Deliverable 3.1

Report on the Methodology to be Applied in the Roadmapping Process

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1 Introduction

The Road4FAME project is developing a strategic research and innovation roadmap for IT architectures and services in manufacturing. The project is focussing on architectures and services which facilitate agile and flexible manufacturing processes, ease interoperability in distributed manufacturing environments, support effective collaboration in context-aware enterprises, and provide the foundations for sustainable manufacturing.

The aims of the roadmap to be generated during the project are to align future ICT (information and communication technology) research with the needs of European manufacturing businesses, and to provide European manufacturing businesses with a reference against which they can derive innovation strategies and identify novel business opportunities.

This document outlines the methodology proposed for generating the roadmap, explaining generic roadmapping background information, the Road4FAME context and then describing in detail the process that will be used throughout the programme of work.

2 Roadmapping Background

2.1 Roadmaps as a framework

Roadmaps provide a structured visualization of particular strategic aspects. They are used to support strategic planning across a broad spectrum of applications. A common roadmap layout, or architecture, will contain two axes, as shown in Figure 1. There is a horizontal, time-based axis; often encompassing the past, short-, medium- and long-term, as well as the vision. The vertical axis usually pertains to perspectives, or dimensions, relevant to the focal point of the roadmap; often represented as horizontal layers, forming a matrix across the time dimension.

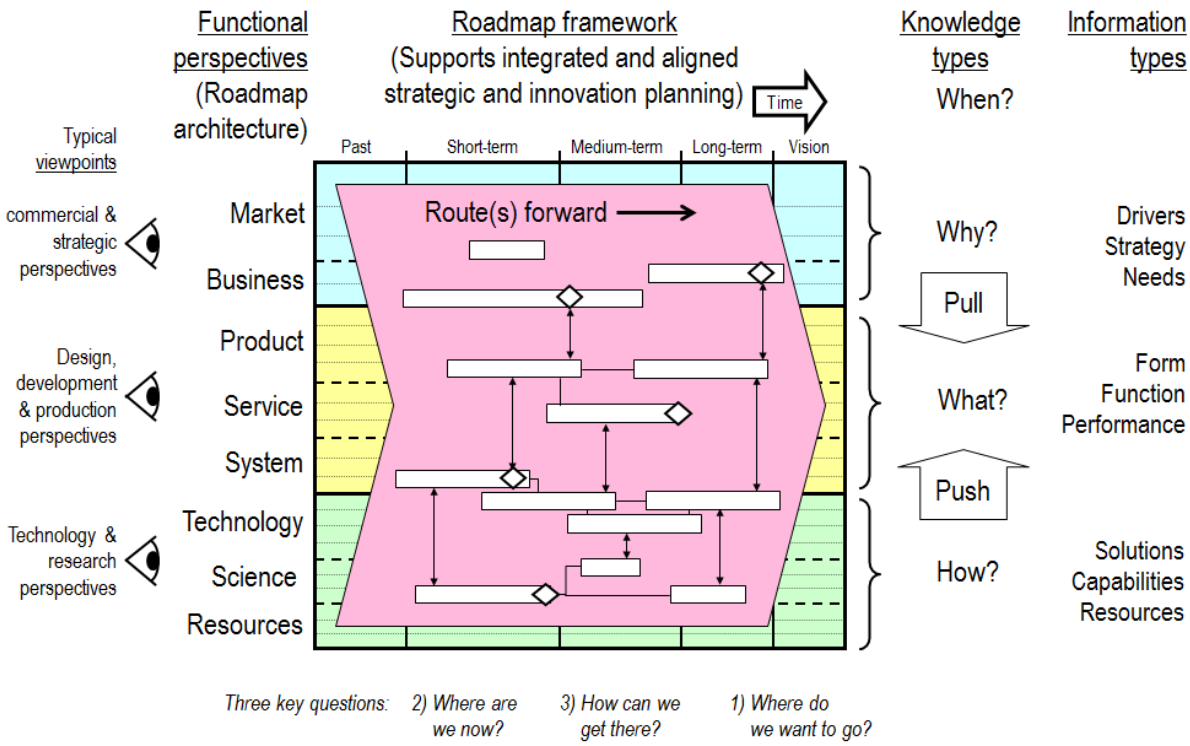

Figure 1 – An architectural framework for roadmapping (Phaal et al., 2004a; Phaal and Muller 2009)

The roadmap allows the integration and alignment of a number of different perspectives across a broad time range. In this way, the development of currently developing, or short-term, underpinning science and technology to support long-term market trends and drivers can be explored. As a result of this flexibility, roadmaps can be applied at different levels – international, industry, company and product-specific roadmaps have been produced (Phaal *et al.*, 2004b, Phaal & Muller 2009). They can also be applied in a hierarchy – with industry-level trends and drivers cascading down through organizational objectives into specific products and technology features and parameters (see ITRS Roadmap at www.itrs.net, for example).

2.1.1 Roadmaps in contrast to scenarios, forecasts, visions and backcasting

Roadmaps differ significantly from scenarios and forecasts which create descriptions of the future, with little analysis of that future's desirability (McDowall and Eames, 2006). In contrast, roadmaps are normative in nature and action orientated, providing a view of a desirable future and a pathway of actions towards it (de Laat and McKibbin, 2003).

It is the normative nature of roadmaps that is shared with visions and backcasting studies (McDowall and Eames, 2006). Vision setting, or visioning, lacks the action plan associated with roadmapping, however does create a desirable direction-setting end point, and for that reason is often used at the start of the roadmapping process. Backcasting studies are most similar in nature to technology roadmaps by setting an end point and exploring all possible routes towards achieving it. Indeed backcasting and roadmaps lend themselves to advocacy purposes by bringing stakeholders together towards a shared vision and commitment to actions (Londo *et al.*, 2012).

2.2 Roadmapping as a process

The roadmapping process is a crucial element of the success of a roadmapping project. Whilst the final output is a roadmap, the process itself is generally considered to be just as important as the roadmap (Phaal *et al.*, 2010 p.108). Thus there has been a significant amount of research into the roadmapping process.

Best practices for a workshop process have emerged from the wealth of facilitations conducted since the process was first developed. Kerr *et al.* (2013) synthesised the growing body of work on strategic technology management tools into seven key principles: human-centric, workshop-based, neutrally facilitated, lightly processed, modular, scalable, and visual. The principles offer guidance to decide on the appropriate form, functions, and features that should be embodied in the workshop process. These principles will be integrated into the Road4FAME process described in Section 3.

This section summarises the most relevant research on the roadmapping process and best practice for the Road4FAME project.

2.2.1 Three distinct phases

The overall structure of the process is widely acknowledged to be made up of three distinct elements. These include preparation, the roadmap development, and the follow-up (e.g. see Garcia and Bray, 1997; Phaal *et al.,* 2010). The distinct activities as described by Garcia and Bray (1997) are outlined in Table 1.

2.2.2 Divergence, convergence and synthesis

Roadmapping processes typically follow a pattern of divergence, convergence and synthesis (Phaal *et al.,* 2010). Brainstorming and scenario planning are divergent activities which benefit the process by encouraging open and innovative thinking by participants. In contrast, convergence requires some discipline to focus the attention onto the most important issues identified in the divergent activity. Thus workshops tend to employ a divergent-convergent cycle of activities, culminating in a synthesis stage where summarising and sense-making help create a coherent set of roadmaps (Phaal *et al.,* 2010).

Table 1: Three primary phases of roadmapping

Preliminary / Preparation	**Development/ Implementation**	**Follow-up**
(1) Satisfy essential conditions. (2) Provide leadership/sponsorship. (3) Define the scope and boundaries for the technology roadmap.	(1) Identify the "product" that will be the focus of the roadmap. (2) Identify the critical system requirements and their targets. (3) Specify the major technology areas. (4) Specify the technology drivers and their targets. (5) Identify technology alternatives and their time lines. (6) Recommend the technology alternatives that should be pursued. (7) Create the technology roadmap report.	(1) Critique and validate the roadmap. (2) Develop an implementation plan. (3) Review and update.

2.2.3 Quality through diversity

To gather a complete range of contrasting perspectives on the complex topic explored within a roadmap, it is widely suggested to include as diverse as possible range of expert participants in the process (e.g. see Phaal *et al.,* 2010). Often this is done collaboratively, in a workshop-based process (Phaal and Palmer, 2010; Phaal *et al*., 2010). Indeed it has been found that a well-designed workshop is an effective method for participants to share ideas and generate a quality roadmap (Kerr *et al.,* 2012b). It follows that the larger the number of participants, and thus perspectives included in the process, the greater the information sharing (Phaal *et al*., 2010). However, whilst there are benefits, large numbers of participants pose significant process management challenges. Phaal *et al.* (2010) warn that the number of participants has a "significant impact on both the impact and complexity of the process" (p.100) and suggest appropriate facilitation approaches, depending on the group size.

Another benefit of the roadmapping workshop-based process is the sense of ownership generated in the participants. Roadmaps are inherently exploratory, rather than prescriptive, and while participants will hold different views of potential futures at the outset, the workshop setting provides the opportunity to share information, debate complex issues and explore different views of potential

futures. As a result, participants build a shared understanding of the variety and complexity of future visions, and therefore the implementation of any path forward then has greater endorsement from all the participants.

2.2.4 Participant selection

Guidance drawn from literature suggests that the quality of the activity can be judged on the quality of the experts participating (de Laat and McKibbin, 2003). Experts should be chosen not only on their credibility and reputation in specific areas, but also those who have a broader knowledge of social, environmental and political systems (ForeIntegra-RI, 2007).

Thus the appropriate selection of participants is vital to the success of the roadmapping process, however every workshop is unique in how it selects the participants. FOREN (2001) suggest a number of approaches, some formal (such as reputational, snowball, co-nomination), alongside less formal approaches such as drawing on personal contacts.

A recent UK Government project conducted on the Future of Manufacturing (Foresight, 2013) provides a useful model for inspiration. Three international workshops were held with 25 participants invited to each, drawn in roughly equal measures from academia, industry and government. The selection of participants was largely made using a reputational and co-nomination model in rounds. The lead experts tasked with writing the report were first asked to nominate reputable experts in their field who were sent invitations. Approximately half of these invitations were accepted, and those that declined were asked to nominate colleagues of similar seniority and with similar experience. In the few occasions when this co-nomination failed to find a suitable participant that was willing to attend, desk-based research by the facilitation team was required to create a long list of potential participants, from which the lead expert panel selected a second round of invitations.

2.2.5 Social inhibitors

Given the social nature of the workshop-based process, underlying cognitive and social processes must be considered. Evidence suggests that workshops are subject to a number of different biases which have the potential to limit their utility. The work of Kerr *et al.* (2012a) identified that for brainstorming activity, there are six prominent psychosocial inhibitors that need to be addressed in order to maximize the productivity of the idea generation phase of a roadmapping workshop. These inhibitors are:

1) Production blocking
2) Cognitive load
3) Task-irrelevant behaviours
4) Evaluation apprehension
5) Social loafing
6) Downward social comparison.

This set of inhibitors can be counteracted, even neutralized, through a combination of:

i. active facilitation,
ii. process design adjustments, and
iii. adopting an empirical/pragmatic approach to roadmapping.

Lessons from this research will inform the design of the Road4FAME workshops in order to maximize the creative brainstorming and solutions identified by the expert participants.

2.2.6 Pre-population of roadmaps with trends and drivers

The activity of recognising and acting on the impact of trends has been widely understood to be a vital element of competitive strategy for a long time (e.g. see Aguilar, 1967). As technology becomes increasing complex and has a larger impact on manufacturing firms, technology intelligence is vital for firms to remain competitive. Kerr *et al.* (2006, p.73) found that technology intelligence "provides an organisation with the capability to capture and deliver information in order to develop an awareness of technology threats and opportunities."

The roadmapping process employs similar techniques for scanning for trends in the external environment (Phaal *et al.*, 2012). This information is typically drawn from the expert participants in the early stages of the workshop, however one mechanism to enhance the information generated and captured is to pre-populate the roadmap prior to the workshop. Approaches for this include a) participants can be requested to prepare in advance, or b) external researchers can be commissioned to identify important trends and drivers.

Collecting information from participants can be challenging. Given that participants are typically experts with busy schedules, Phaal and Palmer (2010, p.66) advise sending a simple one page template to participants, which is structured into perspectives similar to the roadmap so that the thoughts can easily be assimilated in the workshop on pre-printed moveable sticky notes.

Commissioning external researchers in advance has the benefit of ensuring that material is available, however this runs the risk of undermining the roadmapping process by reducing the participants' buy-in to the final outcomes.

In the Road4FAME project, the findings from work packages 1 and 2 are used to not only inform the selection of the four manufacturing scenarios to be examined in detail, but also to pre-populate the roadmaps.

2.2.7 Structured moveable sticky notes

One recommendation from the literature which may be appropriate for the Road4FAME workshops is the use of structured moveable sticky notes. Moveable sticky notes are the primary mechanism for capturing participants' thoughts. Indeed the ability for participants to quickly rearrange or layer notes facilitates the vital process of idea and linkage creation which is a central tenant of roadmapping (Phaal *et al.,* 2010).

Many roadmaps use nothing more than blank notes, however Phaal and Palmer (2010) found that including some structure to the note could improve the quality and consistency of the information captured. Following experience from a recent project similar to Road4FAME, template notes could include space for participants to capture their thoughts and additional information such as timescale, linkages, their name, etc.

3 Road4FAME Roadmap Methodology

3.1 Road4FAME context

Road4FAME intends to generate a roadmap which can provide insight for research and innovation strategy relating to ICT architectures and services enabling manufacturing across Europe, as well as allowing businesses to identify new business models and opportunities relating to this field. Based on the findings in Road4FAME, recommendations for future research and innovation strategies will be developed.

To develop a holistic roadmap, encompassing both the technology-push and the market-pull perspectives found in any domain, primary and secondary research has been undertaken to populate layers within the roadmap, as indicated in Figure 2.

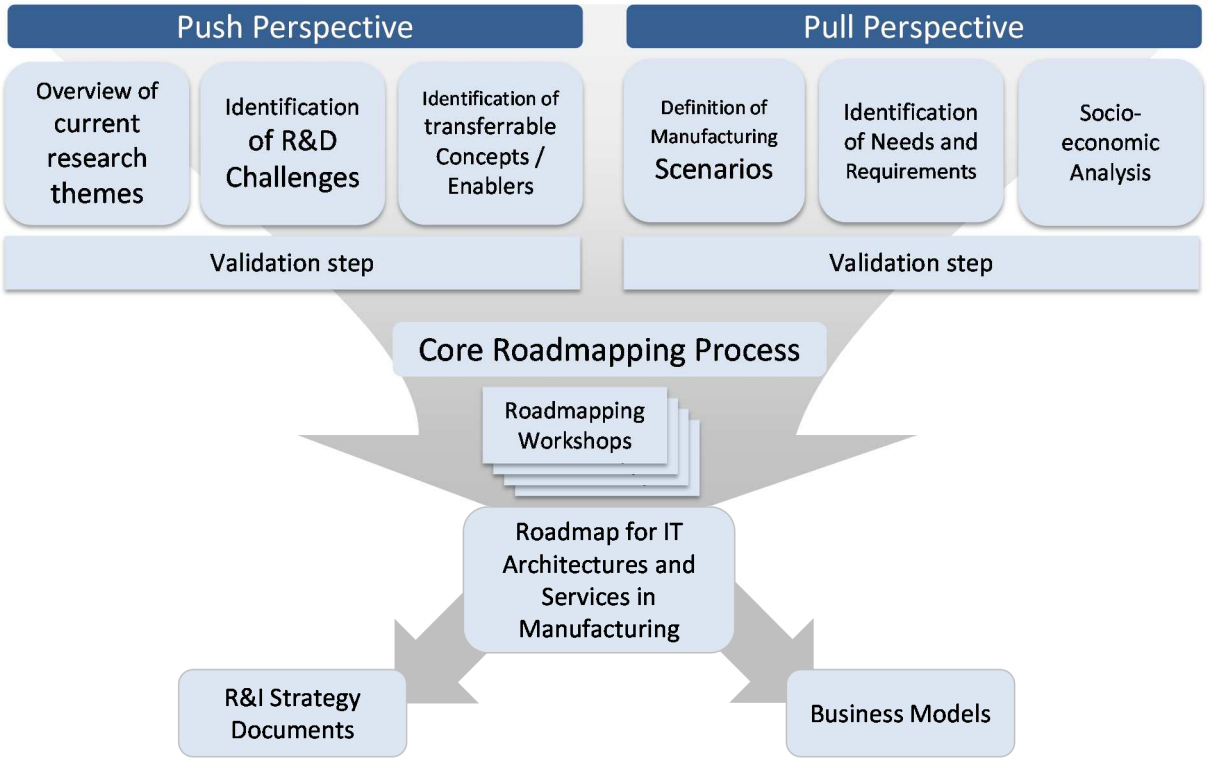

Figure 2 – Road4FAME's roadmapping process

3.2 Technology-push perspective

Work package 1 (WP1) has gathered intelligence relating to science and technology, establishing the push perspective (see figure 2). This information is useful to populate the lower layers of the roadmap architecture in Figure 1 – pertaining to the 'How' and perhaps some of the 'What'.

Deliverable 1.1 – 'Report on Results and Concepts from Relevant Initiatives' (submitted December 2013) summarizes the consortium analysis of 138 recent and ongoing research projects relating to IT architectures and services for manufacturing. The analysis focused on capturing recent and ongoing research activities. Sixteen key themes of research activities were identified, based on their frequency of occurrence in the projects reviewed. They were summarized under the headings

'Factory-level results and concepts', 'Production network-related results and concepts' and 'Other results and concepts'. The data gathered included an indication of the timing important to each theme, to enable transfer of the information into the roadmap architecture. As the review comprised recent and ongoing projects, the topics will primarily populate the current and short-term timeframes of the roadmap.

In a second step, current strategic documents, i.e. roadmaps, focusing on IT for manufacturing were searched for any *future* research challenges they describe. While doing so, several hundreds of research challenges from six strategic documents were analysed and assigned to the key research themes already identified during preparation of Deliverable 1.1. Based on this, Deliverable 1.2 describes and compares both recent and current research activities and research challenges to be dealt with in the future. While the content of D1.1 will be used to populate the current and short-term timeframes of the roadmap, D1.2 contains the content for the population of medium-and long-term timeframes.

The overview of recent and ongoing research activities (D1.1) and the overview of future research challenges (D1.2) has been validated in an expert workshop.

To complete the push perspective of WP1, an overview of IT enablers is to be established. While D1.1 and D1.2 describe research topics specific to the field of manufacturing IT, the overview of IT enablers is to comprise an overview of non-manufacturing-specific IT research which could cross-fertilize manufacturing IT. This perspective will be gathered by an analysis of strategic documents, i.e. general IT research agendas, and will provide input for the IT-enablers layer in the roadmap structure.

3.3 Market-pull perspective

Work package 2 (WP2) establishes the pull perspective, providing a complementary perspective to the push perspective of WP1 (see figure 2). This is perspective comprises an overview of trends which could be of relevance to the manufacturing domain and may thus influence future needs for manufacturing IT. They are reported in Deliverable 2.3 – 'Report on Socio-economic Developments' and comprise megatrends such as demographic change, urbanisation, globalisation as well as lower-level trends with a direct implication for the manufacturing domain, e.g. the increasing demand for personalised products, the need for resource productivity and efficiency, increasing flexibility of production environments, and the optimisation of efficiency.

WP2 furthermore comprises the identification of needs and requirements of manufacturing businesses for manufacturing IT which will be identified in interviews with representatives of the manufacturing industry. The information gathered in WP2 will be used to populate the top layers of the roadmap architecture shown in Figure 1 – relating to 'Why' specific ICT Services and Architectures for Manufacturing are required.

The identification of needs and requirements in Road4FAME is not limited to – but focuses on – four manufacturing scenarios which have been proposed by Road4FAME and have been refined in several iterations with the involvement of the Road4FAME Core Group and Road4FAME Experts Group:

- The Virtual Enterprise: an association of companies that cooperate to jointly identify and exploit new market opportunities, innovate products and to minimize costs.

- The Green Enterprise: a company to which environmental awareness is an important part of the company image and objectives.
- The Manufacturing as a Service Enterprise: a manufacturing company which does not sell products, but offers manufacturing as a service.
- The High-Volume Production Enterprise: a company which produces very-high volumes of goods and increasingly faces the challenge of shorter product life-cycles.

These scenarios will be used throughout the roadmapping process as a means to develop the roadmap, providing a frame for targeted discussions at expert workshops. They will furthermore generate distinct perspectives on the roadmap.

The refinement of these scenarios is to be concluded with the involvement of members of the Road4FAME Experts Group at a workshop on May 2014.

3.4 Roadmapping participants and expertise

Road4FAME involves not only the project consortium, but two groups of stakeholders relevant to the roadmaps being generated:

1) The Road4FAME Core Group comprises a small number of organisations (currently five) which are expected to endorse the roadmap and recommendations which will be put forward by Road4FAME. They are therefore involved in important design decisions regarding the roadmapping work and consulted regularly for their strategic advice, critique and review. The Road4FAME Core Group includes all relevant organisations within the roadmapping ecosystem in the Factories of the Future PPP: the coordinator of the ActionPlanT project (SAP AG), the coordinator of the continuous roadmap development process at EFFRA, and the coordinator of the Pathfinder project (TTS). Other members include important players in manufacturing IT (SAP AG, Atos UK Ltd.) and Politecnico di Milano as an important academic player in the Factories of the Future PPP.
2) The larger Road4FAME Experts Group has been established to provide Road4FAME with a sufficient number of perspectives and expert opinions throughout the roadmapping process. Since the robustness of the roadmap and the recommendations developed in Road4FAME depends strongly on the extent to which a significant number of perspectives and expert opinions can be involved in the roadmapping process, a large and representative Road4FAME Experts Group is of fundamental importance. It currently comprises approximately 60 recognized experts from industry and academia. Many of these experts are also partners in relevant research projects from the Factories of the Future PPP. In a similar manner to the Road4FAME Core Group, the Experts Group serves to endorse the interim and final strategic documents which will be put forward by Road4FAME.

3.5 Architecture

The proposed roadmap architecture was initially sketched out at the project Kick-Off meeting in September 2013, following the generic pattern described in Section 2.1. This initial roadmap architecture built upon the work carried out in the ActionPlanT research programme to identify relevant time periods for the short-, medium-, long-term and vision sections.

The selection of the relevant layers to be included in a roadmap is a key part of any roadmapping process. Relevant horizontal dimensions were further considered and refined at the partner meeting held in November 2013, making use of content from the ActionPlanT research and other production-related roadmaps, to test both the architecture and a vision-led roadmapping process. This resulted in the draft architecture shown in Figure 3.

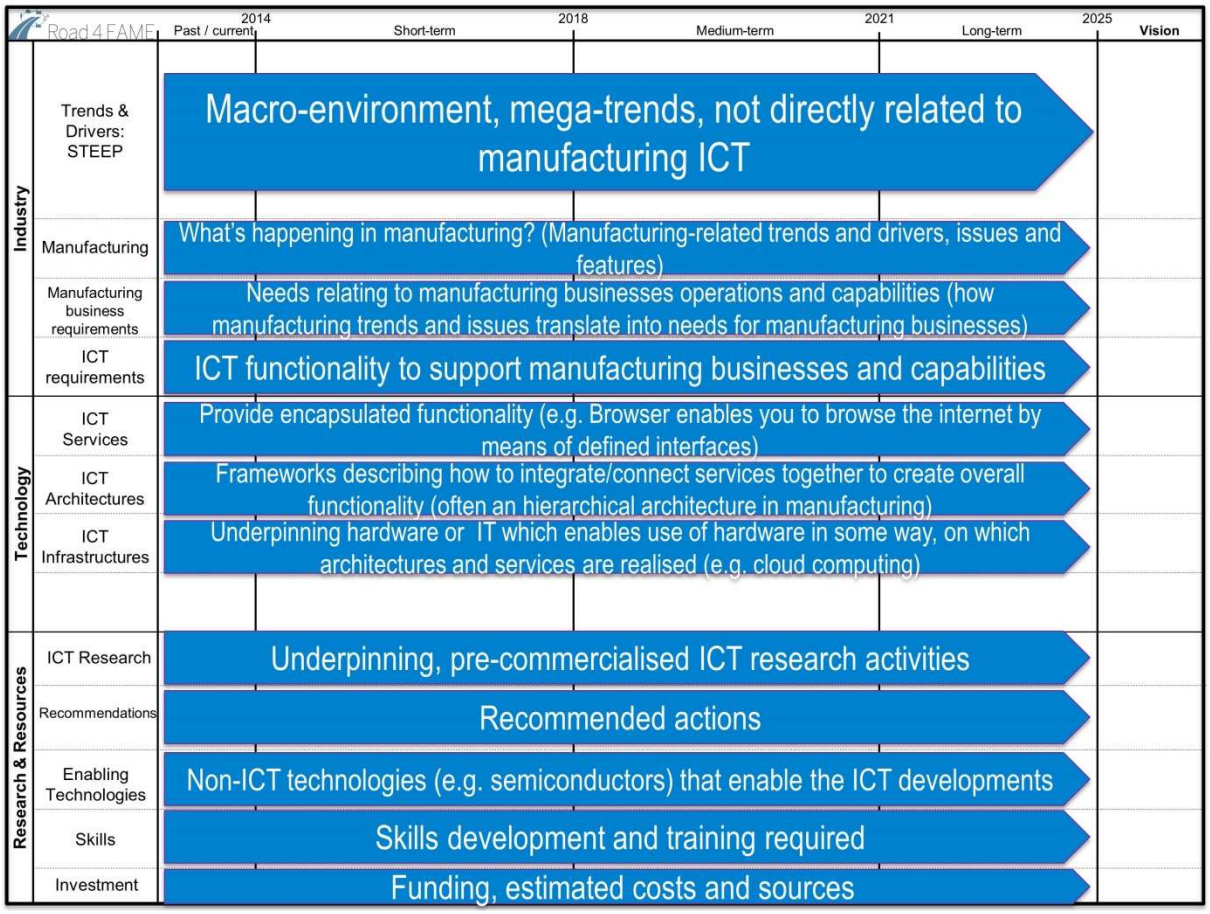

Figure 3 – Proposed manufacturing ICT architectures and services roadmap architecture, agreed at the Road4FAME 6 month partner meeting, November 12-13, 2013

Industry and market dimensions have been included at the top, and typically this 'top third' of the roadmap would provide drivers and trends – 'why' things are done.

- Trends & Drivers includes generic 'STEEP' factors – those macro-environmental sociological, technological, environmental, economic and political factors which are generally applicable.
- Manufacturing – relates more directly to manufacturing industry itself, and looks at trends within the industry.

- Manufacturing business needs – this defines how manufacturing trends and drivers in the layer above translate into needs to manufacturing businesses.
- ICT requirements - specifically considers the functionality required to support the stated manufacturing business and capabilities.

Technology dimensions have been included in the central section, and this middle part of the roadmap considers 'what' needs to be provided to address the needs and trends and drivers in the 'why' section above.

- ICT services - these provide encapsulated functionality – e.g. a browser enables browsing of the internet by means of defined interfaces.
- ICT Architectures – these describe the means of organization – i.e. it is a framework – how to integrate/connect services together to create the overall functionality. Often there is a hierarchical architecture in manufacturing e.g.: - sensors and actors, EPLC level, manufacturing execution system, and then enterprise resource planning (ERP) system.
- ICT Infrastructures – these are hardware or IT related, which enables use of hardware in some way. It is the underlying 'thing' on which architectures and services are realised. e.g. cloud computing.

Research and resources encompass 'how' the 'what' can be achieved to address the 'why'.

- ICT research – underpinning, pre-commercial research.
- Recommendations – actions to be taken.
- Enabling technologies – non-ICT technologies that enable ICT developments.
- Skills – both the skills/knowledge required and also any training needs.
- Investment – funding required for the developments identified, together with potential sources.

Through discussion with experts, review of other strategic documentation, production of Deliverables 1.1 and 1.2, and the first Expert Panel Workshop, held on 6 March 2014, the proposed architecture has been further refined, and is shown in Figure 4. This makes use of key themes around which the roadmap content is likely to be clustered, and should assist in the pre-population of existing data, as well as providing a 'prompt' or 'checklist' for expert participants during the workshops. By leaving some open layers within the architecture on wall charts, Road4FAME workshops will encourage participants to add their own perspectives and thoughts, and not be constrained by the pre-populated content.

Road 4 FAME			Past	Short-term 2018	Medium-term 2021	Long-term 2025	Vision
External & Internal Drivers		Mega-trends and macro-environment: general STEEP					
		Manufacturing-related trends					
		Manufacturing business requirements					
		Business models					
Solutions	Required ICT Capabilities	Strategic investment planning					
		Product development					
		Process planning & development					
		Factory planning					
		Production planning					
		Supply chain management					
		Purchasing					
		Order processing					
		Distribution / sales					
		Manufacturing					
		Stock / warehousing					
		Maintenance					
		Management / administration					
		Education / training					
Research & Resources	(Mfg) ICT Services	Data acquisition Data handling/management Supervision Analytics Visualisation Control Research Challenges					
	(Mfg) ICT Architectures	Service Oriented, Event-driven, Decentralised Research Challenges					
	(Mfg) ICT Infrastructures	Cloud Infrastructures Wireless technologies / Communication networks CP(P)S Research Challenges					
	IT Enablers	Big Data Security System Design System behaviour User interfaces					
	Other Enablers	Skills Investment Standardisation Business models					

Figure 4 – Revised proposed manufacturing ICT architectures and services roadmap architecture

3.6 Initial roadmap population

The revised architecture shown in Figure 4 is expected to iterate further, through initial population of intelligence maps from the primary and secondary research undertaken in WP1 and WP2, during the next few months of Road4FAME.

The Road4FAME holistic roadmap will encompass all of the intelligence gathered throughout the project, but also enable specific foci, namely on the four manufacturing scenarios. In this way, the initial intelligence from WP1 and WP2 will be mapped out, for each scenario, using the architecture proposed in Figure 4. These initial maps will be used to communicate and further validate the information gathered, as well as testing the proposed roadmap architecture, prior to the stakeholder workshops.

3.7 Roadmapping workshops

To consolidate the information gathered through desk-based research, and to explore the medium and longer-term timeframes of the roadmaps for the four manufacturing scenarios in greater depth, workshops will be held to generate further content. This section describes the practical activities and considerations during the pre-workshop, workshops themselves, and follow-up.

The S-Plan process is particularly appropriate for the broad scope of the Road4FAME project. The aim is to identify, prioritize, and explore key issues, research needs, strategic options, and innovation opportunities, which lead to decisions and actions. The foreseen one-day workshop process involves a group of participants populating a large 'landscape' chart in the morning, before identifying points of interest – 'landmarks' – which are investigated in further detail by smaller groups in the afternoon.

It is anticipated that Road4FAME will incorporate six main roadmapping workshops, as shown in Figure 5, starting with an initial 'pilot' workshop, primarily using participants from the Road4FAME Core Group and Experts Group. Participants will be further populating a single landscape architecture, as shown in Figure 4, pre-populated with information from WP1 and WP2. The purpose of this workshop will be to validate the intelligence gathered to date, verify whether or not the architecture requires further refinement, as well as gaining new insights into the steps which need to be taken between the current status and future vision.

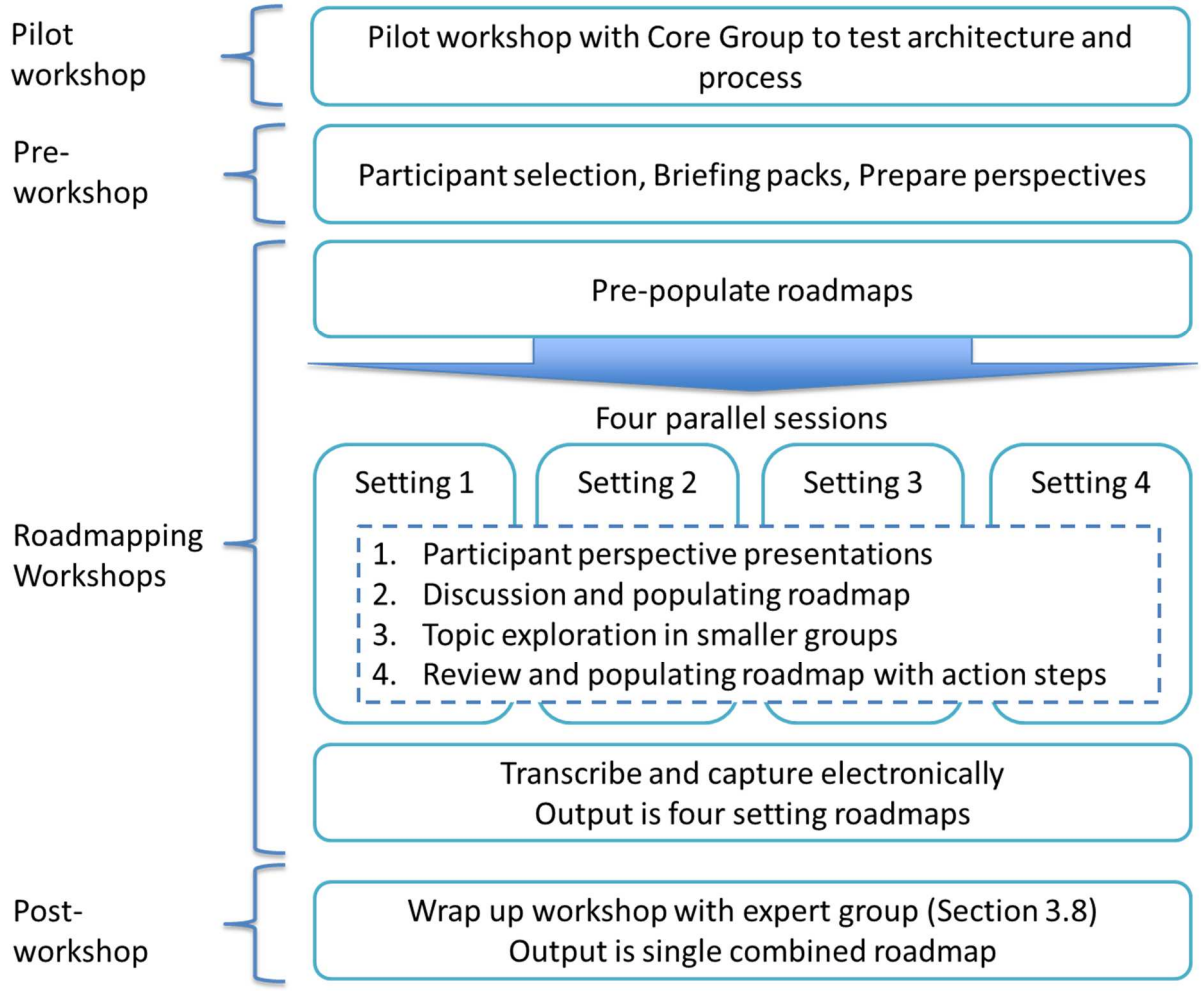

Figure 5 – Proposed roadmap workshop process, to generate and explore four scenarios simultaneously

The outputs of the pilot workshop in terms of content and process will then be used for a one-day event where four roadmaps – one in each of the manufacturing vision scenarios - will be generated and explored simultaneously. In this way participants can make the best use of the time by building

on content that had already been generated, the landmarks to be explored are established as part of the holistic roadmap, and the four scenarios are investigated in-depth.

Finally, after the outputs of the four simultaneous workshops have been reviewed and collated into a holistic roadmap for ICT architectures and services for manufacturing, a further workshop will be held to provide complete validation and endorsement of the outputs. This will incorporate outputs of further work packages which will use the main roadmap content for generating recommendations and exploring business models.

This proposed process follows that recommended by Garcie and Bray (1997), summarized in Table 1.

3.7.1 Participant selection

For each workshop, in a first step, all members of the Road4FAME Experts Group will be asked to indicate their availability at proposed workshop dates using a Doodle® poll. Among the members available at the most suitable workshop date, a selection process will take place to yield the participant structure desirable for the respective workshop. If, for instance, the needs and requirements of the manufacturing industry are to be discussed as part of the workshop, a participant structure of predominantly industrial members is desirable. Furthermore, it may be fruitful to ensure that both experts with an IT perspective and experts with a business perspective are among the participants, to gain a holistic picture at the workshop.

Upon subscribing to the Road4FAME Experts Group, each member has described himself/herself along a set of characteristics which enables the necessary filtering to perform the selection as described.

3.7.2 Pre-workshop

In the run-up to the workshop, a briefing pack will be sent to the participants in order to prepare. This pack will contain a brief and concise description of the background and aims of the workshop, practical arrangements such as information on location and timings, and intelligence maps. The intelligence maps will be briefing material drawn from WP1 and WP2, as described in Section 3.6, to allow participants to become familiar with the information already gathered, and to start to understand the vision which has been articulated in each setting. Participants will be asked to consider the briefing material and prepare their own perspective of the end vision for their particular manufacturing business setting.

3.7.3 Pre-population

Pre-population of the roadmaps has been discussed in terms of the recommendations from existing literature and the type of content in Sections 2.2 and 3.3, respectively. The landscape wall chart will be pre-populated with the information gathered in advance, regarding the broad trends and current status of manufacturing, ICT and relevant research. In this section the practicalities of pre-populating are described.

The information collected as part of WP 1 and WP2 is of significant benefit to pre-populating the strategic landscape layers of the roadmaps. However, as described in Section 2.2, a careful balance must be maintained between improving the quality of the inputs to the discussion, and avoiding

disenfranchising participants who perceive the roadmap as already complete and losing their valuable buy-in to the process and outcomes. It is therefore proposed that information is consolidated in sticky note format in advance of the workshop. This would enable participants to review and interact with the information, and their own contributions on sticky notes would have the same value. Careful facilitation will be required to introduce participants in the right way to the pre-populated information.

Pre-population has been used successfully in a similar recent workshop using this process. A core group of expert participants met the day before the main workshop to brainstorm important historical events that would have an impact on the future of the industry (Ford and More, 2014). The outcomes of this brainstorm were quickly presented to the main workshop group the following day, before allowing time for them to examine the events written on sticky notes and add their own. Another perceived benefit of this approach is for the participants to witness the sort of information to be included and to set the set the scene for the day by creating a positive standard for them to follow – *upward social comparison*.

3.7.4 Process on the day

The Road4FAME workshop will use a standard one-day S-Plan process. This is the most commonly used format and has been found to be a time efficient method to identify, prioritize, and explore key issues, strategic options and innovation opportunities. The S-Plan facilitates consensus among participants on complex issues, aiding decision making and leading participants to develop and agree on action plans for the future (Phaal *et al.*, 2010).

For the four roadmap one-day event, once all the participants have arrived and have been given a general introduction, participants will be invited to join their group for each of the four settings, and the facilitator will lead them through the process of creating a roadmap.

Recognizing that time is scarce in workshop settings, Phaal *et al.* (2010, p.118) describe an efficient process consisting of three steps. The first session is dedicated to understanding the *strategic landscape*. It is at this stage that participants will share their pre-prepared perspectives. Participants will bring different, but all equally valid, perspectives to the workshop. The process of sharing their views is an important step that tends to generate constructive discussions and uncover shared views along with exposing where opinions differ. New insights from the perspectives and resultant discussion will be added to the wall charts, driving the group to reach a common consensus of the vision. Participants will then be asked to consider what is required to move from the current status to the desired vision, working their way across the roadmap architecture, first exploring 'Research and Resources' then 'Solutions'. This should provide a populated landscape chart and highlight some key clusters to be explored in the next step.

The second step is *topic exploration*, where the participants will identify priority technology and research opportunities for further consideration. The group will splinter into focus groups (typically 3-4 people) each exploring one topic. Using the roadmap framework, the group will explore the nature of the topic (issues, options, opportunities) and associated vision and goals. On separate topic roadmap template sheets of paper, the group map out how the end vision could be achieved, including business models, and identify key learning points (such as enablers, barriers, risks, decision points, and knowledge gaps), which will lead to specific recommendations. The design of this

template for these topics will be carefully configured to capture the proposed business models, key actions and recommendations which will be useful for the Road4FAME deliverables.

The third step will be to *review*. The findings from the priority opportunities will be presented back to the group. This process will lead to a discussion and the aim is to determine which opportunities to take forward, and what actions are required to do so within the strategic landscape.

3.7.5 Timing

The following agenda has been used successfully for many similar exercises, and it is expected that the day will follow a similar timing.

8:45 Arrival and refreshments
9:00 Housekeeping, aims, agenda and process
9:20 (Break into four settings) Introductions
9:30 Short presentations of participant perspectives
10:30 Refreshment break
10:45 Strategic landscape activity
13:00 Lunch
13:45 Priority technology opportunities
15:30 Refreshment break
15:45 Feedback and discussion
17:00 Review, way forward and actions

3.7.6 Room layout

Given the four settings being developed in this project, careful consideration needs to be taken to the layout of the room. A previous similar workshop was run in a large room, with each of the four groups allocated a space in each corner, as indicated in Figure 6. This layout is considered more favourable than four separate rooms, because the energy created by the large number of people in one room gives the process momentum, and leverages the power of upward social comparison as described in Section 3.7.3.

Four matching set-ups are created in the corners of a large room (Figure 6). The large roadmap and associated sheets are put up on poster boards, as illustrated in Figure 7.

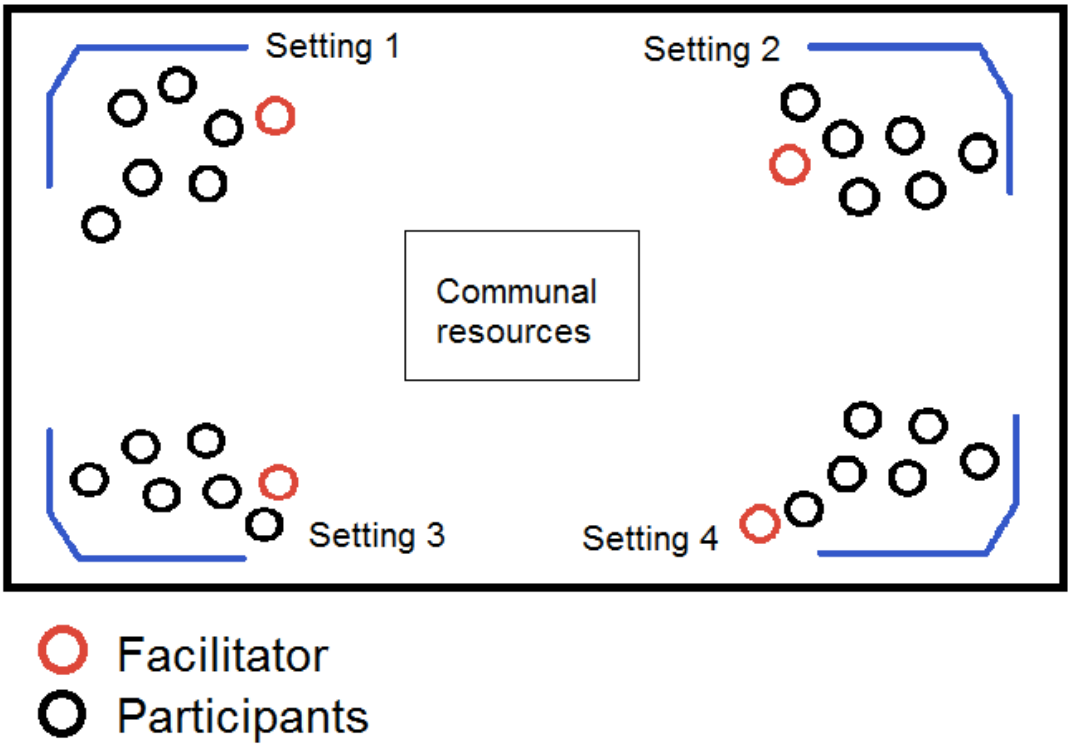

Figure 6 - Suggested room layout with a group in each corner of a large room

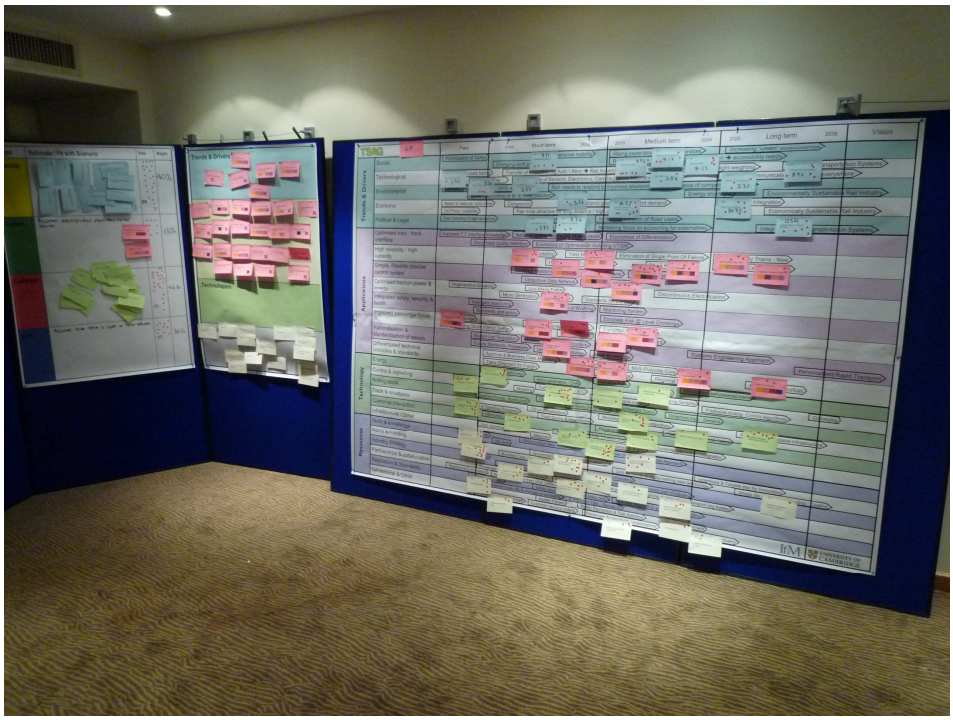

Figure 7 - Poster board arrangement used in similar roadmapping exercise

3.7.7 Role of facilitators

The majority of guidance makes specific reference to the importance of facilitators (for example see Industry Canada, 2002). De Laat & McKibbin (2003) describe how facilitators play a vital role in

maintaining the workshop's momentum, however experience shows that facilitators should intervene as little as possible – aiming to be 'neutral facilitators' (Kerr *et al.*, 2013). Light touch facilitation using a well-structured process encourages participants to fully engage and contribute. Four experienced facilitators will be assigned to each setting and be coordinated on the day by a lead facilitator.

3.7.8 Template notes

As described in Section 2.2, the use of template sticky notes could improve the quality and consistency of the information captured. Template notes will include space for participants to capture their thoughts and additional information such as timescale, linkages, and their initials.

In addition, different templates for the different layers within the architecture are being considered, since different types of information is required within each layer.

3.7.9 Follow up

In the immediate follow up of the workshop, the outputs on all the sticky notes will be transcribed and captured electronically, for circulation and review by participants.

3.8 Final roadmap generation

Once the outputs from the four roadmaps have been transcribed, these will then be shared with the Expert Group for validation and further explanation of particular concepts put forward. The four maps will be refined and the information collated into an overarching Strategic Research and Innovation Roadmap for Future Architectures and Services for Manufacturing in Europe. This roadmap can be viewed from the four perspectives investigated individually, but will also provide an overview, integrating the different perspectives in a communicable, visual format. After the main roadmapping workshop, there will be further verification and validation, particularly exploring the business models and recommendations to implement innovation areas explored for the different scenario settings.

In the workshops, the 'landmarks' identified for further exploration will be explored using topic roadmap templates, together with templates generated to capture insight and expert opinion as to the recommendations, strategic actions and any novel business models or services required. While the landscape gives a general overview, and provides information as to the linkage of research and technology required to meet market drivers, the detailed exploration of these important landmarks will provide insight for work packages 4 and 5: identification of business services and opportunities, and strategic recommendations, respectively. It is expected that the roadmap workshops will provide inputs for these work packages, but that outputs from these work packages will be used to complement the roadmap, particularly in the final roadmap workshop and document generation.

The underpinning details will be described in a guidance document which will include key recommendations for strategic research areas, together with novel business opportunities identified for the manufacturing ICT industry.

The final roadmap will pull together the desk-based research and the outputs from the workshops. It will have a strong visual element to assist with communication, but also detailed recommendations as to how various innovation aspects can be taken forward, based on the expert input received.

4 Conclusions and Next Steps

The roadmap will be generated iteratively, throughout the time of the Road4FAME project, consulting with a wide range of stakeholders, using both primary and secondary research. In this way, there will be a strong foundation describing past and current activities, together with fresh insight into future possibilities. To date a roadmap architecture has been proposed and refined, and a workshop process has been proposed, however both the architecture and the process can be expected to iterate as more intelligence is gathered in this area. The next steps to be taken are to refine the architecture through the creation of the four intelligence maps of the different manufacturing business settings, using outputs of WP1 and WP2, and an initial pilot workshop. Then intelligence maps can then be validated through consultation with the Road4FAME Expert Group and a refined process for the simultaneous workshops can be proposed.

For the initial holistic roadmap, a pilot one-day workshop is planned, with a small number of participants from the Core Group and Expert Group, which should both validate information already gathered, and help to refine the proposed architecture of the roadmap itself. This should ensure when the main four scenarios are explored simultaneously in roadmaps in the autumn of 2014, with a much larger group of participants, that the roadmap architecture and pre-populated information is robust, therefore maximizing the efficiency of the main roadmapping workshops, to elicit new information and insight from the participants.

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