This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under Grant Agreement no. 608813

SAFELIFE-X

Safe Life Extension management of aged infrastructures, networks and industrial plants

Publishable summary

1.1 Executive summary

The transport infrastructures such as roads, railroads, tunnels and bridges form the arteries suppling the European region with vital goods produced by its industrial facilities. Dams, pipeline networks, and gas and electricity plants and grids provide the energy to produce all those goods and to light and heat the buildings where the service sector makes its contribution to a thriving European society. All of these infrastructures are ageing, yet called upon to operate beyond planned service lifetimes.

The project (http://www.safelife-x.eu-vri.eu/) addressed the need to improve ageing management for these infrastructures, so that their availability is maximised and their management even more cost effective. With this goal in mind, the project has decisively contributed to the development of a new European EN Standard providing the aligned a Risk-Based Inspection Framework (Work item WI 00319020 CEN TC 319, maintenance). This standard correspond to the US API580/581 and is of a crucial interest for the European industry. The basis for these activities is the CEN CWA 15740:2008/2011, was provided also in the EU context, in the FP6 project RIMAP. The final text of the new EN standard will be released in autumn 2015.

In addition, it has provided a basis for the more cost-effective solutions for handling the problem of ageing infrastructures and setting up a reference source within Asset Integrity Management, in which a catalogue of the good/best practices and the new solutions for the cost-benefit analysis are provided. The project strategic research agenda aims to clearly specifying the priorities and identifying the Research, Technology Development and Demonstration (RD&D) efforts required to achieve the goal of further improved, safe life extension process. This will significantly improve the European capacity to deal better, with challenges posed to the maintenance and management of aging infrastructures, networks and plants in a globalized context.

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1.2 Summary description of project context and objectives

1.2.1 Context

Infrastructures are vital elements of our economical activities since they provide the bones and the arteries of the creation of added value in the whole value chain.

In SafeLife-X project context, infrastructures are defined as follows:

- Transport infrastructures, such as roads, railways, tunnels, bridges, car parks…,
- Industrial facilities such as plants, installations, dams, pipeline networks and gas & electricity grid.

Europe's, infrastructures, networks and industrial plants are aging. In many cases utilization beyond the design life is essential to keep the various utility systems and with them the European system of systems, functional. Besides that a demand for better asset management within the various European industrial sectors is obvious to satisfy the Grand Challenges (sustainability, energy consumption, environment, employment and social cohesion). The unbalance between societal and political concerns and the resistance against major infrastructure development projects has to be closed by safe extension of lifetime of Europe's existing industrial assets and networks.

1.2.2 Current situation

The current situation on aging management is analyzed in this paragraph considering the studies carried out by international organizations, the initiatives of public authorities after recent accidents and the vision of high level representatives from the industry.

The situation related to aging of infrastructure has been studied in a series of several **international reports**. The conclusions of two of them (WEF and OECD) are briefly presented here to present the current international situation.

World Economic Forum – Global Risk Report 2010[1] and 2011[2],

In the 2010 report, the "underinvestment in infrastructures" is reported as one of the most important risks for our society. The report says:

> ***Underinvestment in infrastructure***
>
> *Multiple studies across the world repeatedly highlighted that vast segments of our water, energy or transport infrastructure are structurally deficient or functionally obsolete, requiring considerable annual investments to avoid catastrophic failure.*

The report shows the interdependence of several risks, and therefore the central role of infrastructures in our economy reinforce the importance to manage properly this risk, and in particular to optimize the aging management.

OECD reports "Infrastructure to 2030"[3] (2007) and "Strategic transport infrastructure needs to 2030"[4] (2012)

The *Infrastructure to 2030* report (OECD, 2006-07) concluded that global infrastructure investment needs across the land transport (road, rail), telecoms, electricity and water sectors would amount to around USD 53 trillion over 2010-30. Annual investment requirements for these sectors amount to some 2.5% of world GDP, which would rise to 3.5% of GDP if electricity generation and other energy-related infrastructure investments in oil, gas and coal are included.

[1] http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2010.pdf
[2] http://riskreport.weforum.org/
[3] http://www.oecd.org/futures/infrastructureto2030/40953164.pdf
[4] http://www.oecd.org/futures/infrastructureto2030/49094448.pdf

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The new report focusing on transport infrastructures points out that "an integrated package of measures is needed to get investments in strategic infrastructure back on track, in countries whose strategic infrastructure is not rated highly enough. The strategic infrastructure package needs to include improvements across all major factors, encompassing: national policy frameworks; more commercial business models; better planning and evaluation; "assured" long term funding and financing; adequate gateway capacity; efficient international and inland connections; and green growth and a "greening of transport".

More information http://www.oecd.org/futures/infrastructureneedscross-sectoralforesight.htm

In addition, in the **several European Member States**, specific programmes on aging management have been launched by public authorities and they involve the most important industry players. The motivation and the rationale for these programmes find their origin in the occurrence of several near-misses or accidents that are attributed to "aging" of the industrial installations.

The EU concerns on aging related to industrial plants has led the Member States to include this issue in the Seveso III directive (DIRECTIVE 2012/18/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC).

The Seveso III directive required that the operators of hazardous establishments consider aging in their safety management system.

Excerpt of the Seveso III directive, Annex III:

(iii) operational control — adoption and implementation of procedures and instructions for safe operation, including maintenance, of plant, processes and equipment, and for alarm management and temporary stoppages; taking into account available information on best practices for monitoring and control, with a view to reducing the risk of system failure; **management and control of the risks associated with aging equipment installed in the establishment and corrosion; inventory of the establishment's equipment, strategy and methodology for monitoring and control of the condition of the equipment; appropriate follow-up actions and any necessary countermeasures**;

In addition, these concerned are aligned with the view from several industry sectors. Indeed, after a ranking exercise using as input the entire Strategic Research Agenda of the European Technology Platform on Industrial Safety, the **ETPIS High Level Group** has identified as one of the "TOP 5" priorities the following topic:

"Methods to maintain safety of aged and repaired structures and provide technologies for life extension & Reliability based design and structural health monitoring (SHM) and risk based inspection technologies"

From all these studies and initiatives, a comprehensive list of critical infrastructures (Table 1) with an assessment of their criticality has been prepared by the IRIS[5] consortium.

[5] http://www.vce.at/iris/, coordinator: Helmut Wenzel, VCE

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Table 1: Critical infrastructure and respective criticality (from IRIS project)

SECTOR	INDUSTRY	CRITICALITY
ENERGY	Electric Power	high
	Gas supply	medium
	Oil supply	high
	Distribution Networks	high
INFORMATION TECHNOLOGY and TELECOMMUNICATION	Telecommunication	high
	Information technology	high
TRANSPORT and TRAFFIC	Aviation	medium
	Navigation	low
	Railways	high
	Road Traffic	high
	Logistics	medium
HEALTH	Healthcare	medium
	Drugs and Vaccines	medium
	Laboratories	low
WATER	Water Supply	high
	Sewerage	medium
NUTRITION	Food Industry	medium
	Food Trade	low
FINANCE and INSURANCE	Banking	medium
	Stock Market	medium
	Insurances	medium
	Financial Service Providers	medium
GOVERNMENT and ADMINISTRATION	Government and Administration	medium
	Parliament	medium
	Juridical Institutions	low
	Emergency Services including Civil Protection	high
MEDIA and CULTURE	Broadcasting (TV and Radio), Printed and Electronic Press	medium
	Cultural Heritage	medium
	Symbolic Structures	medium

Managing assets is about making decisions. From this it follows that lifecycle management (LCM) and in some cases lifecycle consequence/cost analysis is a critical concept for making operational decisions, and therefore should be incorporated in the engineering and management routines of infrastructure systems.

However, several important questions remain before one may conduct a meaningful LCM analysis. These relate to the determination of the lifecycle of a new, maintained, rehabilitated or retrofitted structure and its expected performance along the lifecycle regarding the limit states. The impacts of uncertainty in estimating the risk involved in establishing appropriate demand envelopes for various limit events are significant for LCM analysis in disaster management analyses.

Therefore, infrastructure assessment and management has matured over the past decades. This process has been reactive, driven, to a large extent, by the needs to mitigate degradation or damage that occurred during operation. Today, in an economic recession, with the public focus on climate change and energy issues, infrastructure engineering and management faces a challenge to renew itself. Resilience and sustainability are the overarching long term goals to archive.

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Now, the challenge of safe life extension of infrastructures involves a number of decisive issues:

- The definition of a generic aging methodology through standardized degradation curves is to be brought into the CEN and ISO standardization process.
- Asset management under shrinking budgets requires risk based approaches under probabilistic frameworks. A generic algorithm that satisfies the entire industry is to be found.
- Tools for proper decision making and scenario creation are to be refined. The current fragmented approaches need harmonization and standardization.
- Current decision support tools like a networked capture and treatment of the data and information system. Innovative organizational structures are to be proposed.
- IT-tools are not fully exploited by the current practice. Already existing options for exploitation of IT-capacities are not properly used.
- Data driven technologies have to complement subjective or intuitive expert judgment or steering by operation personal. This would allow a decrease of uncertainties and with it a better prediction of remaining lifetime.
- The transition from reactive approaches towards a new risk paradigm driven management is to be supported. A careful combination of deterministic and probabilistic technologies is to be defined.
- The many valuable results elaborated in the various programs (i.e. NMP, transport, energy, security, environment, ICT…) have to be integrated and harmonized by a strong organization steering in the research and development process (i.e. PPP or JTI models).

1.2.3 Objectives

The overall objective of SafeLife-X was **to build cost-effective solutions to handle the problem of infrastructures aging in the next 10 years (2015-2025) by providing specifications for new RDI projects** (Strategic Research Agenda / Roadmap). It also set up a reference source with AIM (Asset Integrity Management), mapping, catalogue of the good (best) practices as well as with Cost-Benefit analysis and Return of Investment.

The **operational objectives** of the project were:

- To **improve synergy between several industry sectors** concerned by aging of infrastructures and installations,
- To **identify the good (best) practices** for the various steps of aging management,
- To define **a strategic research agenda** (SRA) and an implementation strategy (Roadmap)
- To **initiate and develop pre-standards and** standards that will be the base for an effective resolution of the aging challenges, e.g. for Risk-Based Inspection where the group working on the new RBI European Standard (EN – developed on the basis of CEN CWA 15740:2008) will be included into the work of the consortium (see Box "RBI").

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1.3 Description of the main S&T results/foregrounds

The overall goal of the project was to improve aging management for infrastructures, networks and industrial plants so that their availability is maximize and their management is cost effective.

The project was designed to set up a collaborative process that enables:

- **flexibility** regarding the topics addressed, because the situation on aging management is evolving very quickly around the world
- **reactivity** to invite new experts according to new technological developments or the evolving policies and public debate
- **collaboration** to support the mutual exchanges, the sharing of experience and cross fertilization thanks to a critical mass from various sectors and countries to prepare guidance documents and standards that support a cost-effective aging management.

The most important outcomes of the project are presented below.

1.3.1 Cross fertilization and awareness raising about methods and tools to manage aging

Several thematic workshops were organized during the run of the project to keep the pace in this short project and to enable the development of synergies between the active participants.

The outcomes of the workshops were:

- The sharing on the current and best practices related to aging management and its components
- The synergetic cooperation between experts from research, industry and authorities
- The identification of scientific, technical, technological and methodological improvement needs
- The common vision for safe life extension on Infrastructures, Networks and Industrial Plants

The workshops were open to any participants interested by the activities of the project and the proceedings remain available on the project website when possible.

1.3.2 Creation of a "aging" community

Our consortium has been initiated by the **European Construction Technology Platform** (ECTP), in particular its initiative "reFINE" (Research for Future Infrastructure Networks in Europe) and the **European Technology Platform on Industrial Safety** (ETPIS)[6].

The project SafeLife-X involved several groups of experts, associations and initiatives interested by the topic of safe lifetime extension management.

The project has been structured in 3 groups to obtain the maximum of inputs, advices and directions from a wide community:

- 1st Circle: The consortium (list in the section 1.5)
- 2nd Circle:
  With 25 well known experts representing various industry sectors from various countries, and various associations and authorities, the International Advisory Board (IAB) was an extension of the consortium in terms of skills and geographic distribution. The IAB gathered specialists and experts from various industry sectors (energy providers, service to industry companies such as inspection and

[6] ECTP:, http://www.ectp.org/TFI.asp and ETPIS: http://www.industrialsafety-tp.org/

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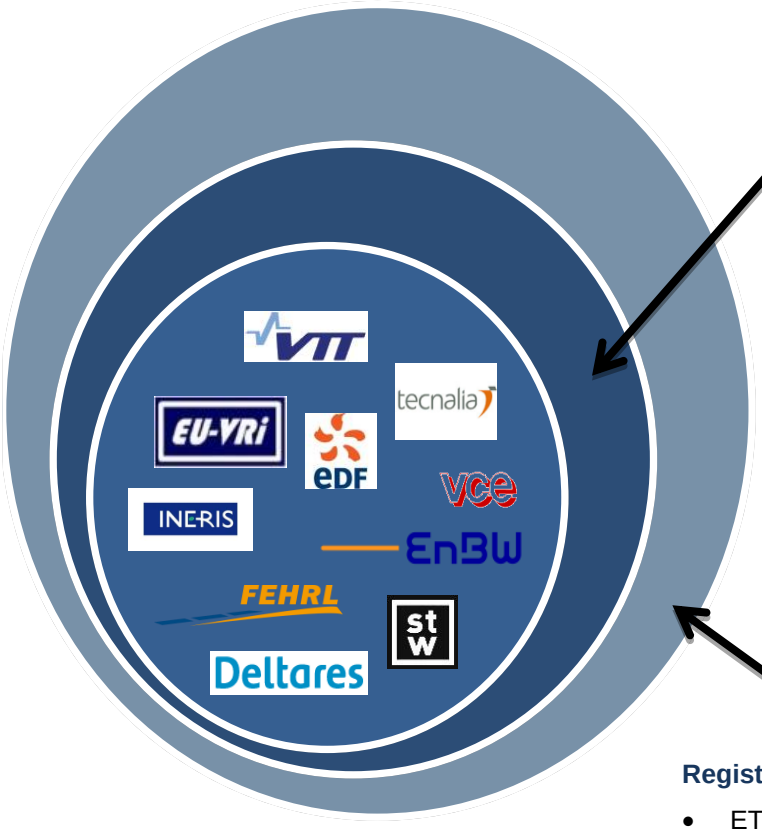
insurance company, infrastructure operators, construction companies, refinery, chemical industry…), from regulators (competent authorities) and policy makers (at national level and international level) as well as from Research Organizations.

- 3rd Circle:
  The 3rd Circle of the stakeholder platform was composed of 138 experts from various platforms such as the European Technology Platform on Industrial Safety (ETPIS), European Construction Technology Platform (ECTP) and Research for Future Infrastructure Networks in Europe (reFINE), and ERTRAC (European Road Transport Research Advisory Council). Its main purpose was to include the views and concerns of the experts and decision-makers.



2nd Circle = International Advisory Board (IAB)

- Johan van Malsen, TNO, Netherlands
- Andreas Rogge, BAM, Germany
- Christian Hoerist, TUV Austria
- Pascale Carmine, STRESS S.c.a.r.l, Italy
- Hamid Sadegh-Azar, HOCHTIEF, Germany
- Sergio Vélez GAMESA Spain
- Olivier Borlet, Améthyste
- Jean-Pierre Hamelin, Soletanche-Bachy (Vinci Group), France
- Miguel Segarra, Dragados, Spain
- Claude Dumoulin, Bouygues Construction, France
- …

Registered interested parties

- ETPIS experts
- reFINE/ECTP experts,
- Other interested experts from other organizations, associations and initiatives

Figure 1: The 3 circles of the SafeLife-X project

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1.3.3 Course on resilience of infrastructures

The SafeLife-X consortium, in collaboration with several members of the stakeholders platform, has developed a course on resilience of infrastructures.

The course addressed this issue primary from the engineer point of view and, after preparing the overview and information about the state-of-the-art focus on some practical examples highlighting aspects of the practical quantitative assessment of resilience.

Course Units:

- Unit 1: State-of-the-art, basic principles, approaches
- Unit 2: Theoretical background, methods, tools, indicators
- Unit 3: Practical application: Industry
- Unit 4: Practical application: civil structures
- Unit 5: Discussion

Lecturers:

- Aleksandar S. Jovanovic
- Cameron MacKenzie
- Helmut Wenzel

1.3.4 Guidance documents and documentary standards

European Norm on risk-based inspection

Risk Based Inspection (RBI) for the in-service activities are still not yet harmonized through the EU. International standards for RBI such as API 580/581 are available, however, it is difficult for the European Industries to refer to international standards since they do not have legal standing and they do not address European relates issues. The project proposal for the development of the European Standard RBIF (Risk Based Inspection Framework) supported by ~27 European companies has been accepted in September 2013. The RBIF standardization project is being developed within the CEN Technical Committee (TC) 319 dedicated to maintenance, and with NEN (Dutch Standard Body) holding the secretariat. The RBIF work item is identified under the number WI 00319020.

The European Standard is based on the frame of the CWA (CEN Workshop Agreement) 15740:2008 document, which specifies the essential elements for risk based assessment of industrial assets according to the RIMAP (Risk-based Inspection and Maintenance Procedures for European Industry) approach. The main purpose of the RIMAP approach enhanced by the current RBIF project, is to ensure that defined and accepted levels of risk related to safety, health, environment and business/production/operation are achieved by using resource-efficient and risk-based (risk-informed) methods of inspection. Standardization of Risk-Based Inspection Procedures concern the following aspects:

- Inspection and its link to maintenance, asset and life management for plants, systems and components;
- Pressure containing equipment and when applicable other types of equipment such as e.g. rotating, electrical, instruments and safety devices;
- Technical and managerial aspects of inspection planning and their application onto overall production and operation;

The RBIF Standard will be primarily, but not exclusively, applicable to oil &gas, petrochemical, chemical, power, and steel industry, but it will be, however limited to nonnuclear applications. The future RBIF Standard will not only help customers on the market to find more "standardized" approaches for decision making but also it will show a more detailed analysis path, compared to other more global solutions.

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Guidance documents

Two guidance documents have been developed. The first one focuses on "Service life expectancy vs. prognosis on remaining service life" and the second one on "Second Guideline: Practical application of CWA 63: 2012"

Managing assets is about making decisions. From this it follows that lifecycle cost (LCC) and in some cases lifecycle benefit/cost analysis is a critical concept for making investment decisions, and therefore should be incorporated in the engineering and management routines of infrastructure systems.

However, several important questions remain before one may conduct a meaningful LCC analysis. These relate to the determination of the lifecycle of a new, maintained, rehabilitated or retrofitted structure and its expected performance along the lifecycle regarding the limit states. The impacts of uncertainty in estimating the risk involved in establishing appropriate demand envelopes for various limit events are significant for LCC analysis in design and in maintenance management.

The CWA 63:2012 was prepared by CEN Workshop 63 "Condition Determination for Integrated Lifetime Assessment of constructed facilities and Components" the secretariat of which is held by ASI. It was developed through close collaboration with experts from the IRIS project "Integrated European Industrial Risk Reduction System", supported by the European Union's Seventh Framework Programme. Work in this project was organized in eight work projects.

The CWA addresses the following major aspects:

- The determination/estimation of the design life of new structures
- The determination/estimation of the residual life of existing structures
- Assessment criteria whether the real degradation process – determined by proper technologies - corresponds with the assumed and applied life cycle model, in order to take corrective measures in cases of accelerated ageing
- Maintenance instructions to ensure the intended service life

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1.3.5 Strategic Research Agenda and Roadmap

The methodology followed when defining this SRA can be seen in Figure 2. The idea that is behind this approach is to address step-by-step analysis in order to reach the ambition: to safely and cost-effectively extend the life of ageing EU infrastructures, networks and industrial plant, using a cross sectoral approach and maximizing competitiveness & sustainability. On the road to the ambition, three main challenges related to social, governance, technical and methodological aspects must be considered. The Strategic Research Objectives will help to address these challenges, to reach the ambition. Finally, a detailed Roadmap will be used for the implementation of the research objectives.

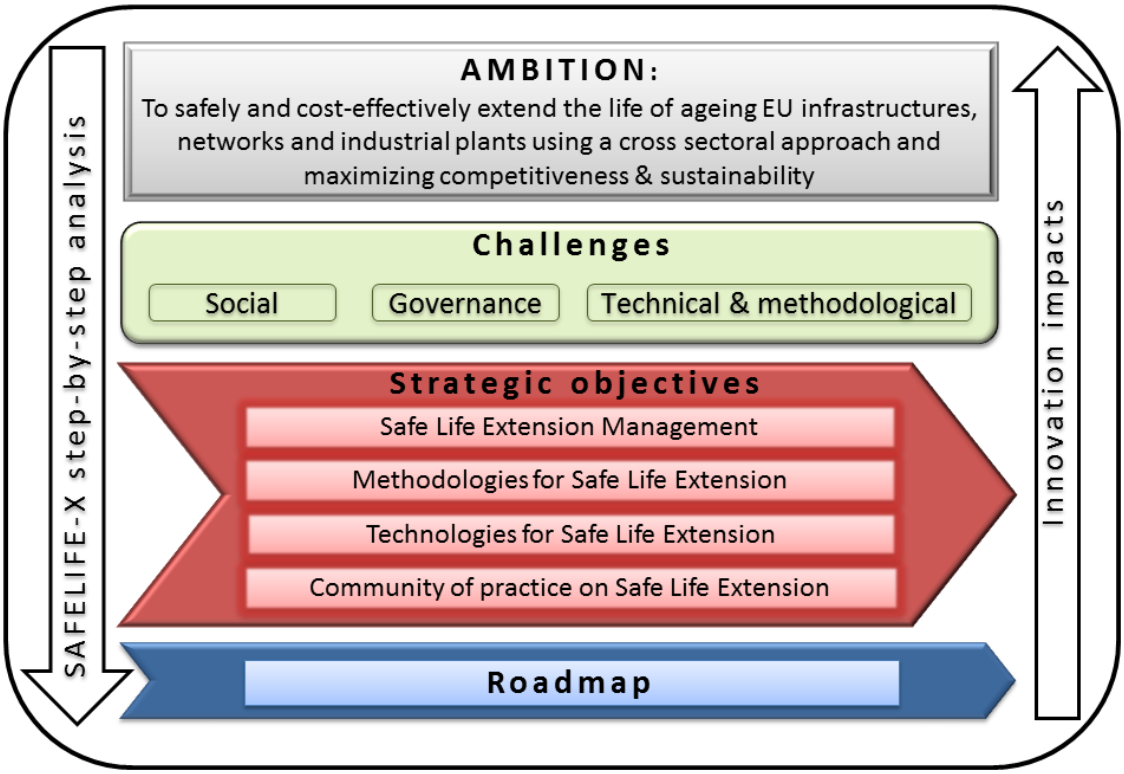

Figure 2: SafeLife-X step-by-step analysis

Thanks to these relevant inputs, the oversight from the different stakeholder and the expressed concerns from the particular use cases, the SafeLife-X project aimed to create a consensus on ageing management, satisfying the demand within various industrial sectors, boosting cross sectoral learning and providing clear needs to be addressed within the European Research Agenda.

The SRA addresses the main RTD themes and research areas for the short-, mid- and long-term and presents a time frame for Infrastructures, Networks and Industrial Plants. It includes a deployment and a communication strategy by means of a Roadmap. Divided in six chapters, it aims to provide solutions and highlight the Research, Technology Development and Demonstration (R&D) efforts required to achieve the vision for safe life extension on Infrastructures, Networks and Industrial Plants.

First chapter provides project background information and references to SafeLife-X work completed within the project and main conclusions /agreements between participants. The information provided is a key guide as there are more than 120 participants, including project partners. The majority of the discussions have been done through workshops where

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all stakeholders have had the opportunity to provide their concerns and needs in a face-to-to face and direct communication basis.

Relevance of ageing and the related concerns per different test cases analysed within the SafeLife-X project are discussed in the second chapter. Details on ageing impact are provided, not only from an economical, but also from the risk and environmental (resources, use, pollution, etc.) perspective. A figure with the impact or a probability of occurrence does not always notice the relevance of a subject, but a fact does. Hence, ageing and its consequences have been illustrated through some real cases. Therefore, the question is: what do we (have to) do with an asset that has achieved its planned operation time?

Chapter three builds the SafeLife-X Project vision, containing an outline of the envisioned core requirements for the extension of life of industrial plants and infrastructures safely.

Chapter four synthesizes the main challenges that are identified in order to reach the vision. The challenges can be summarised in three main topics: social, governance and technical and methodological challenges.

Once the relevance of the issue we are dealing with has been presented, the vision described and challenges are identified, chapter five presents "the bone" for the SafeLife-X Project SRA, where innovation opportunities and targeted research are defined. It will also address and provide the priorities of this SRA and its expected impact on current and futures R&D actions.The research topics have been identified and clustered into 10 focal areas presented in the figure hereunder.

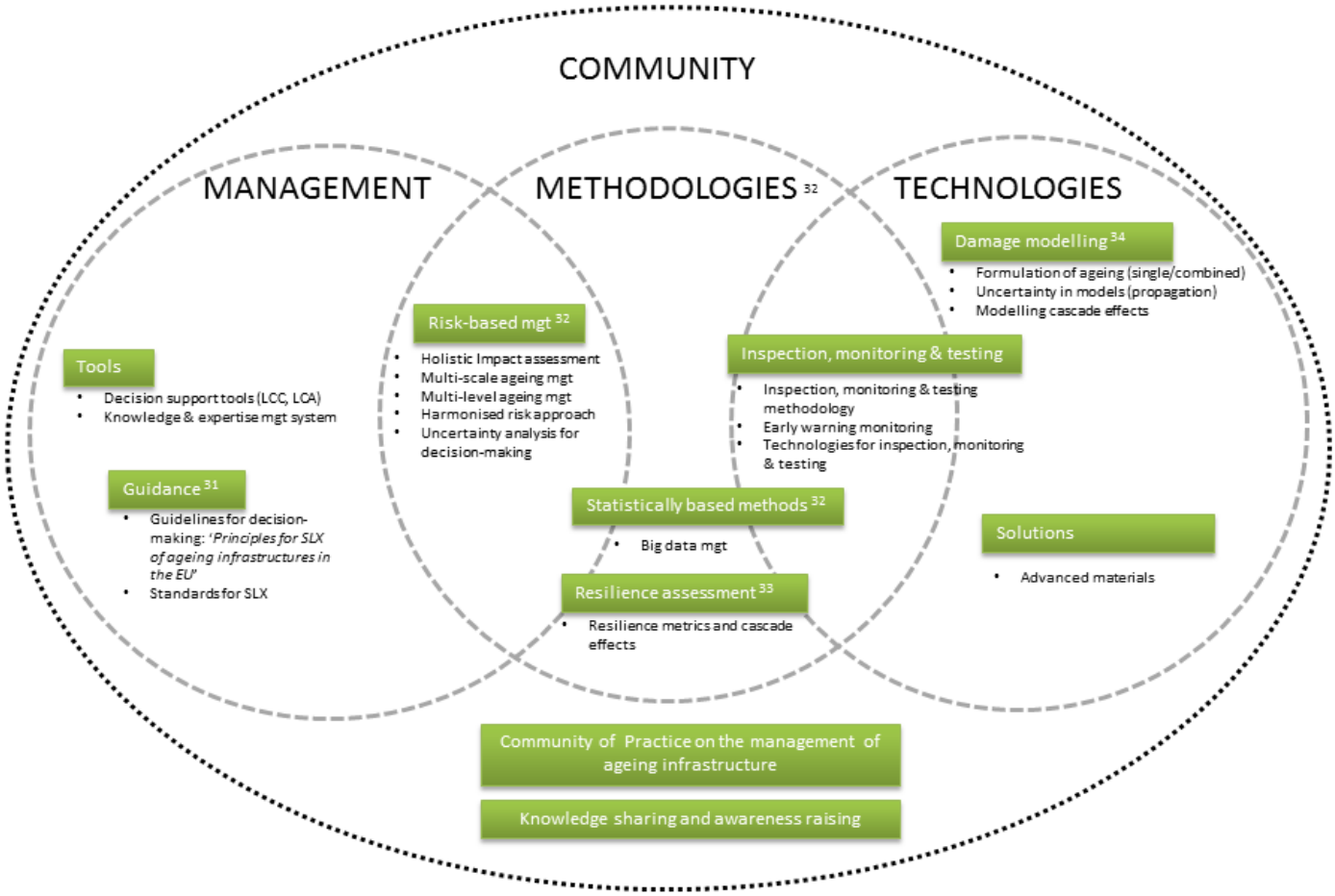

Figure 3: Research and Innovation Priorities

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A final chapter describes how the roadmap for the SRA implementation is constructed, and how the identified challenges described can be overcome, emphasizing those which are quick-wins, complementing and helping to set the SRA priorities.

The research and innovation priorities identified in the SafeLife-X project require logical, operational and strategic sequencing in order to maximise innovation impacts. The 'roadmap' which positions the ten Focal Areas in time and explains their interrelatedness. The following three broad time frames are used:

- **Short term:** 2018 – 2019 (two years): the remainder of the current Horizon2020 EC framework program. As the research and innovation agendas for 2016 – 2017 have already been established, the first opportunity for the SafeLife-X Strategic Research Agenda to lead to Horizon2020 actions will be when the 2018 – 2019 agendas are going to be established.
- **Medium term: 2020 – 2027 (seven years):** the follow-up to the Horizon2020 framework program for research and innovation in Europe.
- **Long term:** Beyond 2027.

A visual representation of the SafeLife-X roadmap towards safely and cost-effectively extending the life of ageing assets in the EU is provided in Figure 4 below. The key elements of the roadmap are comprised of the 10 Focal Areas.

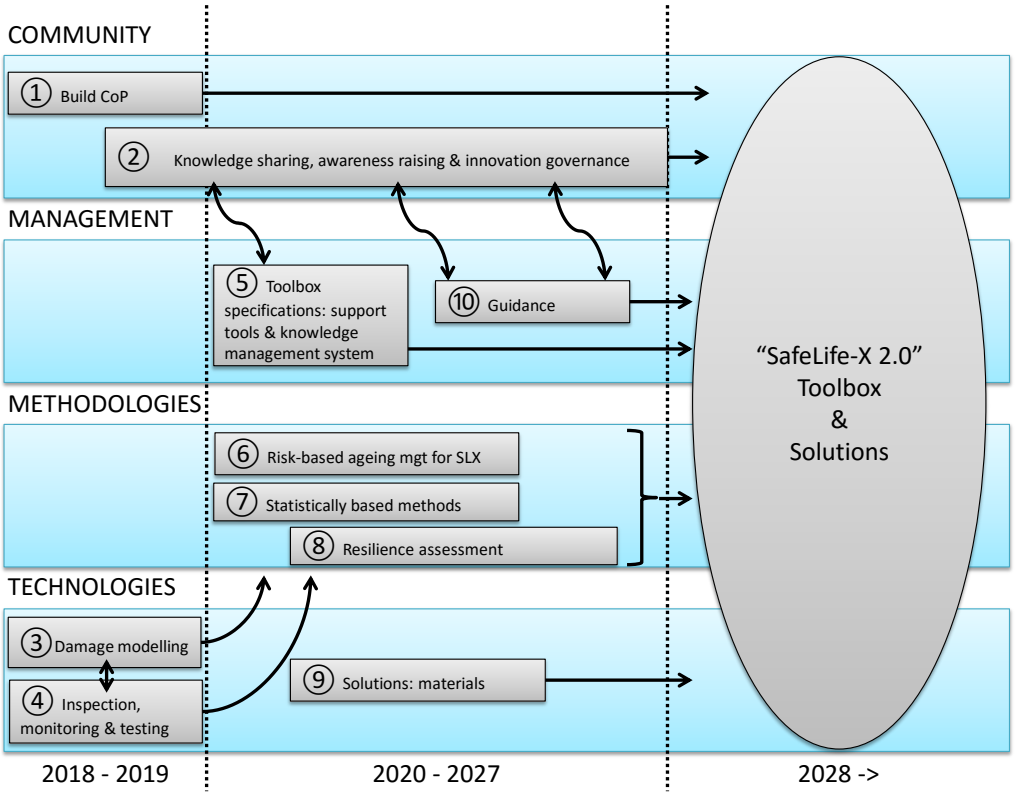

Figure 4 The Safe Life Extension Roadmap: The way forward towards safely and cost-effectively extending the life of ageing assets in the EU.

The ten-step plan represents investment priorities and opportunities. Whilst the steps are listed and discussed in a linear manner, their treatment as an investment portfolio – with multiple actions being undertaken concurrently – is of critical importance to achieve the

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desired innovation impacts. To this end, funding and financing mechanisms are an important consideration.

It is important to note that the ten-step plan itself also needs an owner. It is therefore recommended that ownership of and responsibility for overall oversight and steering of the SRA are explicitly addressed in the early steps of the plan.

Under Horizon2020 the European Commission has several research and innovation actions at its disposal that can be invoked to kick-start the SafeLife-X strategic research agenda. For example, the proposed SafeLife-X Community of Practice (Step 1) could be established through a COST action in the short term (2018-2019). Aspects of the suite of innovations identified under Step 4 (Inspection, Monitoring and Testing) may be amenable to funding through a Fast Track to Innovation (FTI) action. A FTI could rapidly produce plans and arrangements or designs for new, altered or improved products, processes and services for the inspection, monitoring and testing of life-extended assets. Several priority areas for investment in the mid-term ('hard yards'), particularly Steps 6, 7 and 8, could be funded by Research & Innovation Actions (RIA) during 2020-2027, i.e. under the follow-up to Horizon2020. Given the challenges involved in bringing the respective broad theoretical and methodological bases together and translating them into suitable and applicable tools and methods for life extension, collaborative research projects involving multiple research and industry partners will have the highest change of achieving the desired innovation impacts.

In addition to funding research and innovation through relevant Horizon2020 actions, private sector co-funding will also need to be harnessed, both to achieve critical mass in funding levels as well as to ensure the required engagement of private-sector parties with the SafeLife-X innovation agenda. Platforms like the European Construction Technology Platform (ECTP) and European Technology Platform Industrial Safety (ETPIS) provide entry points to brokerage and partner identification. It is recommended that these platforms are utilised further with respect to their end user needs and potential for placing more emphasis on solutions for ageing infrastructure management. With appropriate communication of the SafeLife-X Strategic Research Agenda and clear articulation of the expected returns from co-investment in research and innovation focused on ageing infrastructure management it may be possible to raise significant additional funds from networks like ECTP and ETPIS and thereby step up the SafeLife-X research and innovation activities.

Finally, an opportunity may exist for a 'launching customer' approach to funding. Under this approach a customer of a yet-to be developed product triggers an innovation action by issuing a tender and contracting a research and innovation entity to develop the product. This approach to funding innovations has several attractive benefits, all related to spin-offs and flow-on effects. First, when customers sign up for a new product, for example a wind turbine maintenance company looking for the next generation of sensors, investors are likely to follow. Second, a launching customer can also give important information about the most relevant product features and in this way ensure that the brand new product is fully fit for purpose by the time it is launched. Third, a launching customer also attracts other customers, for similar reasons that it attracts investors. It is recommended in particular that a launching customer approach is investigated as a possible funding mechanism for the suite of actions identified under Step 9 (Solutions: materials). With an emerging Community of Practice in place and several technological and methodological innovations already underway it may well be feasible to harness the innovation potential that resides in the private sector by means of a launching customer approach.

The main outcomes of the project are available on the project website (www.safelife-x.eu-vri.eu).

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1.4 Potential impact

The SafeLife-X project has been designed to maximize the following potential impacts:

Improved synergy amongst major stakeholders in safe life extension

The stakeholder platform and the activities performed during the SafeLife-X project brought together experts in safe life extension from various industry sectors and from various countries. The benchmark exercise and the activities to share practices and experiences contributed to cross-fertilization, transfer of techniques and technologies as well as develop synergies at industrial and regulatory level.

The collaborative processes implemented in the work packages concentrate on the preparation of common documents and this approach stimulated exchanges and mutual benefits among the participants.

Successful creation of value from knowledge is often realized within the so-called 'golden triangle' of cooperation by industry, public authorities and research institutes. Consortium partners and member of the International Advisory Board were chosen to act within this golden triangle. Therefore, public and private owners / operators of infrastructure and of industrial plants cooperated with their colleagues from research organizations and standardization institutes, as well as from public authorities. This cooperation improved synergies among the major stakeholders in safe life extension.

Identification of best practice solutions and research needs

The coordination activities proposed in the project, in particular the WP2 Identification of current and best practices and WP3 Detailed benchmarking were organized to enable the identification of the good (or best) practices from the various sectors involved in the project, and for the various activities related to safe life extension or aging management. After each workshop, the proceedings will be used to develop European Guidance documents and European documentary standards in WP4 *Developing European guidance documents and documentary standards (ENs for Aging).*

These coordination activities in the WP2, WP3 and WP4 enable dthe identification of the best practices, their capitalization in reference documents.

Both ETPIS in its initiative Safe Infrastructure (as part of the SafeFuture initiative) and the reFINE initiative of ECTP have addressed the research needs in the field of safe infrastructures taking into account the EU challenges for the next couple of decades. In this project, experts went deeper in the definition of the research needs thanks to a collaborative process.

The WP5 *Strategic Research Agenda (SRA)* was designed to identify and prioritize the research needs though a collaborative process involving experts from several industry sectors and several disciplines/expertises.

The WP6 *Implementation strategy: technical & economical aspects* was dedicated to the implementation of the SRA, and in particular to identify the solutions to overcome the socio-economical and technical barriers that might delay the adoption of the most cost-effective solutions.

Strategies for the systematic implementation of comprehensive life time extension solutions at European scale

This project was developed at European level, as the objective was to build a solution to handle the problem of European wide industrial plants and infrastructure networks aging in the next 10 years. However the solutions that have been exchanged and capitalized among the partners of this initiative were based on strong interaction with team located all over the world (including USA, Japan, China…).

To sum up, SafeLife-X pulls together a team of companies and individual experts from various technical domains that is not available at a regional or national level. This team has designed the project to support as much as possible a systematic implementation of comprehensive life time extension solutions at European scale, taking into account the international state of the art and understanding the future challenges.

Significant contributions to new standards for life extension

Per design the project, in its WP4 initiated several guidance documents in the field of safe life extension and aging management. Concerning standard documents, the project initiated the preparation of one European norm (EN) on "Risk-based inspection (RBI)" using as basis the CWA 15740:2008 developed during the RIMAP project (Risk Based Inspection and Maintenance Procedures for European Industry).

Since in standardization individual expertise matters, in addition to the activities described above, it is important to underline that the chairman of the EN standard preparation on RBI was also the coordinator of the SafeLife-X project, and several other members of the consortium have led some standardization activities.

Impact on the European 2020 Strategy

On June 27, 2010 the European Council has adopted the European 2020 Strategy[7], a *strategy for smart, sustainable and inclusive growth*

- Smart Growth: Economy based on knowledge (education) and innovation
- Sustainable Growth: Greener, more resource efficient and competitive economy
- Inclusive Growth: High employment delivering social and territorial cohesion

The objectives of the strategy are:

- Successful exit from the crisis
  - sustain demand and stem the rise in unemployment
- Boost competitiveness
  - make EU industry lead in world markets
  - strengthen and modernize our industrial base
- Lay foundations for a sustainable future
  - sustainable growth of economies and societies
  - tackle climate change including energy efficiency
- Drivers
  - Knowledge, Sustainability, Competitiveness, Innovation, Recovery, Social aspects

The achievement of these objectives for the European economy and way of living requires that industry as a whole modernizes itself, improving its efficiency, quality and safety. It also requires improvement in the efficiency, **quality and safety of transport systems**, as mobility is a requirement for the industrial development and also for the well-being of citizens. It is becoming more evident that the industrial and the transport networks in Europe are transnational and increasingly more dependent on each other. Efficiency of industrial production is intimately related with the delivery of materials and products in a timely manner and this can only be viable with adequate logistic and transport infrastructures.

[7] http://ec.europa.eu/europe2020/index_en.htm

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under Grant Agreement no. 608813

Safety is essential for the **human well-being** but also to ensure the efficiency and competitiveness of the industrial and transport systems as a whole. Any disruption in the chain of production and transport has adverse consequences on the affected industries and transport systems, which happens across country borders, as national economies are increasingly interlinked. It is therefore essential that in all European countries there is a consistent approach to safety and that this approach is also maintained consistently across the various **industries and transportation facilities**. This is not the present situation but should be a long-term objective that should mobilize efforts among all parties involved, from Governments to industry, and from technology developers to the public at large.

All industrial plants, structures often include critical structural components. Their structural **integrity** is essential for a safe operation while their design, fabrication routes and life-cycle assessment methodologies should provide excellent in-service efficiency, high cost effectiveness and environmental sustainability.

An increasing number of structures and plants are expected to reach their declared Design Service Goal (DSG) during next decade. In fact in Europe, a significant part of structural components is aged and methods to assess their integrity and to extend their lifetime in safe conditions are essential for efficient management of assets and resources. Research should provide knowledge and procedural basis to justify extended limits of those aged or repaired structures regarding the susceptibility to local or global failures.

Research needs focus to the risk based design, inspection, FFS assessment aspects of critical components with and without welds subjected to normal service as well as accidental loadings.

1.5 Address of the project public website

www.SafeLife-X.eu-vri.eu

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Steinbeis Advanced Risk Technologies GMBH (R-Tech)	
Institut National de l'Environnement Industriel et des Risques (INERIS)	
Fundacion Tecnalia Research & Innovation (Tecnalia)	
Stichting Deltare (Deltares)	
Teknologian Tutkimuskeskus (VTT)	
Forum of European National Highway Research Laboratories (FEHRL)	
Electricite De France S.A. (EDF)	
EnBW ENERGIE BADEN-WURTTEMBERG AG (EnBW)	
VCE Vienna Consulting Engineers ZT GMBH (VCE)	

Table 2: Consortium