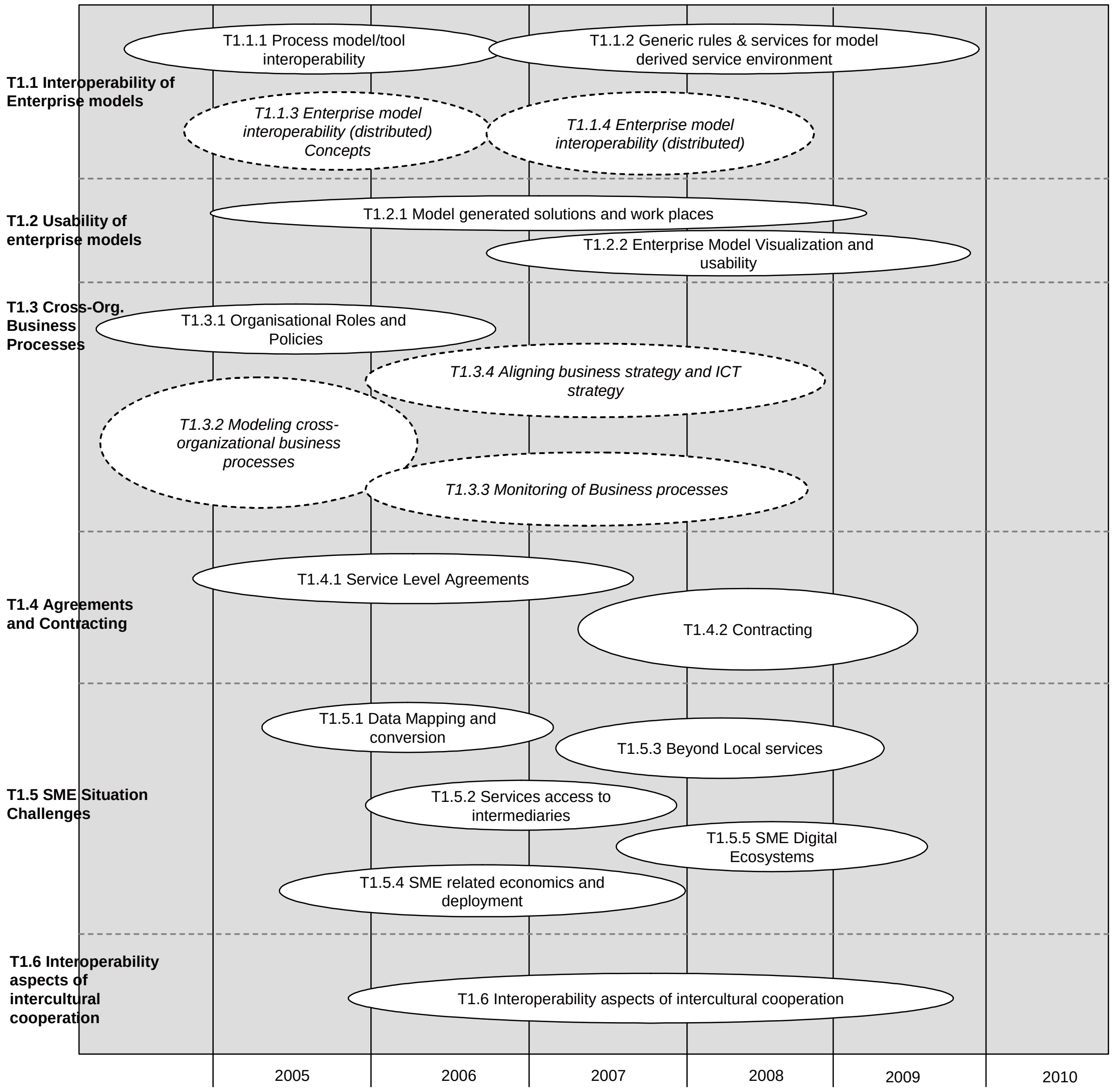

Figure 3 Enterprise (Business/Knowledge) area research challenges
(See Chapter 1 for an explanation of the figure)

works perfectly in one place may not work at all in another, or identical systems may find completely different uses in different situations. Hence, from a cultural stand point, avoiding these kinds of mistakes plays a very important role for the interoperability among Enterprises and the success of business.

Since communication, knowledge and culture are intimately connected with one another, intercultural communication has to be a part of the approach. Also from multicultural coexistence to intercultural cooperation, an information system platform for building and managing a multicultural working group is a great challenge. Based on this platform, the intercultural teamwork management could define the rules of team members' cooperation.

The vision is the availability of easy-to-use and open digital services for interregional collaboration, which bridge the intercultural and technological differences. Concepts should be developed to enhance the enterprise software application and business interoperability as well as to face the challenge of mutual intercultural understanding. An early starting point is already set by the DBE-IP developing an intercultural repository.

4.1. Interoperability of Enterprise models (T1.1)

4.1.1 Process Model/Tool Interoperability (T1.1.1)

Research challenge	Process Model/Tool Interoperability
Description	Process model interoperability enables connectivity and cooperation to perform tasks of a process model as they emerge, supported by a decentralised Intelligent Infrastructure. The infrastructure is given by the components of each single company creating a dynamic network. Networked organisations will be supported for defining and executing task and process as well by giving management views. Work in progress monitoring will be supported.
State-of-the-art	Today the current activities in the OMG (i.e. BPDM) and other organisations are focussing mainly on the computer execution oriented level. Parts are addressed also in the ISO 19440 but this is today not supported and accepted by the industry. ATHENA and INTEROP works on extensions of the UEML 1.0 meta model for process model exchange, and implement a methodology to apply exchange of process models taking into account the achievements of the other industrial oriented de facto standards (BPDM, BPMN). Connectors from visual process descriptions to task enactment support engines are partially in discussions in the OMG/MDA activities as well as in several other research and industrial groups. Three items are identified (1) the conceptual level but with interfaces to the execution levels, (2) interfaces from the conceptual level down to the specification of automated processes in order to allow a seamlessly transformation of conceptual models to execution models, (3) the support of conceptual process models for the orchestration of WEB services. These approaches have been started today.
Research Activity	The actual incompatibility of modelling tools in terms of languages and methodology needs to be bridged. Modelling is still a kind of craft (made by humans). Therefore, it is very difficult to work with models across organisations. New ways are necessary to allow connectivity between process models by developing patterns of process model fragments, procedures and methods for stepwise alignment of process models as well as design principles to ensure the reusability and interoperability of models.

4.1.2 Generic rules & services for model derived service environments (T1.1.2)

Research challenge	Generic rules & services for model derived service environments

Description	This challenge has a high relevance for SMEs to reduce the effort and costs for their involvement in networks and collaborations by finally archiving the technical foundation for a plug and work business environment for collaboration. Digital service environments should provide sets of methods and tools which are adaptable and configurable regarding individual business objectives. Semantic Frameworks and specifications should be provided for independent, decoupled services seamlessly incorporated by interoperability design principles/rules (see T1.1.1) of digital business service environments. A problem example could be the following description (following Issue 256 – Annex II): SME-related economic issues should also look at particular attractors and business drivers for SME involvement in networks and the possibilities for a gradual (or even viral) progress to interoperability. For example, an SME is persuaded of the benefits of X1, but the technology providing that also provides a Y2 capability that makes it easier (or even unavoidable) to move to X2 in the future. A current solution might be low cost access to VPN over P2P, which also implies implicit acceptance of some other things, e.g. standards and ways of working.
State-of-the-art	Standards for the description of web-services such as UDDI/WSDL exist and also the description of the process sequences with e.g. BPEL. Within the ATHENA-IP a concept has been developed called PIM4SOA. PIM4SOA aims to define platform neutral modelling be used to design, re-architect and integrate ICT infrastructure technologies supporting SOA. FP6 projects such as DBE (Digital Business Ecosystems) deal with the development of service ecosystems. These technologies are a starting point but a wider use in industry requires further consideration of the convergence of the existing technologies to achieve plug and work environments.
Research Activity	Design rules/principles, communication rules and standards needs to be developed to achieve “build-in” interoperability not only for IT system but also for enterprises/organisations on a holistic way incorporating all stakeholders internal as well external (e.g. government).

4.1.3 Enterprise Model Interoperability (distributed) – def. of problem / domain / prototype (T1.1.3)

Deleted due to ongoing work (e.g. in INTEROP).

4.1.4 Enterprise Model Interoperability (distributed) (T1.1.4)

Deleted due to ongoing work (e.g. in INTEROP).

4.2. Usability of Enterprise Models (T1.2)

4.2.1 Model generated solutions and work places (T1.2.1)

Research challenge	Model generated solutions and work places
Description	Enterprise collaboration exists progressively on demand and in a flexible way. So rigid solutions do not fit any more. On the other hand in and outside the enterprises exists different viewpoints to the same issue (the one mans floor is the other mans roof). So model generated workplaces can give the different actors in and between enterprises their view they need for performing the work based on one enterprise model. This will lead to less restricted work with much

	better capabilities for collaboration. Model generated workplaces, services and execution platforms for establishment collaborative on demand Extended Enterprises and Networked Organisations will support networked organisations, pursuing on-demand business opportunities, by enabling automatic workplace generation and providing adaptation, collaboration, management and other services.
State-of-the-art	Some single activities (e.g. VIENTO for negotiation) exist which address this topic partially. No clear distinction between execution and conceptual level leads to single integration activities (e.g. enterprise modelling and workflow management systems). ATHENA delivers support for dynamic dependencies between participants, dynamic on-demand business driven processes, situated knowledge and related organisation, product and system aspects. ATHENA defines new approaches for simple and value-driven user involvement in Enterprise Modelling, knowledge architecting, and model generated solutions. The challenge here is to support simultaneously conceptual enterprise model driven and execution oriented work. In the projects ATHENA and MAPPER, the concept of Model Generated Workplaces is taken into account. Nevertheless connecting "enterprise models" with "work models" in order to integrate conceptual and operational work is not enough.
Research Activity	The need is related to the following items: • qualification, selection and context sensitive provision of elaborated documents according to the model • synchronisation of conceptual and operational work • Integration and synchronisation of different kind of models (e.g. product model according to STEP AP214 and Enterprise models) GUI representation • Cross-organisational issues like flexible document hiding in collaborative environments.

4.2.2 Enterprise Model Visualization and usability (T1.2.2)

Research challenge	Enterprise Model Visualization and usability
Description	Currently enterprise modelling is a cost and time intensive activity and quite often still the models are not reused. This leads to a limited use of models even they are intended to be a prerequisite of optimisation and system implementation also across organisations. The models need to be interoperating with the different enterprise system in order to generate an actual representation of the situation and processes of the enterprise for all stakeholders. This will support semi-automatic self optimisation of the enterprise systems and business. This topic requires interoperability research between humans and enterprise modelling tools as well as interoperability between modelling tools and the enterprise systems.
State-of-the-art	Enterprise modelling in 2D and simple 3D via single user interfaces or WEB browsers are available. Embedding of other tools or viewers (e.g. VRML viewer) into enterprise models exists. Target and demand oriented generation of special WEB representations of the model content are offered by modelling tools. Solutions and views for integration of enterprise modelling into the entire company activities are still open questions (missing aspects –such as layout planning, views to aligning strategy and daily business etc.) Corporative modelling environments are still oriented to modelling experts. Easy usable environments (maybe game oriented) are missing.
Research Activity	New user modelling tool interaction within a distributed virtual environment to increase usability, performance and the use of models in the daily work. Models might be created and manipulated by speech, finger pointing, etc. (Human-

	System Interoperability). Modelling tools needs to be adapted to the human behaviour (Interoperable Learning Systems). The models will be integrated symbiotically within enterprises.

4.3. Cross-Organisational Business Processes (T1.3)

4.3.1 Organisational Roles and Policies (T1.3.1)

Research challenge	Organisational Roles and Policies
Description	This research challenge is twofold. It is concerned with the modelling of organisational roles and policies in cross-organisational settings when roles have to be interoperable or at least understandable to an external company. New organisational forms like Virtual Organisations, Extended Enterprises, Electronic Marketplaces and Value Chains require addressing the problem of dynamically changing responsibilities, authorisations and delegations of individual roles and also their relationships with other roles with which they collaborate – be that defined as part of their enterprise contract or the underlying cross-organisational business process.
State-of-the-art	The state of the art is characterised by systems that support static role and policy definitions. ATHENA aims at developing a precise framework for modelling enterprise roles and policies reflecting the requirements of new organisational forms.
Research Activity	Meta modelling based on deontic concepts of – for instance – delegation will enable the precise description of roles and policies. Real-time constraint satisfaction will enable policy conflict detection and resolution. Furthermore, advanced concepts such as dynamic role and policy definition and their influence on enterprise models and the execution of business processes need to be investigated.

4.3.2 Modelling Cross-Organizational Business Processes (T1.3.2)

Deleted due to ongoing work.

4.3.3 Monitoring of Business Processes (T1.3.3)

Deleted due to ongoing work.

4.3.4 Aligning business strategy and ICT strategy (T1.3.4)

Deleted due to ongoing work.

4.4. Agreements and Contracting (T1.4)

4.4.1 Service Level Agreements (T1.4.1)

Research challenge	Service Level Agreements
Description	Currently, there are no agreed representations to state policies, or metrics in Service Level Agreements between organisations in a machine understandable way. Without automated SLA monitoring then inter-company and even intra-company interoperability of services will not be able to be monitored for quality or

	time of delivery which will be required to generate any level of trust.
State-of-the-art	WSLA developed by IBM in April 2003 (http://www.research.ibm.com/wsla/) is the basis for all future developments. The TrustCoM project is developing an approach to SLA linked to BPM.
Research Activity	Languages need to be defined for policies and metrics that can be put into SLA. These could be linked to WS-Agreement as the most relevant existing specification.

4.4.2 Contracting (T1.4.2)

Research challenge	Contracting
Description	Legally binding contracts can be signed using electronic signatures, but the content of the contract is written in a natural language which is not understandable by machines. To facilitate technologically mediated VO, terms and conditions of contracts need to be monitored for conformance to facilitate trust between the parties, and trigger actions when they are breached.
State-of-the-art	There are XML templates for the natural language forms of contracts which are being standardised by OASIS in LegalXML but these only structure the natural language text. Full inference of the obligations from contracts is addressed by deontic logics but they have no tractable proof procedure. TrustCoM is starting to address this issue for VO, but not in a general way.
Research Activity	Languages are required to represent the terms and conditions in a machine understandable form which is verifiably compatible with the natural language text, and implementable in condition/action policy engines for monitoring.

4.5. SME Situation Challenges (T1.5)

4.5.1 Data Mapping and conversion (T1.5.1)

Research challenge	Data Mapping and conversion
Description	Data Mapping and conversion is concerned with the order information and engineering data being transferred between organisations. As the contracting organisations have different processes and systems, the information has to be changed to suit each enterprise. Being involved in the supply chains of multiple OEMs and the suppliers' information bases are all different and different to the SME he is obliged to convert commercial and skill information to Interoperate.
State-of-the-art	Systems are constantly being changed, getting more complicated, outdating previous data, despite standards. Also interpretation difficulties lead to specification contraventions. Systems used by SMEs are simple but mapping of reporting data up stream is incomplete, without manual intervention. Third party services are used to convert data and to provide tools to interface to the SME environment and address issues of trust where clusters are involved.
Research Activity	More significance has to be given to the manual interaction with the IT system according to the absence of complex IT support at SMEs. But also the minimisation of required interaction has to be focused by providing hidden background services from the web applications. Furthermore the user interface should be improved for non IT specialists and it should be a simple task inline with the workflow. So all mappings and conversations needs to be invisible like the "TCP/IP protocol stack" of the internet.

4.5.2 Services access to intermediaries (T1.5.2)

Research challenge	Service access to intermediaries
Description	When clusters of SMEs work together in a supply chain or as a group adding value to each others capabilities to increase their joint work loads or move up the value added chain, they require trusted services to Interoperate across their enterprises. These are generally supplied by third parties. Information passed between enterprises needs to be established and modelled in conjunction with a business model of each enterprise, to ensure that there is an awareness of risks involved. A model is also needed to represent the cluster to interoperate with the individual enterprise models. These need third parties to address trust and privacy issues raised by interoperability.
State-of-the-art	The INTEROP cube showed that most SMEs are contract based supplying to specification. There are a few that form clusters but they vary in form. Most that truly exchange information does it through a third party, due to lack of understanding and trust.
Research Activity	Development of third party services for trust and privacy issues raised by interoperability in relation with interoperability requirements and service offers. This covers cluster models taken into account possibilities (cost, time, and resources), worries and reservations (trust, education …) of SMEs.

4.5.3 Beyond Local services (T1.5.3)

Research challenge	Beyond Local Services
Description	Services will be developed to produce an unbiased mediation/ consultancy service intermediary, providing general services to SMEs, thereby avoiding problems of trust, confidentiality and the need to have an in depth knowledge of IT. These will communicate with trading portals and as well as enhanced back office systems The increase in use of e-Business portals in the pursuance of business and the need to provide more timely information to the customers and suppliers means that the whole nature of inter- enterprise interoperability will move up a level of sophistication and the systems nearer to real time operation.
State-of-the-art	Large OEMs are spending M€ to achieve these objectives utilising EAI technologies, shared data environments and trading portals. These are far beyond the reach of SMEs.
Research Activity	The enhancement of the intermediary approach needs to be examined with respect to the provision of regional and national facilities that work in tandem with e-Government.

4.5.4 SME related economics and deployment (T1.5.4)

Research challenge	SME related economic and deployment
Description	There is a need to be able to determine the impact of change on the business when applying new working practices. This risk analysis needs the development of models based on economics and can be used to justify change. This is particularly true when interoperability costs can be greater than the benefits received.
State-of-the-art	No known work in the area outside of the military and work on value chains. The later is mainly targeted at 'Cost out' scenarios
Research Activity	Cost and risk modelling should be an integral part of interoperability analysis

	when determining the information exchange between enterprises. This is also related to the identification of the value of knowledge and IPR

4.5.5 SME Digital Ecosystems (T1.5.5)

Research challenge	SME Digital Ecosystems
Description	This is concerned with the development of highly interactive relationships in a network of businesses. The ability to form relationships and intertrade in real time contributing to multiple product demands. Based on GRID technologies of computing and information coupled with trading portals. This network will trade in services and production.
State-of-the-art	Modular information and computing technologies based on KBE technologies utilising immersive human involvement are being worked on as islands of interest. The interoperability with the human is needed to be successful.
Research Activity	This real time scenario will require high degrees of interoperability across many skills, necessary to ensure the right business decisions are made.

4.6. Interoperability aspects of intercultural cooperation (T1.6)

Research challenge	Interoperability aspects of intercultural cooperation (Cultural Interoperability)
Description	Globally distributed collaborations raise the importance of cultural diversities as interoperability barrier to a greater extent. Culture gaps or barriers are exemplified by different working styles, different interpretations of words, different perspectives concerning work management and work execution (e.g. by information hiding). A lot of shortcomings of not managing intercultural gaps are e.g. malfunctions of the common solutions, extended project duration as well as misuse of services and tools. Large companies might react by setting-up subsidiaries around the world. But also between these subsidiaries culture difference has to be taken into account for collaboration establishment. An environment is required to develop common business concepts and reduce the culture gaps by improving the communication and understanding. The improved understanding will result in increasing the market opportunities, improved learning from each other and more effective work load balancing.
State-of-the-art	Only few enterprises are well prepared for the cultural diversity of the global market. Many enterprise ventures fail not due to market opportunities, but due to a lack of intercultural competence. An example is the software development in so called low cost countries such as India. Only few companies succeeded in establishing a stable relationship. Another example is that Northern Europe is more on the deal-focused end and Asian cultures are on the opposing, relationship-focused end. The culture challenge is currently addressed by projects such as IST DBE-IP dealing with the culture shift regarding the internet and new economy as well as culture challenges of SMEs. But culture as barrier for enterprise interoperability is not addressed.
Research Activity	Rules and concepts should be developed how to build services and information systems that could cope with the culture differences. An environment for building and managing a multicultural enterprise cluster is a great challenge. Based on this environment, the intercultural teamwork management could define the rules of team members' cooperation. "Best Practices, Constraints of intercultural Collaboration, Requirements for different kind of scenarios" might result in a Intercultural Collaboration Framework

5. ICT Systems and Architecture & Platform research challenges (T2)

The ICT Systems and Architecture & Platform (A&P) area focuses on the ICT solutions that allow an enterprise to operate, make decisions, exchange information within and outside its boundaries, and so on. Software applications have demonstrated lately that they are becoming a critical source of rigidity, both internally and externally. That is, internally due to a certain resistance of software applications to evolve as required by a dynamic enterprise, and externally due to differences with other organisations the enterprise want to cooperate with. Such differences are difficult, expensive and time-consuming to bridge. Today, several technologies emerge or consolidate (from XML to Web Services, from search engines to ontologies). Software components are a long-awaited approach to application development that, with Web Services, is gaining momentum; enhanced search engines will support the discovery of web services over the Net and new technologies, such as WSDL, allow including a software service, developed and deployed elsewhere, in a specific application. The overall execution of the enterprise application will be orchestrated by the business process model identified in the enterprise view and formally (i.e., unambiguously) represented and stored in the ICT view. The ICT Systems include the IT architecture and supporting platforms (A&P). Interoperability at ICT Systems level should be seen as the ability of an enterprise's ICT systems to cooperate with those of other, external organisations. It is concerned with the usage of ICT to provide interoperation between enterprise resources. Cooperation between humans, machines and software programs has to be established by the supply of information through inter- and intra-system communication.

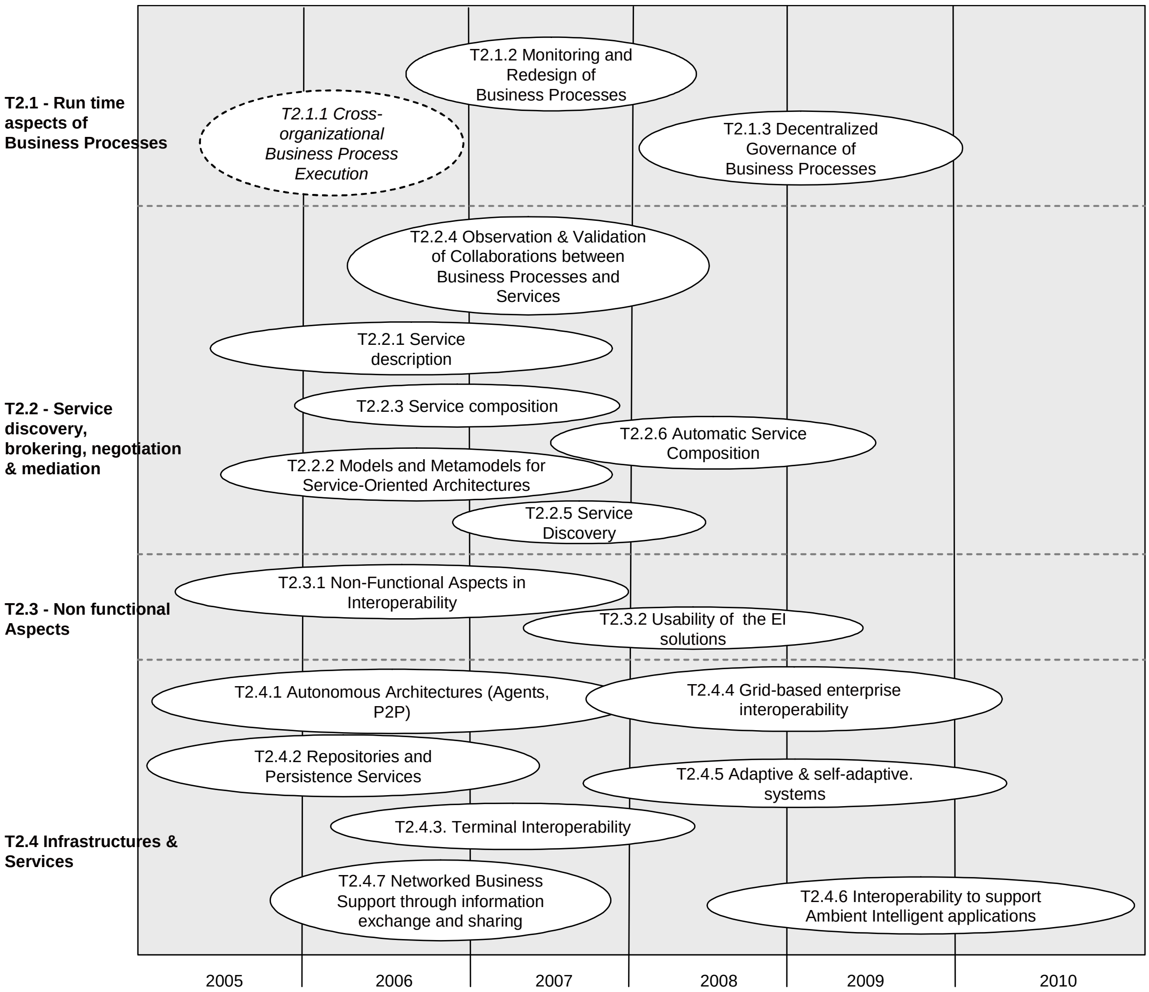

Figure 4 ICT Systems and A&P research challenges
(See Chapter 1 for an explanation of the figure)

In the following, the different ICT Systems and A&P research challenges are described.

5.1. Run time aspects of Business Processes (T2.1)

Business Processes have shown their importance and applicability in organisations' internal automation. An important challenge is now to apply this technology for cross-organisational settings. Research Challenges on modelling aspects for these Business Processes are discussed in section 6 of this document. The research challenges in this section are concerned with runtime and execution aspects of these Business Processes.

5.1.1 Cross-Organizational Business Process Execution (T2.1.1)

Deleted due to ongoing work.

5.1.2 Monitoring and Redesign of Business Processes (T2.1.2)

Research challenge	Monitoring and Redesign of Business Processes
Description	Monitoring Business Processes shall provide transparency of the processes operability and performance. Consequently, monitoring is a subject of Performance Management, and raises the need to acquire, integrate, and analyze performance data from distant entities in a networked environment. Performance data provides input for redesigning processes in case of defects in performance. In distributed business environments, efficient process monitoring depends on the interoperability of the entities' internal information systems. Application of standardized process models and interfaces bridging the gaps between local information systems involved are inevitable in this context.
State-of-the-art	Solutions in interoperability in monitoring and reengineering business are scarce, though presently emerging. Problems to be covered comprise (not exhaustively) harmonization of process monitoring systems, data integration, trust establishment, etcetera. Existing standards such as ebXML do not fully address these issues and must be enhanced.
Research Activity	Development of approaches to monitor the distributed execution of processes by providing information about the state of the processes whilst keeping information about internal process execution private. Redesign of cross-organizational business processes requires a collaborative analysis and modelling effort. An appropriate approach has to be developed. In distributed business environments, efficient process monitoring depends on the interoperability of the entities' internal information systems. Application of standardized process models and interfaces bridging the gaps between local information systems involved are inevitable in this context. Problems to be covered comprise (not exhaustively) harmonization of process monitoring systems, data integration, trust establishment, etcetera.

5.1.3 Decentralized Governance of Business Processes (T2.1.3)

Research challenge	Decentralized Governance of Business Processes
Description	In business networks, governance of processes comprises principles in allocating rights and obligations among the partnering entities, such as mechanisms and directives for operating these processes. Governance of distributed business process requires exchange of a broad variety of data between the collaborating entities facilitated by support of Information and Communication Technologies. Crucial functionalities are data integration from different local information systems, common infrastructures, and application of standards in that field.
State-of-the-art	Efficiency state-of-the-art solutions in ICT support in governing decentralized business environments depends upon the stability of the underlying business environment. Especially in emerging dynamic environments (Collaborative

	Networked Organizations) solutions enabling interoperability are only emerging, and standardization frameworks are evolving. The area of BAM, Business Activity Monitoring, can provide a foundation for further work in this area – in particular through the relationships between multiple instances of these for instance for each of the organisations involved in a virtual enterprise.
Research Activity	Efficient decentralized governance of business processes inevitably requires integrated ICT infrastructures and interoperable services, tools, and applications. Based on BAM, solutions can be found through the relationships between multiple instances of these for instance for each of the organisations involved in a virtual enterprise. Research includes the definition of approaches to gather the necessary information to control and govern processes across organisational boundaries. Consolidation and integration of the information is necessary to provide a sound basis for any governance operations.

5.2. Service discovery, brokering, negotiation & mediation (T2.2)

A major driver for enterprise applications are service architectures. Basic technology and standards for service architectures (e.g. SOAP, WSDL, and BPEL) are available and used. Service Architectures promise loose coupling of application components and the flexible reuse and adaptation of existing components and architectures to new demands. To turn this vision into reality, enhanced functionality is required, including improved Service Descriptions that go beyond traditional syntactical issues. Models and Meta-models that enable service descriptions independently from the concrete realisation, flexible and user-supported Service composition as well as a better understanding of the link between Business Processes and Services.

5.2.1 Service description (T2.2.1)

Research challenge	Service Description
Description	Standardised machine-processable descriptions of services today only address syntactical issues: they describe how to create and send a message that a service can process, and how to understand the response message that the service provider sends back to the service consumer. However, these solutions fall short of explaining what the semantics of the messages are.
State-of-the-art	Services today are described using WSDL files, sometimes complemented by WS-Policy descriptions, but this is still only a technical description of the service. Many ontology-based solutions have been proposed, but none has made it so far past the stage of research project.
Research Activity	Raising the level of abstraction of service descriptions from IT-level to business-level is how we could achieve better service discovery and substitutability. However, ontology-based solutions need not be the only option investigated to reach this goal. The recent success (in the context of Web applications) of simpler solutions based on the use of simple keywords (also known as tags) and ontologies inferred from the use of these tagging mechanisms by non-experts (folksnonomies) would be worth being investigated.

5.2.2 Models and Meta-models for Service-Oriented Architectures (T2.2.2)

Research challenge	Models and Meta-models for Service-Oriented Architectures
Description	The Model Driven Architecture (MDA) approach is promising for the support of Interoperability, because of the possibility to model consistently at different abstraction levels, with well-defined mappings between them. For service-

	oriented architectures, this provides a possibility for platform-independent specifications, which can map to multiple platforms and various service-oriented architecture representations/implementations for the same service. Application of MDA and similar technologies towards Interoperability in general and service-oriented and autonomous architectures and business process management in particular, including adoption and enhancements of standards and open source tools.
State-of-the-art	The OMG MDA approach is now defined and available. Individual models and meta-models are available. Interlinking of these models, transformations of models are insufficient.
Research Activity	Significant research is required to fully demonstrate the value of MDA. Building models and meta-models does not deliver value as such, only model transformations do, and that is where MDA applied to SOA is lacking at the moment. Research is also required to make the MDA-based modelling tools as easy to use as the more ad-hoc modelling tools used today.

5.2.3 Service composition (T2.2.3)

Research challenge	Service Composition
Description	The true value of Web services (just like in the real service economy) lies in being able to re-use and assemble existing services for new purposes, creating added value in the process. Service composition is difficult because it assumes that one can find services at design-time in the first place, and manage the composed services at run-time in order to deliver a given quality of service, even though not all services are under the control of the actor who provides the service composition.
State-of-the-art	BPEL is a technical standard for composing services according to business processes. However, it is not expressive enough for some service compositions and only addresses the problem from a technical perspective.
Research Activity	Work is required on service composition at the business level, which can later be translated, either automatically or semi-automatically, into technical-level artefacts such as BPEL models. Issues of security, trust and distributed monitoring in service compositions need to be addressed as well in the context of collaborative business processes.

5.2.4 Observation & Validation of Collaborations between Business Processes and Services (T2.2.4)

Research challenge	Observation & Validation of Collaborations between Business Processes and Services
Description	This research challenge is concerned with the observation and validation of (cross-organizational) collaborations and behaviour of involved partners. This is achieved by focussing on the observable behaviour of the partners, processes, and services which take part in the collaboration. The goal is to have an integrated perspective on related areas such as monitoring, validating CBPs through simulation, interoperability for emergent behaviour and self-organizing systems and model driven approach for an observation model.
State-of-the-art	Modelling, simulating and executing business processes have demonstrated their applicability within the boundaries of the enterprise. Service oriented architectures emerge as a foundational approach for developing business systems of loosely coupled services that interact to realize (potentially cross-organisational) business processes.

Research Activity	Taking observation and validation to the scale of cross-organizational business processes will require work that fundamentally reconsiders the premises of research on the topic conducted within the borders of one single company. In particular, issues of fault tolerance (how useful and accurate does the monitoring information become in the presence of one or more faulty participants?) and trust (can all the parties be trusted to implement their part of the collaboration and report on it in a trustworthy manner?) need to be addressed. Validation of collaborations encompasses for example adherence of partner behaviour to the expected observable behaviour in the specification of the collaboration. It also includes validation of the soundness and consistency of the collaboration itself. Validation may be achieved either through formal verification or experimentally – based on simulation and observation.

5.2.5 Service Discovery (T2.2.5)

Research challenge	Service Discovery
Description	Service discovery is about locating existing services by querying for their expected functionalities, and as such is the starting point of most service architectures. Brokering, Negotiation and mediation are the bricks we need to make Service-Oriented Architectures robust. Brokering provides the ability to present a single façade for a number of providers of similar services. Negotiation is about a service consumer and a service provider agreeing on the terms of the service consumption, i.e. the technical equivalent of a commercial contract for the consumption of a service. Mediation is a about converting between data formats and protocols that are syntactically different but however have close enough same semantics.
State-of-the-art	UDDI is not used, so discovery as such does not exist. Brokering is difficult because it requires mediation and negotiation. Technical solutions for negotiation exist and are commercialised, but not used on a large scale. Mediation is making progress, but it is still a rather manual task.
Research Activity	All these challenges are the oil in the cogs of the SOA machine. Without them, all service architectures will remain brittle and SOA will never deliver on its promises. In contrast with previous research, more focused research is required in order to address the less ambitious research goals of semi-automatic service discovery. An approach based on the electronic exchange of good practices between SOA builders, as opposed to grandiose goals of automatic service discovery, could be explored.

5.2.6 Automatic Service Composition (T2.2.6)

Research challenge	**Automatic Service Composition**
Description	The true value of services lies in being able to re-use and assemble existing services for new purposes, creating added value in the process. Service composition is difficult because it assumes that one can find services at design-time in the first place, and manage the composed services at runtime in order to deliver a given quality of service, even though not all services are under the control of the actor who provides the service composition. Automatic / semi-automatic service composition can play an important role where service enabled organisations collaborate in a very dynamic environment. Especially where large numbers of partners or service providers have to be coordinated, a manual approach to service composition will reach its limit.
State-of-the-art	Current approaches focus on manual assembly of services into processes / compositions. Descriptions of services are not sufficiently rich to enable automatic / semi-automatic service composition.

Research Activity	Research is required in order to understand how to first achieve manual service composition (still plagued with lots of interoperability issues at the technical level) and semi-automatic service composition before we start considering automatic service composition. If automatic service composition is to be addressed, an interesting research approach would be to combine metadata-based information (service description for example) with feedback from experience, i.e. how well or how many services are used in practice. Automatic / semi-automatic service composition can play an important role where service enabled organisations collaborate in a very dynamic environment. Especially where large numbers of partners or service providers have to be coordinated a manual approach to service composition will reach its limit. Automatic / semi-automatic service composition requires rich, potentially semantically enhanced service descriptions that provide a deep understanding of the functionality. Reasoning using these descriptions promises to support automatic / user-supported composition of these services.

5.3. Non-functional Aspects (T2.3)

Non-functional aspects arise on most sections in this document. Non-functional aspects in this section on ICT research challenges have to do with the technical description and enforcement of these aspects. Another important issue is the usability of solutions for enterprise interoperability. Usability will become a major topic when knowledge and technology has stabilized and need to be made available to industry users. In that sense it is more a medium term issue.

5.3.1 Non-Functional Aspects in Interoperability (T2.3.1)

Research challenge	Non-Functional Aspects in Interoperability
Description	Several key issues related to Interoperability stem from non-functional aspects. They are traditionally introduced for separation of concerns between the main behaviour of an enterprise (functionality) and the supporting technologies and issues causing alternation of the functional behaviour. Common examples of non-functional aspects include quality of service and security, business value, etc. These need to be carefully addressed from a business and strategic standpoint. They have a significant impact on corporate governance and compliance, and are, as a result, of strategic nature within the corporate environment. However, this impact requires us to take a step back and consider their functional implications, in particular considering Enterprise Modelling, Ontologies and Architectures & Platforms.
State-of-the-art	Traditionally non-functional aspects have been seen as Quality-of-Service (QoS) attributes closely related to performance. There is large amount of work on QoS in the context of networking and networking protocols. Lifting QoS to enterprise applications beyond traditional applications in multimedia is an open issue. Work has been carried out e.g. in the TrustCoM project to formalize and model trust and enforce it on a business process level. SLAs are used to represent Trust aspects.
Research Activity	This proposal aims to put right the lack of knowledge about how these strategic issues affect interoperability, and to create approaches and methodologies for their formalization, design, evolution and execution.

5.3.2 Usability of the EI solutions (T2.3.2)

Research challenge	Usability of the EI solutions
Description	The technical solution developed for Enterprise Interoperability will meet the

	technical requirements, but there is no evidence that it will be usable by the appropriate individuals in an enterprise.
State-of-the-art	Specialized tools for tasks in Enterprise Interoperability are available. It can be seen that often these tools are provided by developers for developers addressing a very technical level requiring detailed technical know how in order to use them. On the other side there are very expressive business level tools available that miss the formality needed by IT architects or developers. The expressiveness that is good for documentation purposes prohibits preciseness needed for processing on the technical level.
Research Activity	Generic HCI techniques will be applied to enterprise interoperability systems that do not yet exist. It is necessary to define the various users of the tools in enterprises, undertake task analyses of their roles, define the knowledge requirements to use the tools in each role; design training and help systems to bridge the gap between the skills of those individuals within their organisations and those required to fulfil their roles; undertake diagnostic evaluation of the tools in an enterprise with users who have undertaken training and are supported by help systems. Provide modifications to the overall interoperability tools and the organisational structures on the basis of the evaluation; re-test the modified systems until no significant errors or delays occur for the user population.

5.4. Infrastructures & Services (T2.4)

In the infrastructures for ICT Systems we can observe two major strands of activities:

- Infrastructures and services that support high levels of flexibility using autonomous architectures, Grids, and adaptive systems
- Business IT-System architectures driven by the needs of common enterprise interaction patterns like the sharing of information which can be e.g. observed in Collaborative Product Design or the exchange of information which can be observed in Procurement scenarios.

A relevant and important infrastructure service to support both strands of applications are rich, semantically enhanced, and scalable Repository infrastructures for persistency and interlinking of models representing the different views of a collaborating organisation.

5.4.1 Autonomous Architectures (Agents, P2P) (T2.4.1)

Research challenge	Autonomous Architectures
Description	Software systems of today are often modularised for ease of construction, reuse and maintenance. The structure and relationships between modules characterise the architecture of the particular software system, for example a client-server architecture, or the n-tier architecture common to eBusiness applications. Two emergent architectures are based on autonomous distributed modules: those behind agent-based systems and peer-to-peer (P2P) systems. *P2P systems* are based on equal peer nodes that are both "clients" and "servers" to each other. The Grid is a P2P system, which allows software to be submitted for remote execution in addition to sharing data. *Agent systems* extend the metaphor of peer nodes to a society of collaborating agents. Agents can theoretically be human or software; in practice agent systems often signify a set of software agents. Software agents employ sophisticated communication protocols where the intent of the communication act is explicitly declared (for example FIPA's ACL). They are perceived as being able to act in an autonomous fashion in pursuit of internal goals, and to apply automatic reasoning, these agents are referred to "intelligent software agents". Intelligent software agents are often seen as a metaphor which is particularly suitable for building software to supporting collaborating organizations, where each agent can represent the interests of individual organization. This is also

	possible on sub-organizational level, with agents representing departments, people, machines and even goods being processed on the assembly line. The powerful mechanisms of inter-agent communication, including the use of explicit message intent and formalised ontologies can then be used to achieve semantic interoperability in a (potentially) automated fashion. The goal-driven nature of agents can facilitate negotiation of common goals leading to flexible collaboration and service composition, in other words to interoperability at process and business levels.
State-of-the-art	Industrial applications of agents in inter-organisational context are comparatively rare, with the most frequently cited example of Daimler-Chrysler's use of agents being internal to a company unit. Re-dressing this has been the aim of the EC-funded project AgentCities, who established a global platform of interoperating agent systems, and run examples of distributed collaborative services.
Research Activity	Software agents can be used to achieve the goal-driven formation of both a task-focused team and its workflow, making use of agents' deliberative reasoning and goal-driven behaviour to achieve interoperability at both the process level (forming a collaborative cross-organisational process) and at semantic level (using agents' reasoning and communication mechanisms to ensure shared understanding). A standard process modelling framework, for example based on Petri Nets formalism, can provide the formal basis needed to enable reasoning and predictive analysis regarding consistency of collaborative processes.

5.4.2 Repositories and Persistence Services (T2.4.2)

Research challenge	Repositories and Persistence Services
Description	The use of models on different abstraction levels, like Enterprise/CIM, platform independent/PIM and platform specific, both internally and externally, provides a multitude of requirements to repositories and persistence services. Research and Scenarios show that it is close to impossible to find only one repository or persistence service that meets all needs, but instead also here to accept the situation of heterogeneity – and to instead support interaction and interoperability between repositories.
State-of-the-art	MOF Repositories providing an infrastructure for models and meta-models. Independent Semantics Repositories with only one-way integration with Model/Meta-model repositories. Furthermore, ebXML Registries and UDDI provide registry functionally. Insufficient performance of repositories in enterprise scale environments.
Research Activity	To provide appropriate abstractions to existing repositories enabling the handling of heterogeneous repository infrastructures. Further activities include integration of semantic descriptions into repositories, and meta-models for repositories supporting model persistence, query and transformation. Realize industry strength and scalable infrastructure for distributed repositories. Models and meta-models describing systems and applications need to be stored and made persistent. Model-Driven Interoperability requires scalable, rich and integrated repositories to provide an industry strength infrastructure for model persistence, query and transformation.

5.4.3 Terminal Interoperability (T2.4.3)

Research challenge	Terminal Interoperability
Description	The goal of Terminal interoperability is to offer to any user, the connectivity to any Terminal, on any network, with any content, in a multimodal approach. Concrete research topics include the adaptation of content to the capabilities of the

	terminal, adaptation to the users needs, context, and location, using the most appropriate network.
State-of-the-art	As the wireless network technologies predominate on the mobile devices market, offering mobility to the final user, it is needed to know the standards, the protocols and the services available in the wireless world in order to facilitate the integration with the traditional network technologies and standards. A multitude of standards, service protocols and technologies are available for the development of applications in the Terminal Interoperability scope: IEEE 802.11, Bluetooth, WAP, I-mode, SMS, MMS, portlets, location-based Services, and Wireless Wide Area Networks. Seamless integration of technologies and standards on client and server side is still insufficient.
Research Activity	Understand the user's requirements for adaptable user interfaces. Provide abstractions to the underlying network technology that allows the systems to detect changes in context and adapt by e.g. changing the network protocol.

5.4.4 Grid-based enterprise interoperability (T2.4.4)

Research challenge	Grid-based enterprise interoperability
Description	Service Oriented Architectures operated over the Grid or Web Services provide the opportunity to manage interoperable services within and between enterprises within a single architecture where commodity components can be provided competitively from different suppliers.
State-of-the-art	In the Web Services and Grid stack, the communication level up to service description through WSDL is agreed as international standards, the discovery, negotiation activities are exemplified without QoS and contractual issues, but not agreed; the co-ordination activity is agreed for simple orchestration and under standardisation for choreography without non-functional requirements; a basic security mechanism is agreed; most of the management activities are still at the research stage. There are no studies of Grid based systems in use in business that evaluate the costs and benefits compared to different business models.
Research Activity	To integrate the advances in SOA management into the Grid architecture and specifications.

5.4.5 Adaptive & self-adaptive systems (T2.4.5)

Research challenge	Adaptive & self-adaptive systems
Description	In evolving environment it is important for the systems involved to be able to detect changes and to adapt to these.
State-of-the-art	Systems that can easily be adapted, or that manage their adaptations themselves are an important current research topic. Some support is starting to be commercially available through systems management technologies; self-configuration and self-management are key enablers towards fully autonomic computing.
Research Activity	With a continuously increasing number of systems, it becomes necessary to find efficient solutions for the automatic handling of configuration and adaptation to changes. It is a goal to extend technologies in this area from the support of lower level system management (i.e. through DMTF and similar) to support similar flexibility for the adaptation of systems on the service interface and process support level.

5.4.6 Interoperability to support Ambient Intelligent applications (T2.4.6)

Research challenge	Interoperability to support Ambient Intelligent applications
Description	There is an emerging trend to include more autonomous devices and interfaces into business ecosystems – with enabling technologies such as autonomous devices (i.e. RFID) and agents etc.
State-of-the-art	The area of Ambient Intelligence has been a focus area within EU in the last few years, and there is now an interesting foundation here for further integration in the infrastructure of business ecosystems.
Research Activity	Specific research activities will include a method to represent autonomous devices in existing enterprise systems in order to make the enterprise systems aware of devices and enable their inclusion in Business Processes. Scalable infrastructures will be required as large amounts of devices are expected to be around.

5.4.7 Networked Business Support through information exchange and sharing (T2.4.7)

Research challenge	Networked Business Support through information / (document) exchange and information sharing
Description	Collaboration and interaction between networked businesses can take place using different technology approaches. The focus can be on interchange of information, in forms of formal documents or electronic models, or on collaborative work around shared workspaces. Interchange implies the availability of a comprehensive modelling approach for documents and document models and (semi-)automated mapping and semantics-based transformation mechanisms.
State-of-the-art	The state of the art in the interchange area is characterized by document standards defined in technical specifications. Transformation and mapping is typically supported in a point-to-point fashion without using e.g. semantic information.
Research Activity	Definition of a holistic approach to interoperability to support both forms, namely interchange and collaboration. However, they can be addressed also somewhat independently of each other.

5.5. Supplementary research challenges (T2.5)

5.5.1 Providing role and context based privacy in eBusiness (T2.5.1)

See Annex II, Issue 16.

Research challenge	Providing role and context based privacy in eBusiness
Description	There are some important considerations in developing privacy mechanisms for eBusiness: Only the minimal pertinent information should be provided. Another critical issue is not to overwhelm the users while declaring their privacy preferences. Indeed declaring privacy preferences on the basis of service instances may be quite cumbersome and sometimes even not possible. A user may not in advance know which service she will need. Determining whether the data requested by a Web service violates user's privacy preferences should be automatic. More importantly, in addition to protecting the privacy of data provided by the service consumer, that the current efforts address, there is a need for mechanisms for protecting the privacy of data being accessed.

State-of-the-art	In EU data privacy, namely the right to self-determine the disclosure of personal information in addition to the general principles of processing of personal data is ruled by the EU Directive 95/46/EC[3]. The supplementary Directive 2002/58/EC[4] concerns the processing of personal data in the electronic communication sector. The privacy mechanisms to be developed must be consistent with these directives. The Platform for Privacy Preferences Project (P3P) developed by the World Wide Web Consortium, is an industry standard providing a simple, automated way for users to gain more control over the use of personal information on Web sites they visit. At its most basic level, P3P is a standardized set of multiple-choice questions, covering all the major aspects of a Web site's privacy policies. Obviously, this is not adequate for the privacy of dynamic exchange of data in eBusiness. Furthermore, P3P concentrates on the privacy of the person accessing the data, not on the privacy of the data being accessed. Furthermore, current identity based privacy mechanisms should be extended based on roles because in enterprises, the roles are as important as personal identification.
Research Activity	Developing a context and role based privacy mechanisms for eBusiness

5.5.2 Intelligent Collaborative Planning on the Supply Chain based on Smart Products (T2.5.2)

See Annex II, Issue 17.

Research challenge	Intelligent Collaborative Planning on the Supply Chain based on Smart Products
Description	The smart tags of products together with the agent technology and semantic interoperability of planning data seem to provide opportunities for intelligent supply chain processes.
State-of-the-art	The smart tag technology is improving. The “Collaborative Planning, Forecasting, and Replenishment (CPFR)” guidelines have been developed. Agent technologies as well as semantic mediation technologies are maturing.
Research Activity	Intelligent collaborative supply chain processes exploiting smart products and semantic interoperability

[3] http://ec.europa.eu/justice_home/fsj/privacy/
[4] http://europa.eu.int/eur-lex/pri/en/oj/dat/2002/l_201/l_20120020731en00370047.pdf

6. Methodology Research Challenges (T3)

The **Methodology research domain** area focuses on a holistic approach to develop interoperability, incorporating the understanding and usage of problems and solutions from the previous three areas. Indeed there are different ways to follow to develop interoperability for different purposes and in different contexts. The chapter aims to identify those methodology research topics.

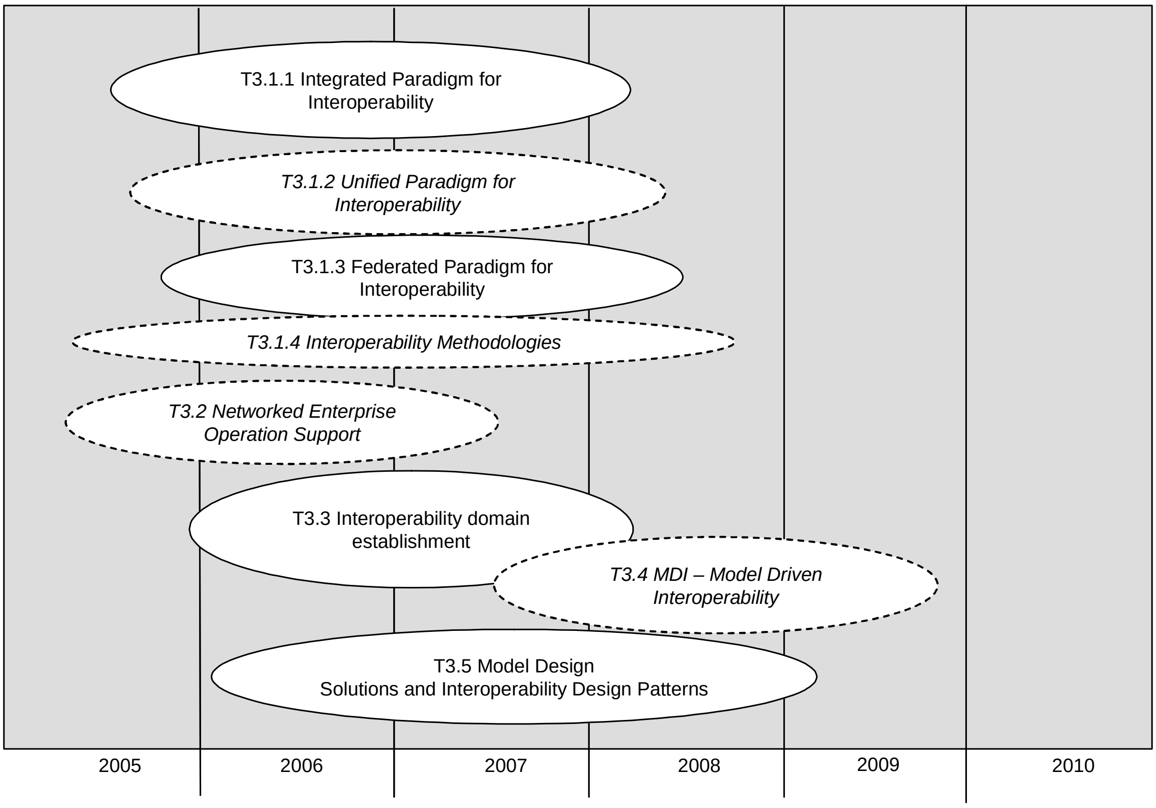

Figure 5 Methodology research challenges
(See Chapter 1 for an explanation of the figure)

In the following, the different methodology and framework research challenges are described.

6.1. Interoperability Frameworks and Architectures (T3.1)

A number of different approaches exist in order to structure more holistic approaches to interoperability. Generally speaking, establishing interoperability means to relate systems together so that they exchange information and services. It is necessary to define a framework by integration, by unification or by federation. We must notice that a framework is just an organising mechanism aiming to structuring concepts and things in a domain. A framework is not an executable entity and does not represent any operational system. Moreover, an interoperability methodology is needed to provide a structured approach showing how to establish interoperability in an organised way.

6.1.1 Integrated Paradigm for Interoperability (T3.1.1)

Research challenge	Integrated Paradigm for Interoperability (T3.1.1)
Description	With *integrated* models the assumption is that there is a *common model form*. Diverse models are built and interpreted using/against the common template. Common or reference models must be as rich as the constituent models. All models can be stored in standard form with information filtered or translated *by*

	the applications. Alternatively, standard models can be agreed to by constituent model owners, as in STEP or ebXML. It is important to note that this common format is not necessarily a standard recognised as such (for example ISO standard). The key issue here is to agree on a common format between systems which want to interoperate.
State-of-the-art	There are enormous difficulties associated with standardizing large numbers of models. Therefore, the ability to deal with something less than integrated models is most certainly necessary. In enterprise modelling area, some standards have been elaborated but they are not mature. They are not well known in industry and not used as such (for example EN/ISO 19439, EN/ISO 19440)
Research Activity	This research will cover the conceptual, applicative and technical layers of interoperability by producing a reference model and methodology, some guidelines and best practices and finally a technical architecture and tools to support it. Some research is still needed to develop better standards acceptable by industry.

Note: The Integrated Paradigm is more oriented to total integration rather than full interoperability. This paradigm is more useful in intra-organisational environments or in the case of company mergers and restructurings.

6.1.2 Unified Paradigm for Interoperability (T3.1.2)

Deleted due to ongoing work.

6.1.3 Federated Paradigm for Interoperability (T3.1.3)

Research challenge	Federated Paradigm Interoperability Infrastructure
Description	This research challenge is currently focused on the design and implementation of the infrastructure supporting interoperability in scenarios adopting the Federated Paradigm (i.e. a multitude of formats for all constituent subsystems is available). The federated model scenario exists if one assumes that no agent successfully or globally can impose requirements for semantic equivalence across all models of a network of enterprises. Models must be taken as encountered. The template is at the meta level and, as in the unified situation, the template is not executable. Interoperability requires that models be *dynamically accommodated* rather than having a predetermined meta-model. This would be furthered with some sort of predetermined terminology system. In a standard that states rules for enterprise network models, where model interoperability is important, the assumption is that the federated situation exists and that the *rules* presented in the standard shall be rich enough to *accommodate the encountered models*, whatever the state.
State-of-the-art	Current solutions for the infrastructure supporting the Federated Paradigm are limited to the information layer and do not address the compound interactions of the business layers of the participating entities. There is no available mature solution in this area.
Research Activity	Main research is the development of a “mapping factory” which will generate on demand customised AAA (Anybody-Anywhere-Anytime) mapping agents among existing state-of-the-art interoperability architectures, enterprise semantics, and models derived from the Enterprise Intelligent Infrastructures of the organisations involved. The proposed contribution intends to overcome multilingual and multicultural barriers, to adaptively and proactively react to changes in the surrounding environment (Ambient Intelligence), and to behave and to negotiate intelligently according to knowledge-based policies and rules.

Note: The federated paradigm aims to develop full interoperability and is particularly suitable for an inter-organisational environment (such as networked enterprises, virtual enterprises, etc.). It is also the most challenging research area.

6.1.4 Interoperability Methodologies (T3.1.4)

Deleted due to ongoing work.

6.2. Networked Enterprises Operations Support (T3.2)

Deleted due to ongoing work.

6.3. Interoperability domain establishment (T3.3)

Interoperability concept and its domain are not clearly defined. We mean that ‘Interoperability’ is still a vague concept and there are too many different understandings and views. Interoperability as a domain of research is not defined. This situation creates a lot of confusion. Clarify and define the interoperability research domain itself is therefore considered as a challenge.

Research challenge	Interoperability domain establishment
Description	This research aims to identify the set of basic concepts, definitions and categorisations that allow defining enterprise interoperability as an area of research, and identifying existing and missing ‘knowledge[5] in the domain. The establishment of the interoperability domain also needs to develop an interoperability framework which structures various interoperability levels and barriers to interoperability so that sub-domains can be defined and relevant knowledge identified.
State-of-the-art	The concept of interoperability is not clearly defined. Interoperability still means many things to many people and is interpreted in many different ways with different expectations. Definitions on interoperability abound, but definitions do not allow a clear understanding.
Research Activity	This research is concerned with defining basic concepts and categorisations in terms of an Interoperability Framework to define the interoperability research domain and sub-domains. It is also concerned with categorisation of interoperability levels and barriers to interoperability encountered at these levels. A piece of knowledge is considered as relevant to interoperability if it contributes to remove at least one barrier at one level.

6.4. MDI – Model Driven Interoperability (T3.4)

Deleted due to ongoing work.

6.5. Model Design Solutions and Interoperability Design Patterns (T3.5)

Research challenge	Model Design Solutions and Interoperability Design Patterns
Description	Acceleration of modelling and implementation by the use of predefined and well

[5] The term knowledge used here means pieces of knowledge (not just information) which solve interoperability problems by ‘breaking down’ at least one barrier to interoperability.

	described design solution components and design patterns. A pattern can be seen as a proven solution to a problem in a given context. A design pattern distils the experience of an expert or the best practices of a community so everyone can apply that expertise.
State-of-the-art	Reference models for enterprise solutions are available. On an abstract level such as SCOR, ITIL, etc.. they are used. Detailed reference models (even if they exist) for industrial sectors are quite often too far away from the requirements of individual enterprises. Design patterns or solution approaches are quite successful especially in the software development domain but not yet applied to enterprise modelling, model based diagnostic, and enterprise model execution. There are no design patterns for interoperability per se.
Research Activity	The use of design solutions will support interoperability in two directions. Firstly, predefined solutions for interoperability aspects will accelerate and secure implementation. Secondly, if the design solution in the modelling approach of a company is known, then the synchronisation of the modelled solution of other companies will be easier. The research can follow a combined approach of bottom-up and top-down. The bottom-up approach starts by collecting good practices and solutions relevant to interoperability that might exist today. Common features/characteristics which govern these good practices and solutions can be identified and design patterns can be derived. The top-down approach starts by studying the existing design theories, design principles, and working patterns relevant to interoperability. Design patterns for interoperability can be developed based on these approaches.

7. Semantics and Ontology research challenges (T4)

The Semantics and Ontology area focuses on understanding the meaning of concepts and terms used by communicating parties. The semantic dimension is therefore a basis for mutual understanding and interoperability between collaborating enterprises. This dimension aims at the vision of automatic understanding and instant exchange of information between enterprises which have never collaborated before.

Semantic interoperability is currently achieved in a manual fashion, mostly through standards governing both the structure of the information being exchanged and the manner in which this information should be processed (for example RosettaNet and ebXML). An alternative approach to overcoming the semantic barrier, which emerges from different interpretations of syntactic descriptions, uses precise, computer processable meaning associated with each concept. This can be achieved using an ontology and an annotation formalism for meaning. *An ontology is a set of shared conceptualisations of entities within an application domain*. The conceptualisations are shared, since definitions and meanings of concepts must be agreed on by the domain community and they should be meaningful for doing business. Concepts are represented by a terminology that is used to annotate the enterprise entities, such as: object, actors, processes, events, messages, rules, and documents.

Explicit declaration of semantics in ontologies and tagging messages with their intended purpose are seen as two mechanisms which allow software processing and automatic reasoning with semantic information, thus paving the way towards automating the achievement of semantic interoperability in eBusiness context.

In today's rapidly changing business environment, enterprises participating in business networks and ecosystems need to align the meaning they attach to their information exchanges, ranging from fields in business documents to concepts related to process goals and activities. Semantic interoperability thus underpins the layers of process interoperability and business interoperability. In open context, where participants may come and go and virtual enterprises should be formed at a short notice, automating semantic interoperability is seen as an important enabler of faster reactions to market opportunities. Techniques and methods, which go some way towards automating semantic interoperability (semantic alignment), have started to appear, but the achieving the goal of automatic semantic interoperability is still a long-term research challenge.

Existing approaches to semantic interoperability are mainly centralised, that is they require all parties to subscribe to a common semantic model providing the shared understanding at a "macro" level. This model can be an accepted standard, a controlled glossary or an ontology.

Emergent research takes on an alternative decentralised approach, which devolves the semantic agreement to pairs of communicating partners. These "micro"-level agreements are established for a specific purpose, ranging from a long-term partnership to individual communications. Such an agreement can be achieved by mapping between individual perspectives, or through negotiating the use of a substitute concept for which this understanding exists. The decentralised approach is more appropriate for dynamic and open business environments, but it has a number of drawbacks, including a large communication overhead. Creating a reliable and industrially-applicable approach for automated semantic agreement is therefore still a long-term research aim. Detailed review of state-of-art in this area is described in the proceedings of the KnowledgeWeb EC-funded Network of Excellence, where it is referred to as "ontology coordination".

In terms of research challenges, we believe that interoperability should be addressed as a systemic property of the set of collaborating entities, arising in connection with their collaboration. An integrated approach, which shares the benefits of centralised and de-centralised approaches to *semantic interoperability,* should be developed to enable efficient and effective processes of semantic agreement amongst collaborating enterprises in open business environments. This approach can use dynamic ontological structures and meaning negotiation mechanisms to identify comparatively stable core ontology, extended by a set of dynamic peripheral ontologies signifying bilateral semantic agreements capable of rapid evolution.

On the figure below, Semantic Interoperability Challenges are grouped according to the specific type of knowledge and knowledge sharing mechanism.

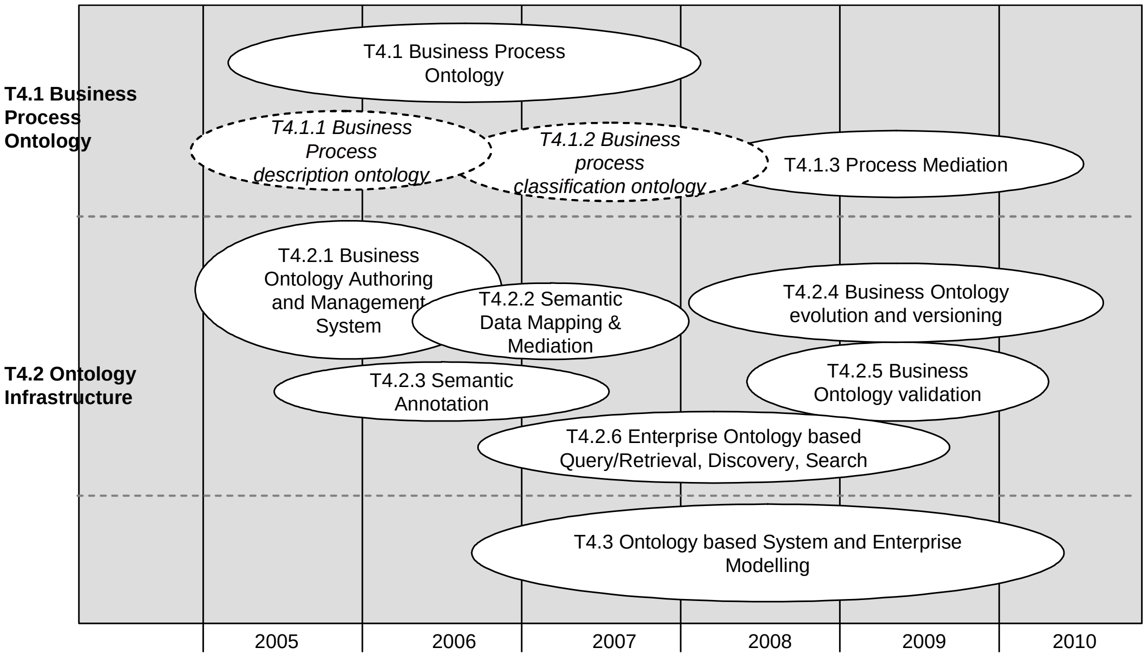

Figure 6 Semantics and Ontologies area research challenges
(See Chapter 1 for an explanation of the figure)

7.1. Business Process Ontology (T4.1)

Research challenge Group	T4.1. Business Process Ontology
Description	Collaborating enterprises maintain shared views of common business processes. Effective collaboration thus means they would have to reach semantic agreement regarding the meaning of different elements of these shared views, such as process states and goals. Encoding such knowledge in machine readable ontologies is therefore a pre-requisite for any inter-organisational process composition and process-enacted collaboration.
State-of-the-art	Researchers have explored the ideas of providing shared business process ontologies to facilitate inter-organisational collaboration and semantic agreement (e.g. MIT Process Handbook, TOVE). As of now, though, there has not been an industrial-strength application of business process ontologies.
Research Activity	Research challenges could be divided according to the subject of the ontological formalisation: • *Business process description ontologies* focus on the semantic annotations used in business process models, defining the vocabulary to be used when describing business processes; • *Business process classification ontologies* focus on “best practice” process models and classifying those in shared taxonomies (classification structures). • *Behavioural mediation* is an orthogonal approach, where a knowledge encoded in a process ontology is used by mediator agents to coordinate the states of business processes in two collaborating enterprises, without requiring both enterprises to use the same process model and execution mechanisms. It is interesting to note that the challenges further down the list are also the ones further into the future in terms of the roadmap timeline. Each of these is now described in further detail:

7.1.1 Business Process description ontology (T4.1.1)

Deleted due to ongoing work.

7.1.2 Business Process classification ontology (T4.1.2)

Deleted due to ongoing work.

7.1.3 Process Mediation (T4.1.3)

Research challenge	Process Mediation
Description	This approach proposes that knowledge encoded in a process ontology is used by mediator agents to coordinate the states of business processes in two collaborating enterprises, without requiring both enterprises to use the same process model and execution mechanisms.
State-of-the-art	At present mediation is mostly used in negotiation protocols, where mediator agents are used to provide impartial arbitration, information hiding, e.g. the identity of the trading parties, or information about sellers or buyers in the marketplace (brokerage). Using mediator agents for process mediation is less explored, and is currently discussed at the level of research idea only, no industrial implementations exist.
Research Activity	• Define approaches to behavioural mediation, using process modelling ontologies for the different parties which need to interoperate at process level. • Test approaches on scenarios with increasing complexity.

7.2. Ontology Infrastructure (T4.2)

Research challenge Group	Ontology Infrastructure
Description	The development of an ontology sharing infrastructure is a key research challenge in achieving semantic interoperability among collaborating enterprises.
State-of-the-art	Tools addressing individual challenges from the list below exist as research prototypes, and Protégé is gaining wide use for larger research-led projects, but an integrated suite of tools which can address these challenges in a pragmatic and integrated manner is yet to be created.
Research Activity	Research challenges related to ontology infrastructures can be divided into the following functional groups (details provided in the tables below): • *Business ontology authoring and management system*, allowing key stakeholders to enter specifications of concepts and their relationships in a sufficiently formalised manner, and to manage the evolution and growth in complexity of these structures; • *Semantic data mapping and mediation* would create tools for automatic or semi-automatic mapping of semantic data held in different ontologies, and translating between concepts thus mapped; • *Semantic annotation* aims to establish structural basis for automatic mapping and analysis by allowing enterprise actors to describe a concept in terms of a set of reference concepts; • *Business ontology evolution and versioning* strives to alleviate the complexity arising out of the evolution of ontologies by establishing robust underpinning organisational principles as well as supporting tools; • *Business ontology validation* is focused on establishing characteristics such as adequacy and minimality in relation to a particular ontology;

	• Enterprise ontology-based query retrieval, discovery and search.

7.2.1 Business Ontology Authoring and Management System (T4.2.1)

Research challenge	Business Ontology Authoring and Management System
Description	The possibility of constructing a reference ontology for a business domain is a fundamental prerequisite when we need to achieve semantic interoperability among enterprise software applications. An Ontology Management System (OMS) is a complex tool that allows domain experts to represent in a rigorous, structured fashion their knowledge of the application domain. Ontology construction and authoring is a continuous process supported by the OMS. The acquisition and storage of domain knowledge is organised according to an ontology meta-model, typically embodied in an ontology representation language, such as OWL (Ontology Web Language), and a set of ontology modelling constructs, made available for ontology building. Existing proposals of OMS, such as Protégé, have been conceived for a very broad range of application. Such wide applicability reduces its effectiveness in specific fields, such as business software interoperability. For this reason, we intend to investigate on a property of ontology languages (and meta-models) referred to as "domain adequacy" and how it will impact on both the ontology language, with its underlying meta-model, and how this would impact on the OMS' support for interoperability.
State-of-the-art	Systems are at prototype and community use level, but only Protégé has a wider user groups, organised user support and frequent updates cycle.
Research Activity	• Usability testing of existing authoring tools • Experimenting with new approaches to visualising ontologies and visually defining ontologies • Developing new approaches to capture ontological knowledge "at the point of need" ("develop whilst using" model) to improve the balance between the substantial efforts expanded to develop a sophisticated ontology and the relatively small benefit which is immediately visible under normal "develop then use" model.

7.2.2 Semantic Data Mapping & Mediation (T4.2.2)

Research challenge	Semantic Data Mapping & Mediation
Description	This research challenge focuses on applying semantics to determining interoperability mappings and the subsequent mediation of the services and data. This approach will allow more dynamic interoperability that will focus on the definition of the business services that need to be utilised and therefore provides a more descriptive framework. Without the development of the technology of mapping and mediation of semantic service descriptions, any solution developed will still be bound to the implementation environments of the user scenarios. Considering semantic interpretations as dynamic and applying them at run-time would facilitate interpretation and choice between business services. This has the potential to deliver true dynamic interoperability at system, business and information levels.
State-of-the-art	Currently, application of semantics is often considered in a static manner and only seeks to provide alternate views to information or services. Ontology mapping techniques exist, but their application is stand-alone and not integrated with dynamic service discovery and system interoperation facilities.
Research Activity	• Define approaches to semantic mapping "on-the-fly"; • Develop services automating the application of semantic mapping; which can

	be reused in different mediation contexts; • Create approaches to automatic semantic mediation using semantic mapping; • Test usability of above.

7.2.3 Semantic Annotation (T4.2.3)

Research challenge	Semantic Annotation
Description	Semantic annotation (SA) is one of the promising methodologies used to explicate the semantic content of a resource in a formal way. This purpose is achieved by associating a resource with an expression based on the concepts and relationships defined in a core Reference Ontology. Typical applications of semantic annotation refer to web resources, but this process can be applied to any information element, such as text documents, enterprise and business models, web service specifications. Semantically enriching the knowledge of an enterprise (documents, business models, and software components), should allow managing the different forms of enterprise knowledge in a unified environment in order to have reachable and reusable resources for enhancing the enterprise's interoperability capabilities.
State-of-the-art	A partial, but significant experience of the development and use of semantic annotation techniques and accompanying tool is provided by the Harmonise project (IST-2000-29329). A semantic annotation method is being developed within ATHENA. Based on this method, a tool for an ontology-based Enterprise Knowledge Repository is being provided. Furthermore, semantic annotation results will be used for business process and web service description annotation.
Research Activity	Semantic annotation allows the creation a semantic image of resources that can be used in several applications. In particular: – Semantic mappings via enterprise and system models: Semantic annotation can be used for a wide range of content-oriented applications such as classification, retrieval, extraction, translation, presentation, and query-answering. The annotations allow classification of documents in semantic indexes that can be used to retrieve the information. One particularly relevant application is to Enterprise Models, and System Models, for the purpose of semantic mappings. – Semantic compatibility analysis: SA can be used to give meaning to software application elements, annotating them with the concepts of a Reference Ontology; this allows to identify similarity and differences and to carry out the preliminary analysis to achieve interoperability. – Reconciliation rules generation: starting from SA expressions of two cooperating software components, it is possible to analyse the information they exchange and, to a certain degree, their behavioural characteristics to produce a set of semantic reconciliation rules. Such rules aim at bridging the semantic discrepancies and to allow (in case of lossless mismatch) for a seamless cooperation.

7.2.4 Business Ontology evolution and versioning (T4.2.4)

Research challenge	Business Ontology evolution and versioning
Description	Business ontologies provide for a machine-readable description of particular business domains. Generally, these should evolve as the business domains evolve. Yet, revising a (particular) business ontology has immediate consequences for those enterprises which commit to it. For example,

	indiscriminate revisions could lead to a misalignment of this ontology with the rest of the enterprise systems, such as data storage and processing modules; and thus comprising the efficacy an ontology-based approach to interoperability. Thus, a controlled approach is necessary to reduce problems and inconsistencies caused by evolution. From interoperability perspective, a business ontology can be used to capture a shared conceptualisation of a domain of common interest for two or more business partners, thus facilitating a semantic interoperability between these partners. For example, members of a logistics marketplace can use a vocabulary built from a shared ontology of transport to describe the procurement and supply of transport services. In an open business environment, a new partner may arrive and offer new services or require more information before selecting from those currently available. To continue our example, an air freight provider may join the logistics marketplace bringing with it new airfreight services. Reflecting this would suggest an evolution in the shared ontology. Problems this may bring should be anticipated and addressed by assessing the need for and when required making appropriate changes in a systematic fashion.
State-of-the-art	To facilitate ontology evolution in an open business domain, CrossWork uses a *devolved* ontology model. Conceptually, this comprises of an evolving core ontology which is common among partners; a number of peripheral ontologies; and importantly a number of mappings which relate these ontologies. Each peripheral ontology reflects an extension of the core in a manner specific to a sub-group or individual organisation. The mappings ensure that any changes in the core ontology or a peripheral ontology are propagated to a necessary level of abstraction throughout the entire devolved ontology structure. Additionally, the mappings inform agent negotiations and support an automatic identification of the most appropriate level from which a change should propagate.
Research Activity	• Develop robust mechanisms for business ontology evolution and versioning. • Tune these mechanisms to multi-actor context, where ontological knowledge is distributed and different nodes evolve in different speed. • Create approaches to semantic data mapping and semantic annotation which use these mechanisms.

7.2.5 Business Ontology Validation (T4.2.5)

Research challenge	Business Ontology Validation
Description	Ontologies provide fundamental infrastructures for interoperability since they are machine-readable formalisations of what is a shared conceptualisation of the domain by two or more partners. As such confidence in these invites a question of validity. Validating an ontology entails checking whether it provides a faithful account of conceptualisation of the domain of interest; and necessarily involves consultation with appropriate experts. Validation at *application-specific* level concerns specific concepts, and validation at *foundational* level concerns a basic vocabulary intended to act as a starting point for ontologies in the (general) domain. In either case, two fundamental indicators of validity are *adequacy* and *minimality*: that is, does the ontology provide a sufficiently detailed account of the business area without being superfluous. Validating *foundational* ontologies is of particular interest to interoperability as these are intended to promote mutual understanding and support negotiation. Two particular related aspects of ontology validation are relevant to interoperability: ensuring the validity of a shared “backbone”; and ensuring that the *knowledge representation* ontology chosen is *epistemologically adequate*, i.e., it can be used practically to capture all of the necessary aspects of the appropriate shared conceptualisation.
State-of-the-art	DOLCE by Gangemi, Guarino *et al*. is a foundational ontology, which underpins the OntoClean methodology, helping to clean the structure of candidate

	ontologies on foundational level.
Research Activity	A potential approach for validating business ontologies in interoperability context, is to do the following for a particular interoperability scenario: • Identify business areas or enterprises. • Identify experts in these domains and asks them to validate proposed ontology structures. • Compare and integrate feedback from the experts from different domains.

7.2.6 Enterprise Ontology based Query/Retrieval, Discovery, Search (T4.2.6)

Research challenge	Enterprise Ontology based Query/Retrieval, Discovery, search
Description	Ontologies can be useful for inter-enterprise query and retrieval of information, since they can ensure both the search and results have semantics which are shared between the two parties – the sender and responder of the query. In terms of information discovery, explicit formalisation of the domain of interest can help focus too general searches which return too many results, or expand searches which are too specific and hence return little results.
State-of-the-art	The EC-funded Growth project MaBE created an ontology-driven search approach to satisfy industrial needs involving the search for strategic suppliers whilst remaining as unrestricted as possible to support creative strategic partnerships. Ontology-driven queries and searches, however, are still firmly in the research domain, and lack industrial applications.
Research Activity	Extend ontology-driven research approaches to work for inter-enterprise context, where both the sender and the receiver of a query can apply ontology-based formulation or interpretation of the information there.

7.3. Ontology-based modelling (T4.3)

Research challenge	Ontology based System and Enterprise Modelling
Description	Instead of treating the world of ontologies as something separate – that is being connected to only through semantic annotation, it is a possibility to directly use an ontology based language for both enterprise modelling and system modelling. The use of OWL in the specialisation of OWL-S for services illustrates this approach. By doing this the knowledge representation power of the ontology language is directly available in the target models.
State-of-the-art	Specialisations/extensions for specifying the particular needs of configurable and parameterised enterprise systems exist, such as OWL-EM (Enterprise Modelling) and OWL-CS (Configurable Systems). However, most system modelling tools use notation-specific XML encodings for their models, for example UML-based enterprise modelling tools use XMI or proprietary formats.
Research Activity	• Create ontology-based modelling approaches and tools, focusing on the semantics of modelling elements rather than on their syntactic representation; • Investigate the ways in which MDA-based approaches can be adapted to ontology-based modelling to achieve model-driven interoperability between enterprises.

7.4. Business Product Ontology (T4.4)

This section contains supplementary research challenges.

See Annex II, Issue 101.

Research challenge	Business Product Ontology
Description	Collaborating enterprises maintain shared views of product data. To ensure an effective collaboration they have to reach semantic agreement regarding the meaning of product data. This refers to the meta level where the concepts like classes and properties have to be defined, but also to the content level where the different domain specific properties have to be defined semantically correct. Encoding this knowledge in machine readable product ontologies is a pre-requisite for any inter-organizational exchange of product data. Since product data is an integral part of business processes it is important to link product ontologies to business processes and business process ontologies.
State-of-the-art	Currently, a number of product ontologies are in use and under development using a number of different languages. Examples are the RosettaNet dictionary, the ECALS dictionary, eCl@ss, GS1/GPC, etc. In the area of standards, currently a number of developments are under way, e.g. for describing cutting tools (ISO13399), optical instruments (ISO 23584), fasteners, measuring instruments (both in ISO 13584), and electrical components (IEC 61360). All these are based on the product ontology language PLIB (Parts library, ISO 13584). There exist a number of other means for specifying product ontologies like ISO15926 which are targeted to specific purposes.
Research activity	Many of the research challenges which have been defined in the context of the business process ontologies are also challenges for product ontologies. But there exist some special aspects which have to be addressed specifically for product ontologies, namely the interaction of product ontologies with business processes and business process ontologies, the management of product data on the basis of product ontologies, and the overall collaboration of competing and partially complementary product ontologies. These are detailed in the following.

7.4.1 Link between product and process ontologies (T4.4.1)

See Annex II, Issue 102.

Research challenge	Link between product and process ontologies
Description	Many business processes are related to products and information about products. Often the product information can influence the business processes - different products and different product groups require special treatment. On the other hand, the modeling of processes and product information should be seen as orthogonal to each other: Process models are developed by different people than product models, and it should be possible to combine advanced models / ontologies from either side to a most powerful tool.
State-of-the-art	Many business process models today do not deal with deep product data, particular if they mainly deal with procurement type processes. They only consider some business properties like identification of products as relevant. Other models which include processes related to engineering are bound to specific product ontologies, as e.g. the RosettaNet Partner Interface Processes (PIPs) which use the RosettaNet Technical Dictionary (RNTD) for definition of product data. The same is true for other e-engineering process models like ECALS (Japan, electronic components) or NAMUR/Prolis (Germany, electric instrumentation of plants) which are built around specific product ontologies.
Research activity	• Analysis of the relationships between business processes and product information and the requirements of process models for dealing with general product ontologies.

	• Development of mechanisms to link process models and process ontologies with product ontologies • Evaluation of these mechanisms by applying it to application cases and by integrating it into emerging process definition standards like ebXML to illustrate the orthogonality of process and product definition

7.4.2 Ontology based product management (T4.4.2)

See Annex II, Issue 103.

Research challenge	Ontology-based product management
Description	Besides being used in inter-enterprise communication, product ontologies are also used internally for structuring corporate component databases. Development of local corporate ontologies will often precede the development of shared ontologies, requesting ontologies and ontology mappings to be explicitly stored in corporate product databases to enable seamless information exchange. To support different actors (e.g. from procurement, inventory management, system design, etc.) who use different product information, flexible view management mechanisms should support both autonomous discipline-specific views and the capability for sharing information between views. Such product databases should allow to store and to query efficiently millions of products.
State-of-the-art	While a number of global players still use item databases where product characterization is described in a single “designation” string, over the last years researchers have explored several database architectures for storing and for querying both instances and ontologies (e.g., OWL, RDF-S, PLIB). These architectures suffer from scalability problems. Concerning ontology mapping, the various ontology models (e.g., OWL, F-LOGIC and PLIB) define different kinds of mappings that are all necessary in the context of product databases.
Research activity	• Develop and prototype new architectures for ontology-based product databases with improved scalability in order to satisfy industrial size applications and support ontology-mapping-based import and export services. • Introduce mechanisms into main stream ontology languages supporting autonomous discipline-specific views and information sharing between views • Design user-friendly ontology-based query languages both for retrieving product within a product data base and for searching over the global network.

7.4.3 Business product ontology development infrastructure (T4.4.3)

See Annex II, Issue 104.

Research challenge	Business product ontology development and deployment / maintenance infrastructure
Description	Designing a single product ontology encompassing all business products is hardly conceivable because of the numerous industrial domains. Because most enterprises use and produce products related to several industrial sectors, they need to deal with ontologies corresponding to several sectors. Thus a key research challenge is to define a framework in which ontologies may be described independently of each others by any consortium or standardization group but where overlaps may be avoided and where common concepts and properties may be shared. Such sharing capabilities should cross the border of ontology languages and models.
State-of-the-art	Numerous ontologies have already been developed providing partial (and not consistent) views of business products such as classification views (UNSPSC, eCl@ss), e-commerce views of retail-sold products (GPC from GS1) or

	engineering views (ISO 13584 / IEC 61360), sometimes restricted to some particular domains (RosettaNet). Over the last couple of years, the Open and Interoperable Domain Dictionary Initiation (OIDDI) gathering a number of global players (ECALS, RosettaNet, eCl@ss, GS1, etc) has shown the feasibility to share information across ontology model borders. Several projects, and in particular the CEN/ISS eCat/Gen-ePDC project, have worked on resolving semantic mismatches between concepts defined in overlapping product ontologies.
Research activity	• Develop a framework offering mechanisms ensuring both interoperability and concepts sharing capabilities to decentralized ontologies. • Define an envelope model for sharing information between ontologies based on different ontology languages and models. • Define mechanisms for synchronizing the evolution of overlapping ontologies developed by independent organizations and processes that want to cooperate.

7.5. Other supplementary research challenges (T4.5)

7.5.1 Semantic Context based Business Document Content interoperability (T4.5.1)

See Annex II, Issue 13. Note that research challenge T4.5.1 can be seen as belonging to research challenge T4.4.1, since documents can be seen as linking product and process.

Research Challenge	Semantic Context based Business Document Content interoperability
Description	Different industries have different data requirements, and this has led in the past to the proliferation of variants even in such tightly controlled standards such as X12, EDIFACT, and RosettaNet. On the other hand, different industries need to communicate without having the interoperability problems. Therefore, there is a need to transform the content of the document from one standard or variant representation into another based on semantically enriched context. UBL and the business context domains it proposes (Business Process Context, Product Classification Context, Industry Classification Context, Geopolitical Context, System Capabilities Context, Supporting Role Concept, Official Constraints Context, Business Process Role concept) can be exploited as a basis to build upon them.
State-of-the-Art	There are several standards for addressing business document content interoperability such as xCBL, RosettaNet Document, UBL and Core Components and OAGIS BODs. UBLs long-term (post-1.0) strategy is to create a technology for the automatic creation of specific document types based on the particular business context in which they are to be used.
Research Activity	Developing Semantically Enriched Business Documents based on context for Automated Interoperability of Business Documents.

7.5.2 Semantic based Interoperability of Business Processes (T4.5.2)

See Annex II, Issue 14. Note that research challenge T4.5.2 to a large extent repeats research challenge T4.1.1 and a bit of research challenge T1.1.1.

Research Challenge	Semantic based Interoperability of Business Processes
Description	As already described business processes are composed of business transactions and OASIS ebBP has already defined the basic standard transactions in eBusiness in an abstract and generic way. These business transactions have to

	be specialized to specific application domains with well defined semantics to be able to support interoperability of business processes.
State-of-the-Art	- ebBP has already defined the basic standard transactions in eBusiness. - Semantic techniques are developing with well established ontology languages and tools.
Research Activity	Developing semantic mechanisms for business transactions to support the interoperability of business processes.

7.5.3 Enhancing Web service registries with reasoning capabilities (T4.5.3)

See Annex II, Issue 15.

Research Challenge	Enhancing Web service registries with reasoning capabilities
Description	Currently semantics is becoming a much broader issue than it used to be since several application domains are making use of ontologies to add the knowledge dimension to their data and applications. One of the driving forces for ontologies is the Semantic Web initiative. As a part of this initiative, W3C's Web Ontology Working Group defined Web Ontology Language (OWL). Enhancing Web service registries with ontologies and reasoning support will help with semantic interoperability in eBusiness.
State-of-the-Art	How to store OWL ontologies into ebXML registries and how to associate these ontologies with Web services have been realized within the scope of the IST 2104 SATINE Project[6]. OWL constructs are represented through ebXML registry information model constructs, and stored procedures are defined in the ebXML registry for processing the OWL semantics. These predefined stored queries provide the necessary means to exploit the enhanced semantics stored in the registry. In this way, an application program does not have to be aware of the details of how this semantics support is achieved in ebXML registry, and does not have to contain additional code to process this semantics. Hence, it becomes possible to retrieve knowledge through queries, the enhancements to the registry are generic and also the registry specification is kept intact. The capabilities provided move the semantics support beyond what is currently available in ebXML registries and it does so by using a standard ontology language. As a result of this work, the IST 2104 SATINE Project Coordinator, Asuman Dogac has been invited to become the primary author of the new normative specification "ebXML Registry Profile for OWL" by the OASIS ebXML Registry Semantic Content Management Subcommittee. Ontologies can play two major roles: one is to provide a source of shared and precisely defined terms which can be used formalizing knowledge and relationship among objects in a domain of interest. The other is to reason by using the ontologies. When an ontology language like OWL is mapped to a class hierarchy like the one in ebXML, the first role can directly be achieved. However, when we want to infer new information from the existing knowledge, we need reasoners.
Research Activity	Incorporating reasoners to Web service registries like ebXML or UDDI.

7.5.4 Semantic based interoperability profiles (T4.5.4)

See Annex II, Issue 18.

Research Challenge	Semantic based interoperability profiles

[6] Dogac A., Kabak Y., Laleci G. C. Mattocks, F. Najmi, J. Pollock, "Enhancing ebXML Registries to Make them OWL Aware", Distributed and Parallel Databases Journal, Springer-Verlag, Vol. 18, No. 1, July 2005, pp. 9-36. (Science Citation Index Expanded, Impact Factor: 00.897).

Description	The approach taken in developing the integration profiles is first to define the basic transactions describing the interactions between the IT systems and then to define the workflows describing the real life business processes by using these transactions together with the standard based interfaces. Although these integration profiles provide interoperability, they are restrictive: they are developed by considering specific use cases and whenever there is a need to cover another use case or any unforeseen variation in a use case, there is no flexible way of composing transactions to a new profile and still maintain the interoperability.
State-of-the-Art	- Integration profiles have been very successful in providing interoperability as demonstrated by the quick and extensive take up by the industry - There are well established domain specific standards, such as Open Travel Alliance in the tourism domain and HL7 in healthcare domain which provide extensive knowledge in the domain which can be used to obtain domain specific ontologies.
Research Activity	The research challenge is developing interoperability profiles where basic transactions together with their semantics are used to form flexible business processes. Considering the developments in the state-of-the-Art, this challenge is not far-fetched but the time is right to address this issue.

7.5.5 Application of ontologies to collaborative community processes (T4.5.5)

See Annex II, Issue 135.
Deleted due to incomplete information.

8. Generic Modelling Research Challenges (T5)

Enterprise Modelling (EM) can be defined as the art of "externalising" enterprise knowledge, to represent the enterprise in terms of its organisation and operations - processes, behaviour, activities, information, decision, object and material flows, resources and organisation units, system infrastructure and architectures. The purpose of EM is to indicate the creation of explicit facts and use of knowledge that add value to the enterprise or to the network of collaborative enterprises. The resulting distributed models can be enacted by business applications and shared by all stakeholders for the sake of improving the performance of the enterprise network.

Interoperable modelling based solutions derived from reference models will contribute towards reducing time to market for a product and service delivery, and reduce risks and costs of systems development, delivery, integration and management. Such solutions can be expected as part of a long term vision of interoperability.

Generic Modelling research is concerned with reference models for interoperability. These reference models must be capable to provide, for instance, suitable distributed models or semantic based model mappings for a particular scenario or project. Research is needed on languages, methods and tools for this category of interoperability in distributed environments. The active use of models in the previously described areas of research challenges provides a link to the foundation of models and their relationships and development, which is a generic area also being worked on in other contexts, like system development etc.

In the following, the different Generic Modelling research challenges are described.

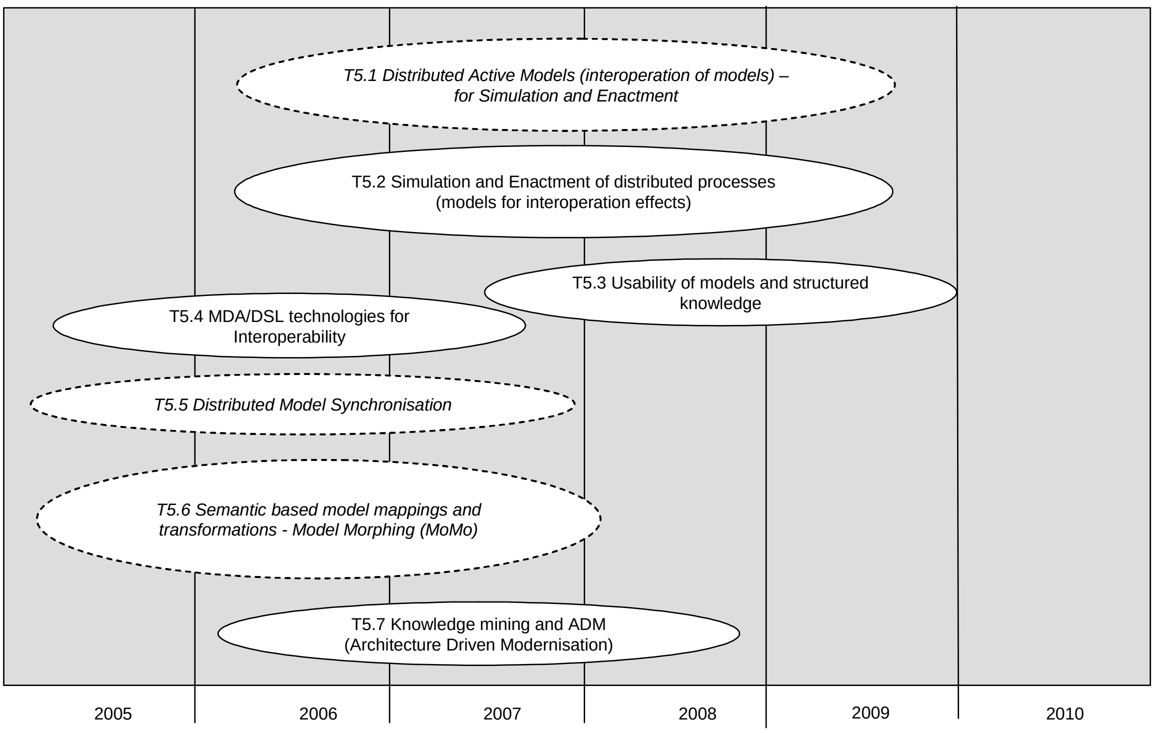

Figure 7 Generic Modelling research challenges
(See Chapter 1 for an explanation of the figure)

8.1. Distributed Active Models (interoperation of models) – for Simulation and Enactment (T5.1)

Deleted due to ongoing work.

8.2. Simulation and Enactment of distributed processes (models for interoperation effects) (T5.2)

Research challenge	Simulation and Enactment of distributed processes (models for interoperation effect)
Description	Problem Statement: In the supply chain type networked enterprises, easy to handle tools and methods are required for distributed interoperable models and simulation, with “plug-in” mechanism for the different simulation model components using the principle of adaptable reference scenarios. Further, an intuitive understandable visualization of data flows is needed as well as user friendly configuration tools. Especially dynamical simulation in a collaboration environment is of high interest.
State-of-the-art	Initiatives, methods, techniques and tools are • "High Level Architecture" (HLA) approach of the US Department of Defence (DoD), which is an IEEE1516 and OMG standard. • the MISSION project (IMS/ESPRIT 29 656 (FP5) • EURO SIW, a specific group within the Simulation Interoperability Standards Organization (SISO) is following this research via regular workshops
Research Activity	Distributed simulation is not yet a standard technique – however it will be necessary in the future. For example the view of supply chain will change more and more to a value chain. Hence, competition is no more seen only between singular enterprises but now between different enterprise networks. Supply chain simulation with interoperable models will help to plan, optimize, execute and control its processes

8.3. Usability of models (T5.3)

Research challenge	Usability of models and structured knowledge
Description	Problem Statement: The formulation of structured knowledge/information from unstructured or proprietary information. The knowledge must be integrated into the configuration of workflows, simulation and application products. To realise the integration between the models and the business processes an interoperating middleware between them and the applications, the workflow and simulations. This will allow a real time reaction to business changes.
State-of-the-art	Currently there are some methods being investigated but the resources and computational power needed would appear to be excessive and not practical to use in an operational scenario. An interactive enterprise to enterprise interoperation of business must be realised. Some work is being carried out on the Model driven integration work in INTEROP.
Research Activity	Legacy systems and the need to migrate to or co-exist with, cause the requirement for a new environment of applications, information sources etc. Issues with interoperability demand that ontologies are automatically produced from several independent unstructured information bases that can be used to carry out mappings and allow information merging or application interoperability.

8.4. MDA/DSL technologies (T5.4)

Research challenge	MDA/DSL technologies for Interoperability
Description	Problem Statement: To achieve interoperability, Model Driven Architecture and

	Domain Specific Languages are needed, which are approaches to build and evolve systems based on the use of multiple models (and languages) on various abstraction levels – with well defined relationships and transformations between.
State-of-the-art	OMG is working on providing standards around the concept of MDA (Model Driven Architecture) and Microsoft is focusing on the concept of the creation of Domain Specific Languages under their Software Factory initiative. A number of projects, initiatives, conferences and workshops all over the world are currently focused on realising the visions related to this area.
Research Activity	MDA/DSL technologies will play an important role for the future support of any model driven approaches to Interoperability. These will be enabling technologies for the creation, transformation and management of models on different abstraction levels – both in the Enterprise model domain, and in the System model domain.

8.5. Distributed Model Synchronisation (T5.5)

Deleted due to ongoing work.

8.6. Semantic based model mappings and transformations (T5.6)

Deleted due to ongoing work.

8.7. Knowledge Mining & ADM (T5.7)

Research challenge	Knowledge mining and ADM (Architecture Driven Modernisation)
Description	Problem Statement: A method is required to create more abstract models from more specialised ones, like creating platform independent models (PIM) from platform specific models (PSM) or code. It also includes how to create computation independent models (CIM) as the context for PIM models. This is a prerequisite for model driven interoperability, as the first step always will be to (re)create models of the external interfaces of existing legacy systems.
State-of-the-art	Since information often has been lost in previous specialisation steps, e.g. from PIM to PSM, or from CIM to PIM, it is normally not possible to fully automate this. However, various semi-automatic tools, with user interactions in forms of queries and decision on alternatives would be useful to have. The topic is currently not directly addressed, but it is acknowledged that this will be an important part of future solutions.
Research Activity	This topic is important for creating models for existing systems and services. In order to use a model-driven approach in general, it is necessary to have available models for existing systems and services, as well as corresponding Enterprise context models. Knowledge mining/Data mining is one area that can contribute to this, combined with Reverse Engineering approaches, as being worked on, and standardised around, in the OMG topic of Architecture Driven Modernisation (ADM).

8.8. Knowledge-driven support for interoperability in virtual organisations (T5.8)

See Annex II, Issue 97.

Research challenge	Knowledge-driven support for interoperability in virtual organisations
Description	The activities of: • assembling a virtual organisation (VO) through enterprise negotiation • detailing the design of the value chain within the VO • operational management of the value chain are creative processes where the knowledge and experience of individual experts within collaborating enterprises is the critical success factor. Whilst each may be expert in his own field and his own enterprise, his/her knowledge of the fields of other experts, and especially of other enterprises in the (potential) VO is likely to be very limited. This gives rise to major risks of suboptimal design and operation of the VO as individual experts make locally ideal choices which conflict with the interests of other enterprises and/or areas of expertise. Distributed decision making is an essential feature of the VO which restricts the opportunity for early recognition of such decision conflicts, but the cost is potentially very high (e.g. re-design or re-construction of manufacturing facilities; reduced capacity leading to lost market; unplanned outsourcing, etc.). The challenge here is to design a methodology and software capable of acquiring and applying knowledge about each enterprise/expertise which is critical to decision making across the VO so as to detect conflict rapidly, as soon as design decisions are proposed, without requiring constant and detailed review of all decisions by all contributing experts. Only where conflict resolution is required are expert enterprise contributions invoked. The benefits to industry and the EU economy of meeting this challenge include: • reduced costs and improved productivity in VOs; • accelerated VO start-up and consequent enhanced opportunity to exploit markets; • enhanced operational flexibility leading to better market exploitation; • reduced risk in collaboration
State-of-the-art	The principle of applying intelligent software agents called moderators, to detect decision conflict and orchestrate resolution, has been demonstrated in the fields of concurrent engineering design (MOSES project funded by EPSRC GR/H24273), and distributed manufacturing system design (MISSION project IMS/ESPRIT grant reference 29 656). However both these demonstrators were dependent on specific implementations of integrated design software and shared databases, which limits application in the field.
Research Activity	To meet this challenge research must extend currently demonstrated capabilities to include moderation of operational decision-making, whilst at the same time exploiting the development of interoperability of enterprise systems across the VO to make moderators independent of software platforms. Identification of the structure and range of knowledge needed for moderation and defining a meta-knowledge structure for this is necessary, and must recognise that each enterprise in a (potential) VO has knowledge about itself to contribute to the mutual benefit of the VO (but see also Research Challenge: Knowledge sharing and protection in virtual organisations).

8.9. Knowledge sharing and protection in virtual organisations (T5.9)

See Annex II, Issue 98.

Research challenge	Knowledge sharing and protection in virtual organisations

Description	Each enterprise member of a virtual organisation (VO) brings with it knowledge about itself and about collaboration which it has evolved through experience over time: indeed in a knowledge economy this may be the enterprise's chief asset and most significant contribution to the VO. This knowledge can loosely be categorised as: • knowledge which must be shared with the VO to enable operational or design decision making (e.g. current despatch status of goods); • knowledge which is commercially sensitive but which will enable better decision making for the VO (e.g. current capacity availabilities); • knowledge which is part of the core intellectual property of the enterprise and which cannot therefore be shared (e.g. proprietary technology); • knowledge relating to other, competing VOs which therefore must not be shared (e.g. market planning); The challenge here is to provide flexible, but usable, mechanisms to allow enterprises to control the sharing of knowledge to the mutual benefit of the VO, without losing control of commercially valuable asset. Reliable and controlled mechanisms for this should also permit enterprises to routinely pool knowledge as they join a VO knowing that the existing structures and mechanisms protect sensitive knowledge automatically. The benefits of meeting the challenge will be: • enhanced control of the VO and thus more effective market exploitation; • improved trust within the VO leading to the widest acceptable knowledge sharing, leading to improved decision making; • accelerated and more flexible formation of VOs enhancing market opportunities.
State-of-the-art	Little research has been found in this area.
Research Activity	Research must identify a more complete categorisation of knowledge "sharability" than above, identifying both the levels at which sharing can occur and the stages in the VO life-cycle where sharing requirements/restrictions may change. Structures to allow control of shared knowledge, and particularly to make shared knowledge properly available through interoperable systems, are also needed.

8.10. Knowledge capture, creation and application in virtual organisations (T5.10)

See Annex II, Issue 98.5.

Research Challenge	Knowledge capture, creation and application in virtual organisations*
Description	Each enterprise develops through experience its own knowledge of the process, requirements, risks and benefits of collaboration. Similarly each VO generates enterprise knowledge about the particular collaboration, this being not only valuable to the VO through the remainder of its life-cycle, but also contributes a legacy of knowledge for each and every participant in the VO. Enterprise knowledge includes, but is not restricted to: • best practice in formation of collaboration; • ways to access reliable sources of information on new collaborator capabilities; • current collaborator capabilities; • risk factors in collaborative working; • generic interoperable process templates; Such enterprise knowledge is not restricted to the needs of established enterprise processes: indeed the most valuable segments of enterprise knowledge are likely to arise out of the need to recover from failures of

	established processes, and to drive process re-design as necessary. Sources of enterprise knowledge are therefore informal, lying outside the range of data exchanged in documented enterprise processes, and including ad hoc informal communications between stakeholders who do not usually interact under documented processes, and understanding of one-off decisions beyond the scope of routine operation. Enterprise knowledge therefore cannot be seen as embedded in enterprise ontologies, but is perhaps independent of or orthogonal to these. The challenge is to create tools and methodologies for capture of enterprise knowledge, recognising that it is constantly evolving, and to make it available for re-use in a manner which benefits the competitiveness of EU enterprises. Issues relating to the structure and availability of enterprise knowledge include: • some knowledge is part of the core intellectual property of the enterprise and cannot therefore be shared (e.g. proprietary technology); • further knowledge relates to other, competing VOs which therefore must not be shared (e.g. market planning); • some knowledge must be shared with the VO to enable operational or design decision making (e.g. current despatch status of goods); • some knowledge is commercially sensitive but which will enable better decision making for the VO (e.g. current capacity availabilities); • underlying knowledge of best practice in collaboration, and available in the public domain can be embedded in all implementations of enterprise knowledge bases; • knowledge of best practice within an business sector may be made available to any implementation for that sector; • VO knowledge must be controlled and disseminated to VO members in a way which respects individual IP but gives added value to all collaborators; The benefits of meeting this challenge include: • enhanced ability to form new collaborations rapidly, thus encouraging collaborative enterprise and increasing competitiveness in global markets; • reduced risk of error in forming and operating VOs through the application of knowledge and experience available within the enterprise, within the VO and as public domain best practice; • increased confidence in enterprises embarking on collaboration, perhaps for the first time, and especially in the case of SMEs who have the opportunity to build on experience of others in the sector; • the progressive evolution of an EU knowledge base on enterprise collaboration, underpinning this area of the knowledge society.
State-of-the-Art	Little research has been found in this area.
Research Activity	• Review of the sources available sources of enterprise knowledge within a VO, and the potential methods of capturing this data. • Identification of appropriate knowledge structures to maintain enterprise knowledge, including control of shared access. • Determination of interoperability requirements for the sharing of enterprise knowledge. • Investigation and creation of implementation platforms to meet the above requirements. • Identification of collaboration best practice, to populate general and sector specific best-practice knowledge bases, and the implementation of these in a form accessible to enterprises.

9. Other Challenges (O)

9.1. Ensuring seamless research/standardization interfaces (O1)

See Annex II, Issue 138.

Research challenge	Ensuring seamless research/standardization interfaces
Description	EU and national projects seldom take due account of need to provide inputs into standardization. Understanding of complex standards issues, including knowledge of the plethora of standards bodies, is poor
State-of-the-art	COPRAS IST Project (CEN, CENELEC, ETSI, W3C, The Open Group) is preparing initial generic guidance material and helping improve awareness, including through specific case studies related to FP6 projects
Research Activity	FP7 will by its very nature (e.g. technology platforms) require specific arrangements by programme or sector, though hopefully these will be along generic guidelines. For standards issues related to enterprise interoperability, a systematic and dedicated centre of expertise should be established, with the participation of relevant standards bodies