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SHARING KNOWLEDGE AND EXPERIENCE ABOUT BINAURAL SOUND: A WHITE PAPER BASED ON STORY MAPPING

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ABSTRACT

Although known for a long time, binaural spatialization now stands as one of the best ways of producing a genuine sound immersion. Two microphones placed inside the ears of either a sound technician or a dummy-head are enough to create a compelling sensation of real-life, arising a great deal of interest among audiovisual creators and distributors as well as in the industrial sector. But for the operators, this biomimetic approach represents a paradigm shift. Developing binaural tools or products requires pooling several types of knowledge: research advances, production workflows and actual use cases. The project of a white paper was initiated to address this need by crossing two expertises: scientific research on 3D sound (technology, sound perception, neurosciences, etc.) and audio production in binaural (technological processes, recording and playing conditions, dedicated writing, impact on the listener, use cases, etc.). In order to make exploration of such varied knowledge easier, especially by heterogeneous publics, the white paper will take the shape of an interactive multimedia tool, inspired by story mapping and based on the geography of an imaginary planet. Through intuitive browsing, this tool will offer access to numerous resources (audio, video, textual, graphs, pictures etc.) which are currently scattered between research labs and production structures.

Keywords: *binaural, immersion, story mapping, education*

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1. INTRODUCTION

Today there are many domains where sound immersion may greatly improve the Quality of Experience (QoE) [1] or even provide new functionalities (e.g. Human-Machine Interaction, see the Chapter "Assessment of binaural-proprioceptive interaction in Human-Machine Interfaces" in [2]). The scope of application extends from audio or audiovisual content (radio, television, music, live events etc.) [3–6] to communication [1], museography [7] and video games. Virtual or augmented reality (more generally eXtended Reality or XR) opens now new opportunities [8]. Among all 3D audio technologies, binaural sound [9,10] holds a particular place. It is an old technique (1930), which has been long-overlooked [11], except that everyone passes through it to perceive and analyze sound scenes. Even more, one must be aware of the fact that any soundfield, whether natural or artificial, is going to be processed and assessed by the binaural system of a human being. Thus binaural spatialization can be seen as a kind of reference of spatial hearing [2, 12, 13]. As the closest method to natural listening, binaural technology may seem simple and intuitive to use. However, experience shows that creating binaural works requires to have an expert knowledge of many issues at all stages (writing, recording, post-production, rendering). For instance, when a natural soundfield is recorded by a dummy head, the sound engineer must be aware that the entire sound space is captured (i.e. target sound sources and potential interfering sources), meaning that there is no "off-camera space". This has an impact on the writing, the directing and the post-production. Another issue concerns the way the listener is addressed. Indeed, due to natural immersion of binaural sound added to headphone rendering, the sound scene pervades the intimacy sphere of the listener,

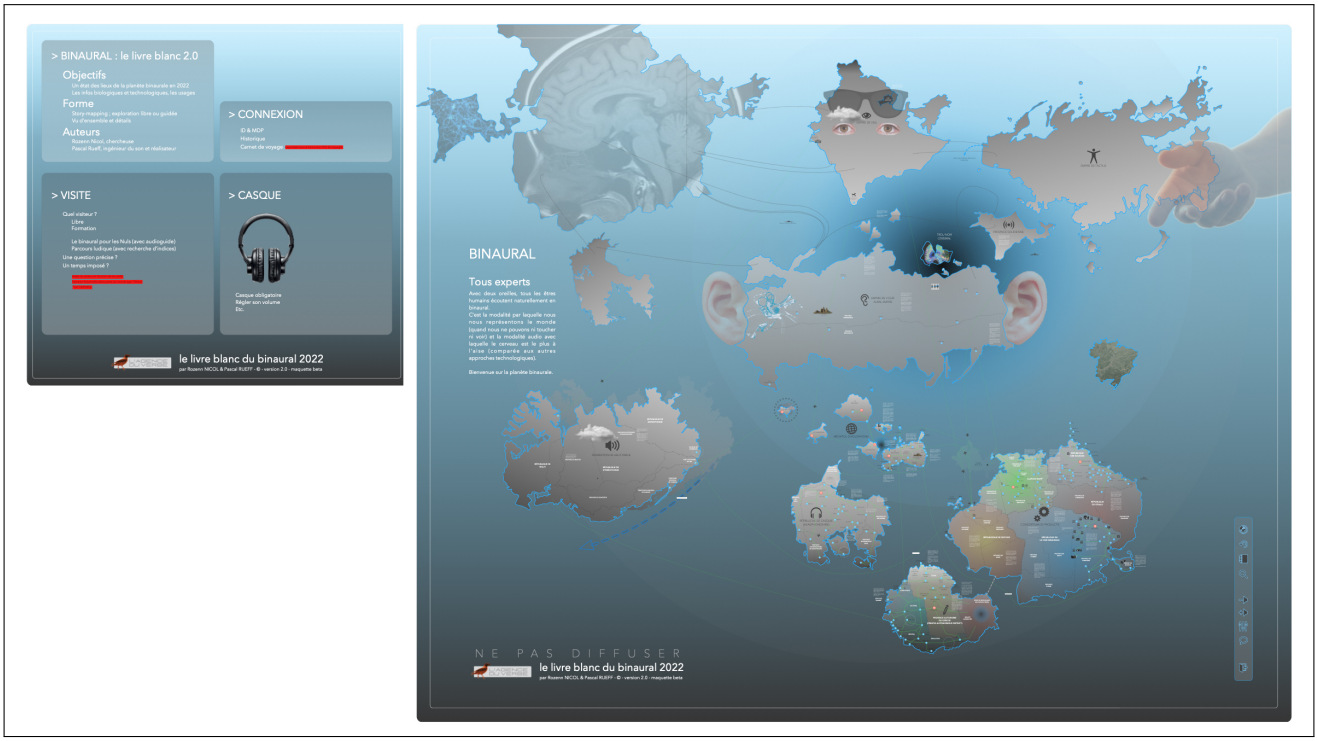

Figure 1. Preliminary prototype design of the white paper: Overview of the whole interface based on the "Binaural Planet". Pilot version in french.

which can lead to very strong effects, but must be used with subtlety.

Moreover, people involved in binaural production have heterogeneous backgrounds and cultures, which can make it more or less difficult to understand certain aspects. This is all the more complex as it is necessary to integrate various types of knowledge (hardware, software, scientific studies etc.).

As the attention for 3D audio is becoming general [4, 6], a white paper providing a hierarchical exploration of binaural technology appeared as a relevant solution to help any practitioner in this context. The overall project will be presented in this paper, starting by recalling its motivation in Section 2. Then Section 3 will describe the content. As for the formatting of information, it will be inspired by story mapping [14], allowing interactive and multi-level navigation (see Fig. 1). This point will be detailed in Section 4, before concluding.

2. MOTIVATIONS OF THE PROJECT

Now binaural sound has been taken out of the labs [15, 16] and stands as one of the best ways of producing a genuine sound immersion. Two microphones placed inside the ears of either a sound technician or a dummy-head are enough to create the illusion of natural listening : the real-life sensation is compelling [11]. More importantly, binaural sound is a technically lightweight solution: the binaural stream is only composed of 2 signals and is rendered by conventional headphones. Furthermore, acceptance of headphone listening is no longer an obstacle since smartphones have invaded our lives. For all these reasons, this 3D audio approach, which enables a natural immersion of the listener inside the soundscape, arouses a great deal of interest among audiovisual creators and distributors as well as in the industrial sector [3].

However, for the operators, this biomimetic approach represents a paradigm shift. Between scientific knowledge, production workflows and actual use cases, it may be difficult to find the existing expertise. Moreover this expertise needed to implement binaural technology cov-

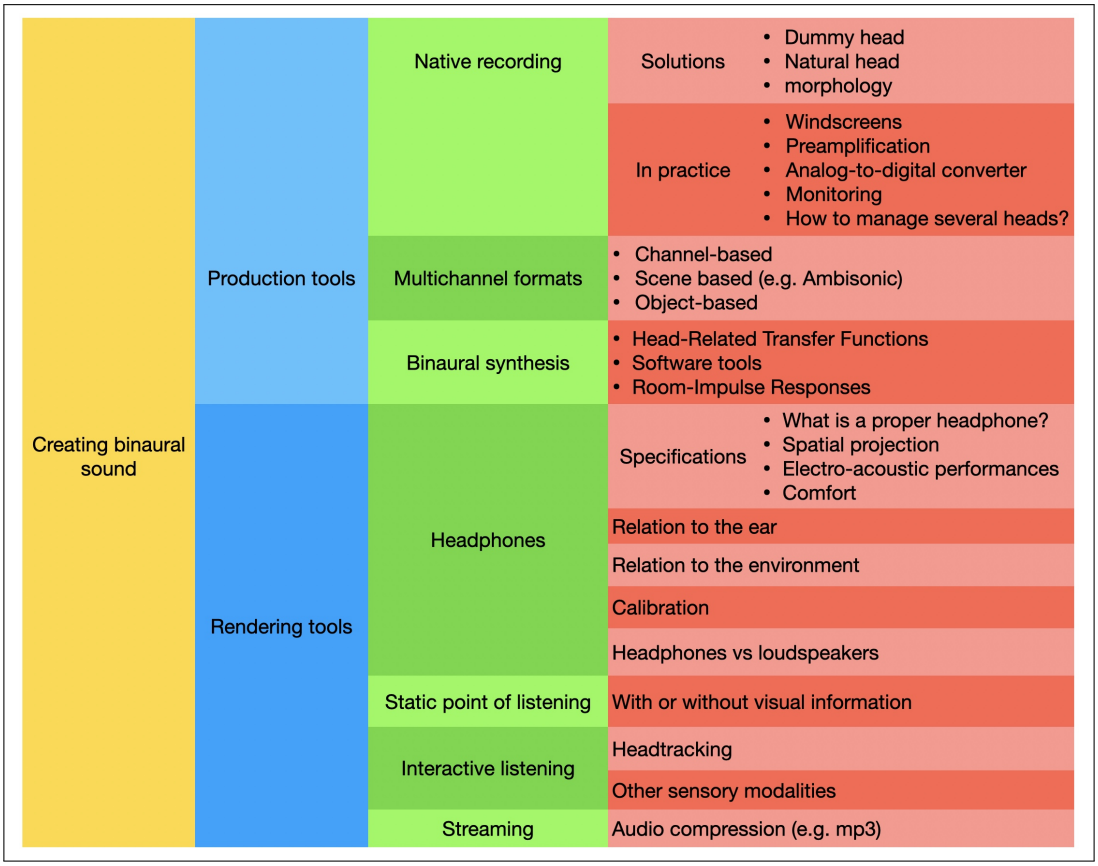

Figure 2. Preview of the white paper contents (resulting from a mind map): First levels of the tree structure corresponding to the creation of a binaural sound.

ers many areas: signal processing, acoustic transducers, sound perception, cross-modal interactions etc. To answer this issue, the project of a white paper on binaural sound was initiated, with the dual ambition of aggregating knowledge of various natures (i.e. research studies and results, software and hardware implementation, and best practices learnt from case studies) and sharing this knowledge with heterogeneous audience (i.e. researchers, students, sound engineers, authors, producers, distributors, etc.).

3. CONTENT: FROM THEORY TO PRACTICE, AND VICE-VERSA

The objective of this white paper is to present the different steps of the creation process of a binaural sound, starting from the recording to the diffusion. An overview of the topics covered is given in Fig. 2, Fig. 3 and Fig. 4. Practical aspects will receive a scientific insight, explaining the origin of the choices and methods applied (Fig. 5). Prior to the recording, the writing phase must also be carefully considered to take into account all the specificities of the 3D approach. In the same way, it is fruitful to analyze the perception of a binaural reproduction in the light of auditory cognition (Fig. 3).

In addition, binaural technology must be placed in the broader context of sound spatialization, which requires to provide knowledge about related topics such as: other 3D audio methods, signal processing, spatial audio perception, cross-modal interaction (particularly interaction between auditory and visual stimuli), without forgetting the historical perspective. Furthermore, one should bear in mind that, as previously mentionned, binaural listening is a kind of common denominator to all forms of spatial au-

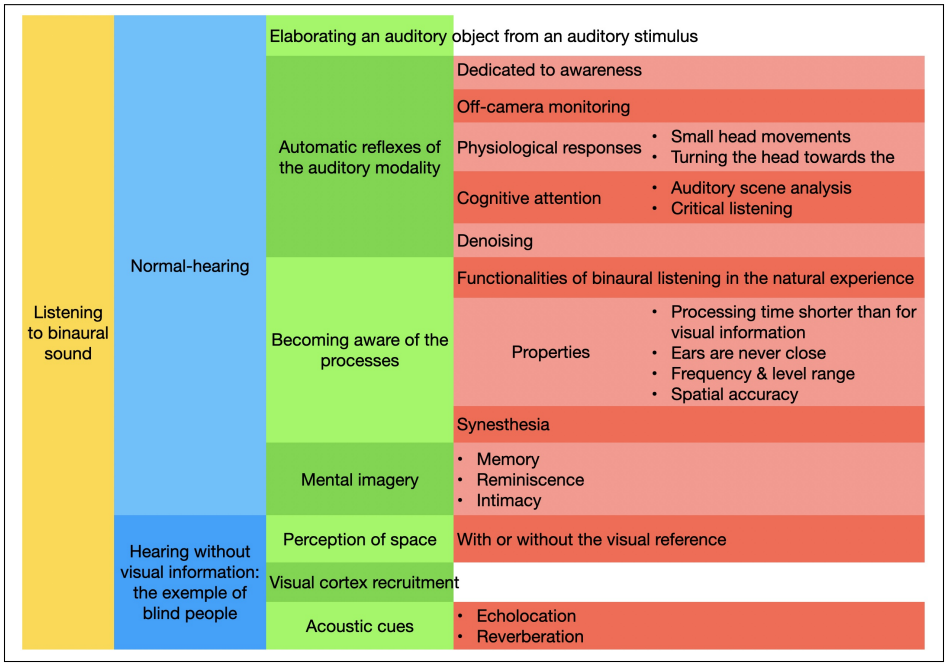

Figure 3. Preview of the white paper contents: First levels of the tree structure corresponding to the listening to a binaural sound.

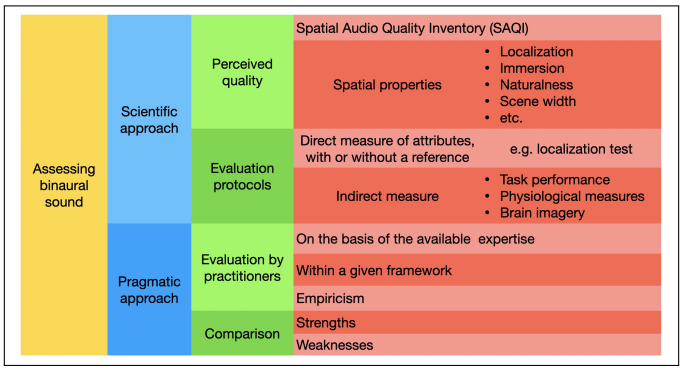

Figure 4. Preview of the white paper contents: First levels of the tree structure corresponding to the assessment of a binaural sound.

dio. It is not only the reference of listening experience in our daily life, but it is also the way by which we analyze the soundfield reproduced by any method of sound spatialization. Lastly, it is worth highlighting that, for all 3D audio formats, binaural decoding is an elegant way to create a virtual loudspeaker setup, which becomes more and more attractive as the number of channels is very high and makes a real implementation too expensive or complex [17].

Beyond the scope of the topics covered, the information made available will take various forms: theoretical content, scientific studies, graphs, illustrations by audio or audiovisual content, audio software and hardware tools or products (e.g. dummy-heads, microphones, headphones, Digital Audio Workstation, signal processing libraries etc.). Thus the diversity of expectations of audiences as varied as researchers, engineers, authors or producers could be addressed. Moreover hierarchical presentation will help each one to select the detail level adapted to his(her) understanding of the field.

4. IN THE FORM OF STORY MAPPING

To achieve this ambitious project, both in terms of content and reach, the concept of story mapping [14] appears as a promising solution, allowing to pool interconnected skills of various origins (scientific, biological, technological) and make their exploration easier. The white paper will take the shape of a map describing an imaginary planet, the ”Binaural Planet” (see Fig. 1 and Fig. 6), where each main topic is presented as a continent (e.g. ”Headphone

Figure 5. Preview of the white paper contents: First levels of the tree structure corresponding to the scientific keys for a deeper understanding.

Republic", "Empire of Eyesee", "Aural Empire", "Tactilean Empire") or an island (e.g. "Binaural Island", "Ambisonic Island", "Psycho-acoustic Island"), which may be divided in several countries corresponding to sub-topics. For instance, the continent named "Creating Consortium" is composed of the "Republic of the Binaural Way", the "Clan of Native", the "Republic of Rendering", the "Republic of Sources", and the "Republic of Assessment". The visitor can see the whole content at a glance. Then, through intuitive and interactive browsing, allowing one to zoom in or out, according to one's tropisms, this map-like tool offers access to a vast number of resources (audio, video, textual, graphs, pictures...), which are currently scattered between research labs and production structures.

To travel up and down the binaural planet, the visitor has the possibility to select the travel option best suiting his(her) wishes, needs or profile : free browsing, mapped out route, search engine, quick look of the busy traveller type or treasure hunt, available from age 7 to 107. The selection of the language version (either french or english) is also available. The interface then invites him(her) to make his(her) way through the Empire of Eyesee, the Aural Empire, the Tactilean Empire or the Solidian Territory, to visit the Monophonian, Stereophonian and Multi-C Republics, to travel the length of the Holophony Archipelago before calling at the Isle of Binaural, where scheduled connecting services to the Psychean and Acoustean Islands can be found.

Furthermore, with this type of media, updating the content is very easy: you just have to add Points Of Interest (POI), like in the GPS (Global Positioning System) environment. This property is valuable in a context where technologies and uses evolve rapidly. Our understanding of the underlying phenomena is also continuously enriched. Besides, while the initial version will be created essentially by the two authors of the present paper, future evolution may include contributions from other people. The white paper could thus become a collective work, in which the first two authors would play the role of an editorial board. The integration of such contributions will be simple with the concept of story mapping.

5. CONCLUSION

The project of a white paper on binaural sound was presented. For more than 20 years, the authors (a researcher in spatial audio and a sound engineer expert in creating binaural pieces) have worked together to establish a state of the art in the field of binaural production. Now the objective of the white paper is to bring together all the knowledge gathered and to share it for free with all the diversity of the public concerned. This white paper will take the original form of an interactive multimedia tool, inspired by story mapping. The project is supported by the French Society of Acoustics (SFA). Several actors of the academic or industrial community (for instance: the International Master IMDEA of Le Mans University [18], the Master *Image & Son* of Brest University [19], the Lab-STICC –*Laboratoire des Sciences et Techniques de l'information et de la Communication et de la Connaissance*– [20], France Médias Monde/ RFI Lab [21]) have also shown a strong interest in its realization. The technologies to develop this product are available and a graphic web studio likely to devise this educational tool is identified. Next step will be to initiate partnerships in order to secure its funding and start the pre-production phase.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] J. Skowronek, A. Raake, G. Berndtsson, O. Rummukainen, P. Usai, A. Gunkel, M. Johanson, E. Habets, L. Malfait, D. Lindero, and A. Toet, "Quality of experience in telemeetings and videoconferencing: A comprehensive survey," *IEEE Access*, vol. 10, pp. 63885–63931, 2022.

[2] J. Blauert, *The Technology of Binaural Listening*. Heidelberg: Springer Berlin, 2013.

[3] `www.bili-project.org`. Accessed: 2023-04-25.

[4] J. Kares and V. Larcher, "Streaming immersive audio content," in *Proc. of the AES Conference for Virtual and Augmented Reality*, (Los Angeles, USA), 2016.

[5] `www.dolby.com/technologies/dolby-atmos/`. Accessed: 2023-04-27.

[6] M. Gorzel, A. Allen, I. Kelly, J. Kammerl, A. Gungormusler, H. Yeh, and F. Boland, "Efficient encoding and decoding of binaural sound with resonance audio," in *Proc. of the AES Conference on Immersive and Interactive Audio*, (York, UK), 2019.

[7] `hyperradio.radiofrance.com/blog/projets-blog/hotel-de-la-marine-quand-le-son-3d-transforme-une-visite-en-experience-inedite/`. Accessed: 2023-04-25.

[8] J. Yang, A. Barde, and M. Billinghurst, "Audio augmented reality: A systematic review of technologies, applications and future research directions," *J. Audio Eng. Soc.*, vol. 70, pp. 788–809, 2022.

[9] R. Nicol, *Binaural Technology*. AES Monograph, 2010.

[10] `www.binaural.fr`. Accessed: 2023-04-27.

[11] S. Krebs, "The failure of binaural stereo: German sound engineers and the introduction of artificial head microphones," *Icon*, vol. 23, p. 113–144, 2017.

[12] J. Blauert, *Spatial Hearing: The Psychophysics of Human Sound Localization*. MIT Press, 1996.

[13] J. Blauert and J. Braasch, *The Technology of Binaural Understanding*. Springer Cham, 2020.

[14] J. Patton, *User Story Mapping*. O'Reilly Media, 2014.

[15] www.bbc.co.uk/rd/projects/binaural-broadcasting. Accessed: 2023-04-27.

[16] hyperradio.radiofrance.com/son-3d/. Accessed: 2023-04-27.

[17] K. Sunder, K. Jain, R. Cohen, and G. Lurssen, "Reliable and trustworthy virtual production workflow for surround and atmos," in *Proc. of the AES 153rd Convention*, 2022.

[18] https://imdeacoustics.univ-lemans.fr/en/index.html. Accessed: 2023-05-10.

[19] https://www.univ-brest.fr/isb/. Accessed: 2023-05-10.

[20] https://labsticc.fr/en. Accessed: 2023-05-10.

[21] https://www.francemediasmonde.com/dp/rfi/fr/90-RFI-Les-voix-du-monde.html#/page/90. Accessed: 2023-05-10.

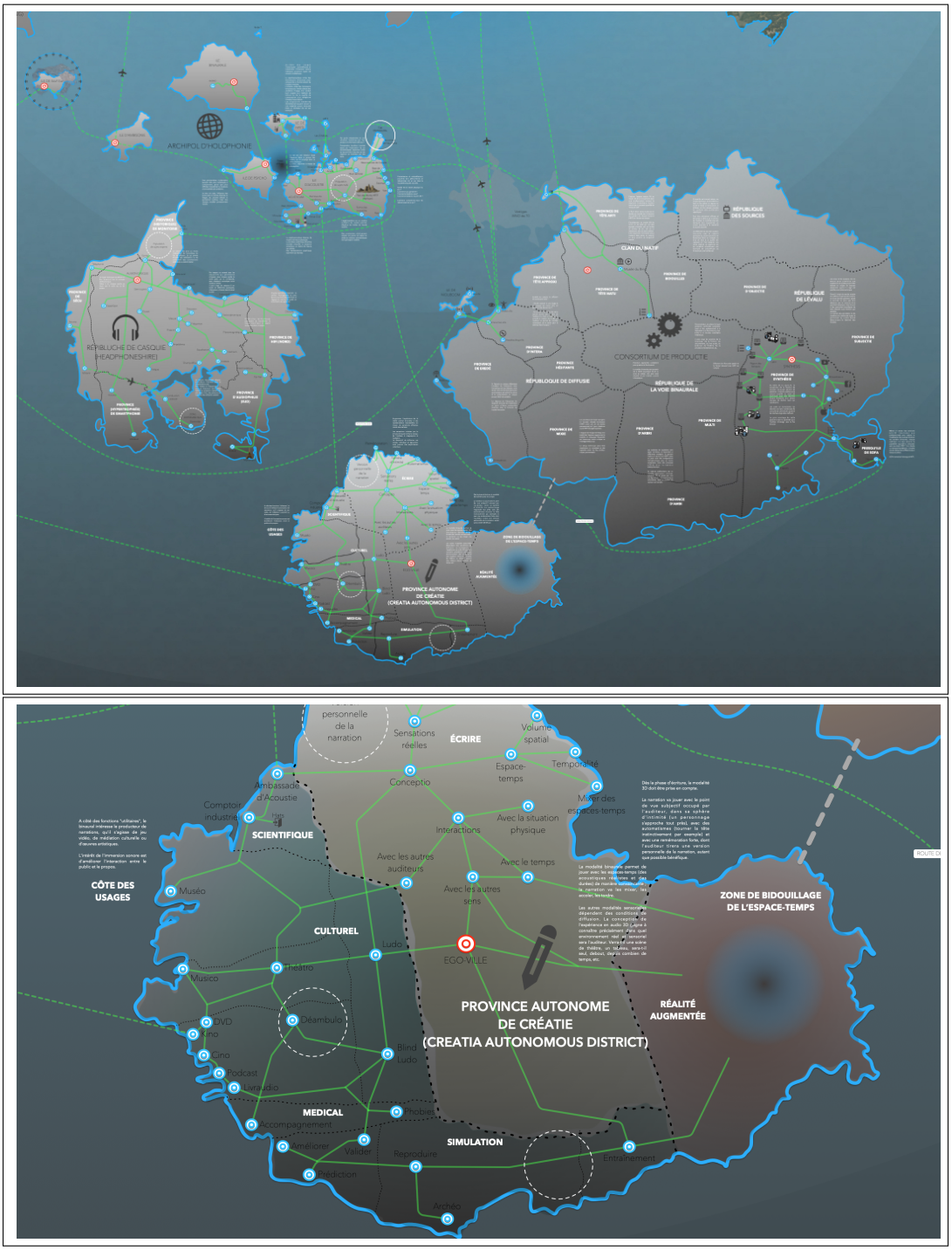

Figure 6. The concept of story mapping applied to the white paper: Examples of the ”Consortium of Production”, the ”Republic of Headphones” and the ”Creatia Autonomous District” (top) and enlarged view of this latter (bottom). Pilot version in french.