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Executive Summary

Aim of the Deliverable. *This deliverable was set up to define the functional requirements in the application area "VFX Production based on computer simulation" for the first.stage software.*

Brief Description of the Sections of the Document. *Section 1 introduces the reader to the application area in which the requirements are developed within this document. Section 2 describes scenarios in which the future use of previs with the first.stage software is described for the specific application area. These scenarios are mainly inferred from the outcome of the interviews and special application knowledge by the authors. Section 3 describes individual use cases of the first.stage software specific to the application area. Finally, section 4 derives the functional requirements for the first.stage software from the previously described scenarios and use cases.*

Mayor Achievements. *Definition of 8 different Use Cases that can be comprised in 5 different categories (Previs and Pre-production, Concept Development, Pipeline, Realism Goal and Libraries), and definition of 6 different Requirements (Documentation, Assets Import, Assets Export, Licensing, Agile Parametrization, and Integration Capabilities) that respond to the said Use Cases.*

Summary of the Conclusions Obtained. *We've collected a positive feedback on the expected outcome of first.stage (the toolset). The participants in our survey have insisted in the necessity of a strong pipeline integration, in which first.stage is fully compatible with other content production platforms, and in which our libraries are platform-agnostic and can be integrated in third-parties' software easily. Computer simulation is mentioned as a key to speed-up physically-based animations and achieve an excellent level of realism even on early stages of development of a digital content*

Content

1 Introduction

In this document the functional requirements for previsualisation in the application area “visual effects based on computer simulation” are developed.

Visual Effects (also known as VFX) are a collection of content production techniques that are used mainly by the Film, TV and Animation Industries to enrich the looks of an audio-visual content, normally as a substitute of practical visual effects (built as part of the set or produced without the use of computer graphics).

VFX are also used in Stage Productions and Videogames, which often contain cinematics (this is, small film pieces that introduce the player to its backstory, and that drive its narrative along the game).

VFX have gradually replaced practical visual effects, as they become more and more realistic. This realism, especially when creating a VFX that relates to real-life (explosions, water, clothes, smoke…), requires computer simulations; e.g., fluid simulation allows producers to produce digitally any liquid that will be shown on screen, something that cannot be achieved with traditional animation techniques, or that would require an enormous effort to replicate without the aid of computer simulations.

To develop these requirements, interviews with different VFX producers were conducted.

1.1 Methodology

The process of defining the requirements for the VFX application area consists of four consecutive steps, including interviews, scenarios, use cases and deriving the functional requirements. This is an informed process based on relevant literature [1, 2, 3].

First, semi-structured interviews with professionals from the application context were conducted. The objective of the interviews was to obtain information on procedures adopted by users and on their expectations of the system and gather information based on the user's experience. The interview targeted current and envisioned previs practises, experience with previs and workflow, areas of improvement, current disadvantages of previs and limitations in everyday work, as well as preferences in the application area, ideas for the integration of previs in the future using 3D tools, and possible impact on the production. Individual questions based on the person being interviewed as well as follow up questions were allowed in order to spark idea generation and the exploration of alternatives.

For the VFX application area, interviews were conducted with the following persons:

- **Silvia Rasheva**, Producer at Unity Technologies; Adam demo (interactive short film) and Unity’s 2017 technical demo (confidential project; VR / interactive short film).
- **Raúl Rubio**, CEO, Co-Founder and Creative Director at Tequila Works; RiME video-game cinematics and The Invisible Hours (confidential project) cinematics.
- **Miguel Arjona Villanueva**, R&D Director at Altran Europe; Industry 4.0 (confidential project; interactive short film for training purposes).
- **Jean-Colas Prunier**, Creative Director at Crytek; FilmEngine project.

From these interviews we derived use case scenarios which generalize the answers from the interviews. For this, key statements were extracted from the interviews concerning tasks, workflow,

benefits and drawbacks of used software, input/output hardware, natural interaction techniques as well as preferences for new software. From these statements, scenarios were derived that summarize all statements from the different interviews and generalize from the concrete answers given in the interviews. Further, we developed individual use cases describing each of the tasks from the scenarios in more detail. Pre- and postconditions as well as a detailed description of the tasks are made.

From the scenarios and detailed use cases the final functional requirements for the Visual Effects application area were extracted. The requirements for each use case were derived first based on the content as well as the pre- and postconditions of the specific use case.

As different use cases can derive the same substantial requirements, the requirements were grouped and combined if possible. Driving actors and roles for the requirement were also considered in the process of grouping the requirements.

The following key statements were collected from the interviews:

- Computer simulation is essential to replicate real-world phenomena in a photorealistic way. Traditional animation is too expensive, and cannot achieve the same level of realism.
- Photorealism is a must for any audiovisual content that aims to be “immersive”. This is particularly important in Augmented and Virtual Reality experiences, as well as for stage production, in which real-world elements must coexist with digitally-produced VFX.
- VFX tools must be part of a standardized production pipeline and workflow. Input and output files must be compatible with other content production tools.
- New formats and media will be produced in game engines. VR and AR experiences require interactivity, and this can only be easily programmed on game engines; however, even traditional Animation films are being produced on these platforms.

Based on the interviews, different scenarios for the use of previsualisation for VFX production were developed. They are listed in the following section.

2 Scenarios

In this section, scenarios are developed that describe the future process of previsualisation with the first.stage software. Typical VFX production staff that will use the software is put in a fictional setting where the first.stage software will benefit the application area.

2.1 Computer Simulation Fosters New Ideas on Creative Directors

Silvia is working together with an internal client to develop a new audio-visual piece (an interactive short-film, produced on a game engine, and compatible with VR). This short-film must be representative of the state-of-the-art in VFX production, as it will be used as marketing material for their internal client’s software offering (a game engine); they want it to showcase how it is possible to create any kind of complex visuals for Animation, Advertising, Films and Games by using their tool.

However, the tool has its limitations, so the creative team under Silvia’s lead have restrictions that will undermine the visual impact of the short-film. They must be aware of the restrictions even before the

previsualisation process (this is, when conceptualizing the short-film), to avoid developing a story, setting or scenario that will be too hard or even impossible to create in a game engine.

When confronted to the idea of having a previsualisation tool that might help them to develop simulation-based VFX in a very early stage, and then to export the resulting animations (the simulation output is always a simulation or a photorealist picture) to include them on their game engine as a production asset, they expressed a huge interest on the project. Right now, their creative team tries to avoid using VFX based on particle, fluids, rigid and soft bodies, clothing, wind, fire, explosions and fractures because they are difficult or impossible to produce within their tool; this often translated to an apparent lack of creativity, when it is a consequence of the lack of simulation tools within the game engine.

If they could use a previsualisation tool whose output would be .fbx animation files, then those assets could be imported in their game engine and used to produce a better short-film, without the creative restraints that they initially forecasted in the conceptualization phase of the project. Computer simulations can solve creative problems in a seamless production pipeline and this can greatly foster creativity on producers and their creative teams.

The specific technical requirements described by Silvia include: Full import method from Maya and 3D Studio Max, cloth and ropes simulation, advanced fractures and daemons, concave & convex rigid bodies, soft bodies + rigid bodies interaction, .fbx export, file compression methods for “per vertex” animation, and complete workflow within Unity 5 (import, simulation, and export if necessary).

2.2 Workflow Simplification

Raúl is producing a video game that contains multiple cinematics (in-game videos, as a sequence of short-films) that drive its story, and that introduce the player to the setting, characters and universe in which it unfolds.

They are using a game engine to render the final animation and as their main pipeline tool, as the assets (3D models, textures, lighting presets) of the cinematics are shared with the game and must have the same visual quality.

However, some of the VFX that they are planning to include on the cinematics cannot be produced within the game engine, which lacks the computer simulation tools that are available in other content production tools for the Film, Advertising and Animation Industries. They do not want to discard them, so their only chance is to create a workaround and a very complicated pipeline, in which they: 1) Once the conceptualization phase is due, they develop the 3D models and textures in a modelling software tool (e.g., 3D Studio Max); 2) They import those assets to the game engine and fine-tune them, since some materials won’t look right on the game engine’s proprietary rendering shaders (this is their previsualisation part of the process); 3) They export again the assets to another content production tool (e.g., Maya) in which they use computer simulation tools to create animations for clothes, wind, hair, fire, fractures, collisions and so on; 4) They re-import the final animations to the game engine, in which they can proceed with the development of the cinematics. This is their pre-production and production part of the process.

The idea of being able to merge the creation of animations (via computer simulations) with their previsualisation process, by using first.stage as a previsualisation tool, was interesting to them. Raúl

mentioned that this would greatly improve the time and costs of their previs and pre-production phases, as they would only need to include one tool on their pipeline to solve both the previsualisation of the assets, the layout of their virtual stages, and the simulation of every VFX they might want to add to the scene.

The specific technical requirements described by Raúl include: Full import method from Maya, .fbx export, file compression methods for “per vertex” animation, keyframe animation (targeted animation / simulation), fractures and explosions, file compression methods for cloth simulations based in bones, and workflow within Unreal Engine 4.

2.3 Immersiveness as a Must

Miguel is managing several R&D Projects for an international Engineering firm. Some of those projects are about developing new machinery and tools for the 4.0 Industry (this is, factories and logistic platforms what are mostly automatized and in which human tracking of every process acquires a more strategic role). Machine-to-machine communication will be the norm in the future, and humans must learn how to interact with these new automated systems in factories and other workplaces.

So, the R&D projects he is managing revolve not only around the development of these new systems, but also around how to train new personnel to work with it. This training must be as close to reality as possible, but often the creation of a real-world scenario for training purposes is too expensive and slow. They are interested in creating a virtual replica of any factory, and to train its workforce in an immersive environment that is very close to the real experience.

Achieving the highest level of realism is a must in this case, because the future worker of a 4.0 factory must feel secure when in front of a real-life situation, even if her / his training was entirely virtual. Realism must not only relate to the visual aspect of the scenario, but also to the physic behaviour (animation) of every object in it.

This requires computer simulation, that must be implemented on the final VR experience or interactive film. However, this content cannot be created before the construction of the workplace (because the final location of every asset is sometimes not decided before the actual construction of the factory), nor too late after it’s completed. The content must be easily editable and must remain in a previsualisation stage for a long time before it can be rendered (compiled, in the case of VR experiences) right after the completion of the factory or logistic platform.

Miguel showed great interest in having a tool like first.stage for the previsualisation of this training contents, as they would be able to simulate the behaviour of the machinery right as it is being built; this transcends the concept of VFX, because they would not only use first.stage to create an immersive effect and improve the realism of their short-films and VR experiences; they would actually be contrasting the real-world experience that the workers will face with their virtual training course. Miguel foresees that this could even help them to prevent potential hazards on the workplace.

The specific technical requirements described by Miguel include: Full import method from 3D Studio Max, BIM and parametric modelling tools, .fbx export, file compression methods for “per vertex” animation, exposition of simulation parameters and results for Engineering evaluation, advanced daemons, targeted animation, and workflow within Unity 5 and / or Unreal Engine 4.

2.4 Simulation as the Centrepiece of Future Contents

Jean-Colas is the Creative Director of a software tool that aims to be part of the production pipeline of future contents, ranging from traditional Animation to VR experiences. Their software tools are a spin-off project of a game engine.

They are actively searching for new middleware tools that will improve the previsualisation stage for the users of their software. It is important to note that they want it to be able to carry every phase of the development of any content, from previsualisation to final rendering.

Computer simulation tools seemed interested to Jean-Cola's team and they elaborated on the idea of it being used as a centrepiece of the whole layout process. If every time a user wants to include an asset (a 3D model) on the scene he's required to set the physical properties of the said object (weight, optical and physical properties of its material, centre of mass, mobile parts…), then the whole scene could be simulated in a later stage, providing comprehensive animations for every asset. E.g., an explosion would affect every asset in a different way, depending on its weights and closeness to the explosive element, and while flying, every asset would collide with each other producing fractures, additional explosions and so on.

This is a radical change of philosophy regarding VFX production; normally, VFX was considered an add-on to improve the visual quality of a given content and it implied that it's a "trick", something unreal that sometimes drive users or spectators off, due to its lack of realism and immersiveness. On the other hand, if computer simulation is the centrepiece of a virtual scene, then VFX are a natural consequence of the realistic interactions between any asset (object; physic dynamics), or between objects and light (rendering). This is a game changer for the content production industries, as its aiming to an agile, cost-effective production of new media with a photorealist aesthetic goal.

Jean-Colas said that it would be great if first.stage libraries (not only for computer simulation) would be available for thirds parties to integrate them in their own content production platforms. This would require us to work without any compromise on a given game engine – keeping our libraries as agnostic as possible – to facilitate later integrations.

The specific technical requirements described by Jean-Colas include: Full import method from Maya, Cinema 4D, Rhinoceros and 3D Studio Max, .fbx export, workflow within Unity, voronoid and irregular fractures, ropes and cloth simulation (bones and per vertex), and workflow within CryEngine / FilmEngine.

3 Use Cases

In this section use cases are developed that describe typical tasks performed with the first.stage previs software.

Scenario	UC #	UC Name	UC description	Actors	Flow
3.1 Computer Simulation Fosters New Ideas on Creative Directors	UC1	Concept Development	A list of features of first.stage is considered in the	Creative Director, Producer	Checklist of features of the tool during brainstorming

			conceptualization phase to foster new ideas		
	UC2	Previs and pre-production	First.stage is used to previsualize the concept, but also to generate new production assets (animations)	Creative Team, Development Team, Producer, Directors	Import of pre-production assets to first.stage, and export of .fbx to a game engine
3.2 Workflow Simplification	UC3	Pipeline	First.stage substitutes several content production tools for computer simulation	Producer, Development Director, Technical Lead	Analysis on the time and cost profit of using first.stage instead of several tools
	UC4	Previs and pre-production	First.stage merges the production of physically based animations with previs; this is, previsualisation and pre-production	Creative Team, Development Team, Producer, Directors	Import of pre-production assets to first.stage, and export of .fbx to a game engine
3.3 Immersiveness as a Must	UC5	Realism Goal	The previs stage includes several iterations, until the pre-produced content is immersive enough to be considered a valid virtual training experience	R&D Team, Directors, Creative Team, Producer, Developers	Constant iteration of both virtual and real-life environments to achieve the most realism
	UC6	Previs and pre-production	First.stage is used in a constant process of previs and pre-production, during the construction of the workplace	Creative Team, Development Team, Producer, Directors	Import of pre-production assets to first.stage, and export of .fbx to a game engine
3.4 Simulation as the Centrepiece of Future Contents	UC7	Libraries	First.stage libraries are part of a content production platform	R&D Team, Directors, Creative Team, Producer, Developers	Integration of our libraries in a third-party platform
	UC8	Previs and pre-production	First.stage is used due to its computer simulation capabilities as the layout core	Creative Team, Development Team, Producer, Directors	Import of pre-production assets to first.stage, as part of a game engine of production tool

3.1 UC1: Concept Development

Short Description:

A list of features of first.stage is considered in the conceptualization phase to foster new ideas among the Creative Team.

Precondition:

A list of features and visual examples are provided along with the first.stage software package, for users to explores its potential before using it.

The list is available online, in a documentation section for first.stage, and is updated whenever a new feature is available.

Postcondition:

The list of features and its visual examples must be representative of the final quality that can be achieved with the first.stage toolset.

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3.2 UC2: Previs and Pre-Production

Short Description:

First.stage is used to previsualize the concept, but also to generate new production assets (animations) that can be used in later stages of the creative process.

Precondition:

First.stage must be compatible with most file types and content production platforms (especially with 3D modelling, animation, texturing and motion capture tools) to be able to import seamlessly the pre-production assets created with them.

Among the software tools that were mentioned in the interviews for a required compatibility, are: Maya, 3D Studio Max, Cinema 4D, Rhinoceros and BIM tools.

Postcondition:

First.stage must be compatible with most file types and content production platforms to be able to export seamlessly the pre-production assets created within first.stage with computer simulations.

It has been specifically required to include support of .fbx files as an export method for physically-based animations. The said .fbx must be optimized in size, via compression methods and optimization, to be used in game engines.

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3.3 UC3: Pipeline

Short Description:

First.stage substitutes several content production tools for computer simulation.

Precondition:
The user is currently using several tools to produce different physically based animations and simulations, which can be solved all at once by using first.stage (e.g., RealFlow on Cinema 4D for fluids, CaronteFX on Unity for fractures, Maxwell Render on 3D Studio Max for photo-realistic textures).

Postcondition:
The cost of first.Stage is competitive and lower that the cost of having licenses for different content production platforms and their respective computer simulations plug-ins.

Any commercial or marketing document about first.stage must also state that there is time saving by using a tool that is fully compatible with current production pipelines and cost savings as there is no need for special training or overspecialized professionals to use our toolset, as its learning curve is not steep, and the use of NUI guidelines, hardware and tools can ease its use.

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3.4 UC4: Previs and Pre-Production

Short Description:
First.stage merges the production of physically-based animations with previs; this is previsualisation and pre-production in a single stage.

Precondition:
First.stage must be compatible with most file types and content production platforms (especially with 3D modelling, animation, texturing and motion capture tools) to be able to import seamlessly the pre-production assets created with them.

Postcondition:
First.stage must be compatible with most file types and content production platforms to be able to export seamlessly the pre-production assets created within first.stage with computer simulations.

It has been specifically mentioned that production platforms could be game engines (Unity 5, Unreal Engine 4, CryEngine / FilmEngine), along with traditional content creation platforms like Maya.

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3.5 UC5: Realism Goal

Short Description:
The previs stage includes several iterations, until the pre-produced content is immersive enough to be considered a valid virtual training experience.

Precondition:
A digital / virtual representation of the machinery that will be 4.0 factory must be imported in first.stage as 3D models; the correspondence of this asset with its real-life model is essential to obtain a high-fidelity simulation of its behaviour.

Postcondition:
It must be possible to iterate several times on the computer simulation until the virtual representation of the 4.0 factory matches the real-life workplace. The final iteration before production must be done once the construction is over.

Simulation data and parameters must be exposed when producing simulations for engineering and training in 4.0 factories.

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3.6 UC6: Previs and Pre-Production

Short Description:
First.stage is used in a constant process of previs and pre-production, during the construction of the workplace.

Precondition:
First.stage must be compatible with most file types and content production platforms (especially with 3D modelling, animation, texturing and motion capture tools) to be able to import seamlessly the pre-production assets created with them. Platforms with required compatibility: Maya, Cinema 4D and 3D Studio Max, among others.

Postcondition:
First.stage must be compatible with most file types and content production platforms to be able to export seamlessly the pre-production assets created within first.stage with computer simulations. Platforms with required compatibility: Maya and Cinema 4D for the production of audiovisual pieces (specifically animation and VFX), and game engines for the production of VR / AR experiences and in-game cinematics for video games.

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3.7 UC7: Libraries

Short Description:
First.stage libraries are part of a content production platform.

Precondition:
The libraries that constitute first.stage must be software agnostic, so they can be implemented as middleware in third-party platforms.

The said libraries must be developed, when possible, in C++.

Postcondition:
The output of the libraries must be compatible with the rest of the workflow that is provided by the content creation platform in which they have been implemented.

Libraries in C++ must be wrapped in C# code as plug-ins for current production platforms (e.g., as plug-ins for Unity 5).

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3.8 UC8: Previs and Pre-Production

Short Description:
First.stage is used due to its computer simulation capabilities as the layout core.

Precondition:
First.stage must be compatible with most file types and content production platforms (especially with 3D modelling, animation, texturing and motion capture tools) to be able to import seamlessly the pre-production assets created with them. Platforms with required compatibility: Maya, Cinema 4D and 3D Studio Max, among others.

Postcondition:
First.stage must be compatible with most file types and content production platforms to be able to export seamlessly the pre-production assets created within first.stage with computer simulations. Platforms with required compatibility: Maya and Cinema 4D for the production of audiovisual pieces (specifically animation and VFX), and game engines for the production of VR / AR experiences and in-game cinematics for video games.

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4 Functional Requirements

4.1 Requirement: Documentation

Driven by: Creative Director, Producer

Related Use Case: UC1

Description: First.stage must have both technical and marketing documentation, in which its features are exposed along with creative examples and case studies.

4.2 Requirement: Assets Import

Driven by: Creative Team, Development Team, Producer, Directors

Related Use Case: UC2, UC4, UC6, UC8

Description: First.stage must be compatible with most file types and content production plat-forms (especially with 3D modelling, animation, texturing and motion capture tools) to be able to import seamlessly the pre-production assets created with them. Platforms with required compatibility: Maya, Cinema 4D and 3D Studio Max, among others.

4.3 Requirement: Assets Export

Driven by: Creative Team, Development Team, Producer, Directors

Related Use Case: UC2, UC4, UC6, UC8

Description: first.stage must be compatible with most file types and content production platforms to be able to export seamlessly the pre-production assets created within first.stage with computer

simulations. .fbx files are mentioned as an important file type to support (all simulations must be exported as physically-based animations in .fbx). Maya and Cinema 4D for the production of audiovisual pieces (specifically animation and VFX), and game engines (Unity 5) for the production of VR / AR experiences and in-game cinematics for video games.

4.4 Requirement: Licensing

Driven by: Producer, Development Director, Technical Lead

Related Use Case: UC3

Description: First.stage must be licensed or purchased by users in a similar fashion to other content production tools, to allow an easy comparison between platforms in terms of price, license term, time saving and features. This has been mentioned as a key factor to decide on the use of our toolset.

4.5 Requirement: Agile Parametrization

Driven by: R&D Team, Directors, Creative Team, Producer, Developers

Related Use Case: UC5

Description: Computer simulations must be described in clear, intuitive, easy-to-learn parameters, to accelerate the many iterations that could be needed when a virtual animation need to match exactly the behaviour of a real-life object / machinery. Parameters must be self-explanatory, as well as documented in the technical documentation of first.stage. Parameters and simulation data must be exposed for engineering purposes (training in 4.0 factories and simulation optimization for improved realism).

4.6 Requirement: Integration Capabilities

Driven by: R&D Team, Directors, Creative Team, Producer, Developers

Related Use Case: UC7

Description: First.stage is comprised by a series of libraries that are showcased in a Unity application. However, the libraries must be kept as agnostic as possible of any content pro-duction platform, to facilitate a potential integration of the said tools as middleware in a third-party platform.

Libraries should be written in C++ code when possible and wrapped in C# modules (plug-ins) to ensure its compatibility with current production pipeline tools.

5 Assessment of Output Quality

In order to assess the quality of the requirements gathered in this document and to ensure that these are valid requirements, two steps were performed based on common user experience guidelines and practises [1]. First, after gathering all requirements for all four application areas of the first.stage project, the requirements were reviewed and prioritized by each application partner. Prioritisation included all requirements, sorting them in either of the three categories low, medium, and high priority. Thus, less important requirements could be identified in order to focus on core and the most important functions of the future system while at the same time incorporating a control loop that allows for dismissal of certain requirements, which however was not the case. All requirements were kept. However, the order of implementation is highly dependent on the priority of the requirements. The

prioritized requirements can be found in Deliverable 1.5. This step ensures that only valid and important requirements result from the requirement analysis.

As a second step, the requirements are subject to constant validation, change and rework in the process of testing the prototypes developed based on these requirements. These efforts are rooted in Work Package 6. Based on the iterative approach of software development practices [1], on the basis of the initial requirements and their priorities, first prototypes are developed. These prototypes are tested iteratively in the application context with professionals. Based on the results of these tests, the requirements are adapted and new ones are added if necessary. In addition, non-functional requirements regarding the interaction with the system are gathered based on first user tests of prototypes, as interaction requirements are often hard to obtain from users without much technical knowledge. The results of the new and re-worked requirements can also be found in Deliverable 1.5.

6 References

[1] Rex Hartson and Pardha S. Pyla. The UX Book: Process and Guidelines for Ensuring a Quality User Experience. Elsevier, 2012.

[2] John M. Carroll. Making Use: Scenario-based Design of Human-Computer Interactions. MIT Press, 2000.

[3] Klaus Pohl. Requirements Engineering: Fundamentals, Principles, and Techniques. Springer Publishing, 2010.

7 Document History

Ver.	Date	Changes	Author
V1.0	08/11/2016	Creation of the document	Gustavo Liévano
V1.1	11/11/2016	General iteration of the text within Next Limit	Gustavo Liévano
V1.2	14/11/2016	Second iteration of the text with members of the consortium	Gustavo Liévano
V2.0	16/11/2016	Finalised version	Gustavo Liévano
V3.0	28/11/2016	Updated version	Gustavo Liévano
V4.0	23/04/2018	Updated version including officer's comments	J.A. Clemente

