Prototyping Future Scenarios For Urban Planning Through The Production Of Virtual Reality Scenes

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Abstract
Designing 3D urban scenes for Virtual Reality (VR) offers the opportunity to transfer future scenario narratives to multiple publics involved in urban planning. Nevertheless, there is a current lack of conceptual frameworks to produce VR environments out of future scenarios. This research explores how scenarios might be enhanced and communicated through VR narrative environments. It elaborates and test the Scenarios-to-Scenes' framework, encompassing three steps: (i) generation of future stories; (ii) real/virtual places; and (iii) VR experiences. The framework was tested with urban planners, academics, and media communication experts in two collaborative workshop settings. This process illustrated the frameworks' capacity to enable the expansion of scenario contents out of diverse participants' interpretations and to transfer key narrative and design elements for the VR scenes.

Keywords: scenario prototyping, Virtual Reality, narrative environments, 3D urban scenes

1. Introduction

Urban planning is an activity deemed to the co-production of endurable future by multiple actors. Scenario writing, as the dominant technique for representing futures in scenario planning methods, offers the potential to engage the natural ability of humans for making sense of stories (Burnam-Fink, 2015), creating a common understanding about urban change. But it is the design of narrative environments (von Stackelberg and Jones, 2014), using a wider array of forms to experience the future –perceptually, cognitively, emotionally–, which may foster the transferability and usability of scenarios across different professional and non-professional domains in urban planning.

The concept of scenario prototypes encompasses all those narrative forms – i.e. stories of the future – that bring abstract or partial ideas/images of conventional future-scenario narratives into a present experience of such future. The here called *narrative prototypes* use fictional/speculative stories as mechanisms to explore and tests complex concepts. In science-fiction prototyping, such concept probing depends on how scenario narratives deploy one *novum* or multiple *nova*, that is, "primary points-of-reference" that make readers to distinct fictional futures from their home reality (Raven, 2014): e.g. disruptive technology, concept, event... Immersive Virtual Environments are being explored as the ultimate means of producing scenario prototypes, combining Virtual Reality (VR) capacity for sensory immersion and spatial presence with the natural capacity of humans for building their own stories about places (Stepanovic and Ferraro, 2020).

The production of VR 3D urban scenes using scenarios to transform present places into virtual futures offers the opportunity to expand scenario narratives towards richer narrative

environments. Nevertheless, there is a current lack of conceptual frameworks to deal with two main challenges of VR scenario prototyping: interpreting scenario narratives in multiple geographical contexts, enabling its localisation; and adapting scenario contents to visual communication of VR scenes, balancing "spectacular" realism with efficient 3D-scenes design.

The first challenge has been addressed from a narratological perspective. How futures are experienced from multiple audience is mediated through narrative elements embedded in scenario prototypes (Raven and Elahi, 2015). The first element is the *story-world*, or the spatial and temporal setting of the events. Beyond a mere "context for the story", future changes can be translated into a sequence of spatially and temporally relevant places in the synthetic VR space (Vallance and Towndrow, 2022). The second element is the *story* or "plot", as the sequence of contingently related actions having an identifiable beginning, middle, and end (Shearer, 2004) – typical "story arc". The focus on "actions" and "actors" and finite story arcs may contribute to create interpretative frames for explaining complex causation underlying future change – e.g. motivations, triggers, contingencies… (Derbyshire and Wright, 2017). The third element, *narration/storytelling*, involves the form of the narrative discourse – i.e., the explanation of why something happens (Shearer, 2004) – in connection to alternative narrative strategies (Raven, 2014; Raven and Elahi, 2015). On one hand, strategies focusing on realism though comprehensive worldbuilding connects better with the paradigmatic forms of presentation (i.e. exposition, argumentation) of technical/academic environments. On the other hand, those strategies highlighting the story rely on the description of actors and their actions, in line with narrative presentation (von Stackelberg and Jones, 2014).

The second challenge involves how previous narrative elements are translated to the codes and languages of VR scenes. Despite urban scene ontologies offer a full menu of choices based on functions and architectural typologies (Berta, Caneparo and Rolfo, 2020) or identified objects (Zhang *et al.*, 2018), such ontological frameworks are not enough to anticipate the multiple meanings captured by scenario narratives (Wu *et al.*, 2022). Interpretative frameworks may require the adoption of semiotic approaches to VR, which distinguish between previous *syntaxis/sematic* levels of communication, capturing the structure and meaning of content to be decoded by the user (i.e. the 3D scene model), from the *pragmatic* level, or how VR users "decode" such content (Barricelli *et al.*, 2016). Highlighting the later, VR scene production (as other computer interface designs) is a generative process, that is, it creates a representation of the message together with a "model user" able to interpret it (Barr, Biddle and Noble, 2004). Classic narrative semiotic models based on actors' participation into actions (as subjects, objects, senders, receivers, helpers, opponents… in Greimas' actantial model) may become useful tools, in combination to the abovementioned narrative strategies, for anticipating how publics create meaning through key transformations (Hebert and Eveaert-Desmedt, 2011). In the same fashion, virtual environments deploy a set of affordances and visual stimuli (i.e., a perceptual map) that guides VR users through a set of discoveries, barriers and rewarding experiences. The same grammars used for analysing narrative strategies in 3D games and virtual environments can turn into generative systems to produce them (Fencott, 2001).

Considered the previous challenges, semiotic principles and analytic tools, this research aims to design and test a framework for converting *Scenarios to Scenes* (StS framework). This framework relies on expanded scenario narratives and 3D urban scene concepts as prototypes for creating immersive VR narrative environments, as explained in Section 2. In addition, the applicability of the StS framework was tested in 2 sequential collaborative workshops (see Section 3), exploring contributions and limitations of the StS process from three main dimensions (see Section 4): the capacity of participants to translate original narratives into a set of specific changes, events, and actors; their capacity to connect the narrative with real and/or

virtual places; and their capacity to elaborate communication strategies that explicitly consider how users interact with given places in order to gain understanding about the original narrative.

2. Designing The Scenario-to-Scenes (StS) Framework For Prototyping Future Scenarios

The aim of the *StS framework* is to support the use of any conventional scenario narrative to elaborate full-fledged narrative strategies based in the production of VR narrative environments. The framework relies on the design of two complementary narrative prototypes: the expanded scenarios and the 3D-scene concepts. *Expanded scenarios* consist of more detailed account of key future events and actions, as a future story illustrating main scenario changes in specific places and moments. The *3D urban-scene concepts* (henceforth "scenes") encompass a set of visual and logical specifications of the model representing the place, mapped by a set of visual stimuli and interactions of an imagined VR user's experiences. The StS framework guides the design of both prototypes by enabling three generative processes[1] triggering each other (Figure 1): the future story generation, the place generation, and the VR experience generation. Each process is interpreted through alternative *story models*, as described below.

The future-stories generation process rise the general question "What happens in the scenario World?" It aims at the generation of future themes (henceforth *themes*) capturing how the original scenario narratives represents their underlying image of the future (in the mind of scenario authors). Themes are "controlling ideas" that help to elicit the shape, value – intrinsic, instrumental, symbolic– and direction of narratives (von Stackelberg, 2011). Using archetypical Greimas' actantial roles[2] as interpreters (Hebert and Eveaert-Desmedt, 2011), we translate the generation of future themes through the 3 types of associations between actors. The *action themes* refer to an *agent* introducing a key *change* for understanding the future – i.e., *novum*: e.g., a pedestrianisation project (change) proposed by city planners (agent). The *transformation themes* define the nature of change, in connection to two actors: the *system* receiving the change, and the *regulator* motivating the agent to perform it. In the previous example, car congestion problems (regulator) motivate city planners to perform the pedestrianisation of some commercial street (system). The regulator has the role of activating and deactivating the agent at the beginning and the end of the story. The *transition themes* define how the agent performs the change, as enabled by *helpers* and hindered by *barriers* to change: e.g. the plan faces retailers and car-drivers complains (barriers), that address by increasing environmental awareness (helpers). Each theme enables a new interpretation of original scenario narrative, which can be expanded into new future stories.

The *place generation* process consists of representing future stories through complementary "where" questions. Place concepts (from now, "*places*") are those settings required to interpret abstract thematic actors as concrete symbols, icons, indexes, or metaphors that can be apprehended by a figurative observer. According to the meaning transferred, places encompass (Agnew, 2011; Zhang *et al.*, 2018): *locations*, as generic or specific sites of reference where key changes of the story happen (e.g., the city centre streets in the previous example); and *story locales*, as concrete urban entities – workplaces, homes, shopping, streets, people, vehicles –

[1] While conventional semiotics studies the interpretation of signs, generative semiotics revert the semiosis process to generate signs. The current approach is based in the infinite semiosis process described through the Pierce semiotic triangle: object, representant, interpretant (Barr et al., 2004).
[2] The Greimas' actantial model defines 6 pairs of complementary roles that can be taken by actants (disregarding their figuration: i.e., human or non-human, material or abstract): *subject/object*, *sender/receiver*, and *helper/opponent*. Any archetypical story takes a subject that gets some object of value, motivated by a sender, to take it to the receiver. The success of the quest is supported by helpers and hindered by opponents.

representing main actors' states, activities or behaviours (e.g., the pedestrian areas representing the plan). Places can be direct references to the elements that will be represented in 3D urban scenes (virtual places), so they can extent location with a set of details aimed at building a sense of reality through future routines. Narratively, such *sureties* will act as reinforcers of *surprises* in VR experience generation (Fencott, 2001). The expansion of places may encourage the generation of new future stories.

The *VR experiences generation* process is driven by the question "what happens in the VR scene?" VR experiences define alternative stories on how imagined VR users interpret previous places by interacting with them. The VR user's story model uses the actantial model in combination with the *surprises* of the Perceptual Opportunities model (Fencott, 2001) to define 3 types of *VR experiences* in the 3D scene. The *exploration experiences* are based on a VR user *activity* reaching some *reward*, namely a memorable opportunity for immersion, presence, and embodiment: e.g., for the previous future story, discovering that people in a near street are not moving because heavy traffic. *Discovery experiences* use *attractors* that direct users towards the activity (*retainer*); e.g., user sees/hear a distant crowd waiting. Attractors can be just calls for attention or work as more complex retainers of the reward (being also a rewarding experience by themselves). *Navigation experiences* (E3) create *connectors* - paths, movements, challenges and decision points - taken by user-explorers in their progression toward the reward; e.g. main street axis, people moving from/towards reward's direction. VR experiences are final interpreters of the whole StS process, so they may trigger re-interpretations of places, themes, and even original narratives.

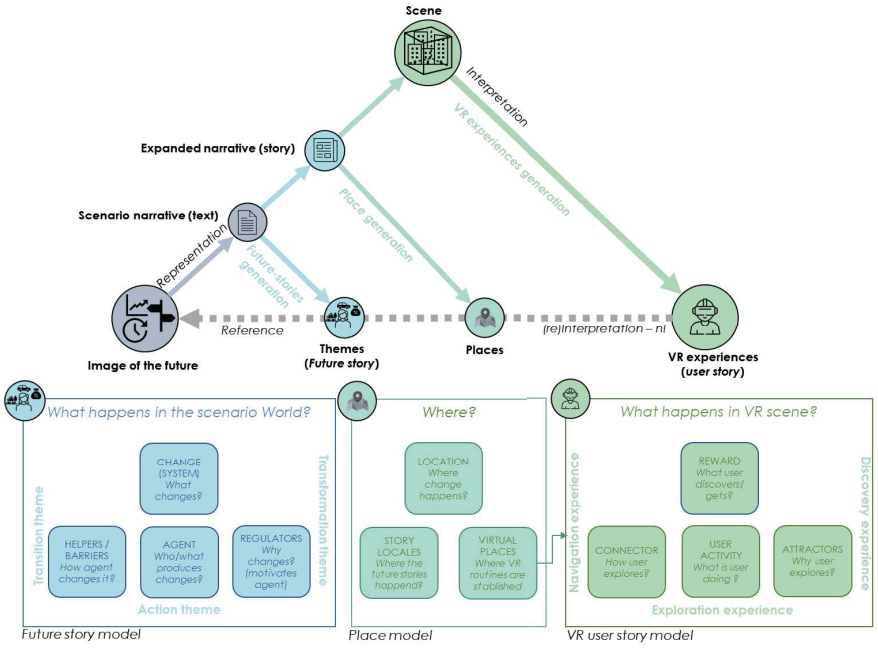

Figure 1. StS Framework overview for producing VR narrative environments.

3. Implementing And Testing The StS Framework

This research aims at assessing the applicability of the StS framework for building VR narrative environments enhancing scenario communication. The StS was tested in 3 participative workshops of 2-hours length (approx.), with 4 participants each. The aim of those workshops was to generate expanded narratives and VR experiences' concepts based on the development of VR scenes from Project TRANSURBAN's narratives. Those narratives addressed the original project's aim of generating disruptive scenarios about land use and transport integration scenarios for the Henares corridor in 2050. For convenience, only one of the three different future-scenario narratives, *High levels of insecurity in urban areas*, summarised in Soria-Lara et al. (2021, p. 8):

> [The future] is strongly affected by a high level of insecurity in urban areas. Walking and cycling are not advisable. The modal split would be drastically altered, with the private car dominating all daily trips –work, shopping, and leisure. There would be also preferences for increasing the level of car sharing, as well as for the promotion of clean and autonomous vehicles with zero emissions. Public green areas would be removed and recovered for car infrastructures. There would be a preference by high-income families for living in the city periphery in private communities. Land uses would be highly segregated in homogenous areas connected by motor[ised] infrastructure. City centres would be mainly transformed into work destinations, with most employees commuting from the city's periphery. Low-income families would also tend to live in those insecure city centres.

Two types of workshops were planned in sequence. The first kind, here-called *consultancy workshops*, focused on the future story and place generation processes before conceptualising VR experiences; and the second kind, called *VR production workshops*, focused on validating and expanding proposed VR experiences from consultancy workshops according to their communication opportunities. Participants' engagement was equally directed to experts and practitioners familiarised and not familiarised with the geographical context of the scenario narratives, integrating both at the end. None of them knew the TRANSURBAN scenario narratives, to ensure their genuine interpretation.

Two consultancy workshops were held independently, one involving academics (Workshop 1), and the other, practitioners and policymakers (Workshop 2). In each case, participants' expertise covered either urban and transport planning areas (or both). The central activity consisted of selecting and developing future stories and potential locations out of the reading of TRANSURBAN's narrative, creating newspaper future headlines to capture it in a future story, and voting them either by credibility, relevance, or degree of surprise. Participants used the future story model to analyse the most voted news and to expand actors and themes. Then, they proposed place models connected to previous themes, adopting the perspective of a future photographer illustrating the headline's story. A first unstructured attempt to ideate VR experiences was made, creating chains of routines and surprises for imagined VR users' interactions. Participants were encouraged to agree on central actors, locations, and avatars before enriching stories and connecting elements.

The results of consultancy workshops fed a *VR production workshop* (Workshop 3) targeting VR/3D environment designers and visual media communicators. This workshop was focused on the intricacies of developing the VR experience and the 3D scene prototype. Dynamics for this workshop mostly consisted of the selection, validation, and refinement of ideas from previous workshops. Firstly, facilitators presented participants with a synthesis of 2 VR user stories resulting from the first workshops, consisting of a set of story maps pointing at relevant interactions and decision points. Then, facilitators asked them to suggest main messages, interesting places, and moments of each user story. After comparing user stories with the

original future stories, presented as conceptual maps similar to Figure 2 (see section 5.1.), participants chose 1 story and focused on elaborating VR experiences using the complete VR user story model. Finally, results were synthesised on a raw storyboard representing potential user pathways and key scene elements.

During all workshops, the research team acted as facilitators, guiding participants through the StS process, moderating discussions and providing with different materials: templates, boards and post-its and pins to place over them. The team recorded the audio and video and collected the filled materials. The analysis of all these contents consisted of the writing of ethnographical notes describing key events in the interaction of participants with the assumptions, models, and processes of the StS framework (see previous section); this process was supported with the elaboration of more structured conceptual maps representing the story models (see Figures 2 and 3 at the end of Section 4), and semantic maps representing elicited connection between themes, places, scene elements and VR experiences (not included in this publication, but used internally to offer some of the insights of section 4).

4. The StS Framework In Practice: First Insights And Learnings

4.1. Interpreting And Expanding Future Scenario Narratives

For the first stage of the StS framework, the *future-stories generation process*, we tested the capacity of consultancy workshops' participants (W1 –academics– and W2 –practitioners–) to translate original narratives into a set of actors and themes. Future story models were expected to work as flexible narrative structures capturing how participants interpreted as a group what is happening in the world of the original scenario narrative.

Participants read original scenario-narrative at the beginning the abovementioned workshops and were encouraged to focus on certain aspects to individually create news' headlines about the Henares Corridor in 2050. Most of the proposed headlines offered paradigmatic presentations of social changes depicted in the original narrative. In W1, the most voted headline was titled "The new urban walls", highlighting spatial segregation into "two cities", based on social class differences. In W2, participants chose the headline "Health issues increase due to lack of contact with outdoor environments", which brought isolation and public space deterioration as core themes. Both choices were influenced by its perceived credibility, and, in W1, also by its relevance.

The selection of headlines clearly shifted the thematic focus of the narrative towards social issues, which occupied the centre of the analysis and development of both headlines. Figures 2 and 3 (upper part) show the future story models proposed in W1 and W2, respectively.

Looking at the action themes (i.e. agent-change axis), social dynamics were seen as cause of the main future change in W1, the "urban wall" concept. Similar social dynamics (encapsulated in "society" as an actor) became the agent of W2's change: citizen isolation. The agent in W1 was defined by merging other headline proposal ("Delocalised"): a "disruptive technological innovation" exacerbating class differences in access to services. Nonetheless, the nature of this disruption was not defined until the place generation stage. Defining the central change was especially difficult in W1, where one of the participants (well familiarised with scenario-planning methods) resisted the linearity of the model and highlighted the complex feedback loops between social, economic, and technological systems. Similar dilemmas on causal loops between insecurity, isolation, and public-space deterioration rose in W2. This time, facilitators amended some of these issues by improving the explanation of the whole model, offering narrative examples based on a popular tale, and by emphasising the idea that, for convenience,

the choice must accept the perspective of the headline, even if there are "many ways to tell the same story".

Concerning the transformation themes (i.e. regulator-change axis), regulators were mainly depicted by organisations, collectives, and institutions (policymakers and planners). The interpretation of the "regulator" role was fitting in W1, where participants defined a new world order led by tech companies as the motivator of the technological disruption. Conversely, in W2, the figure of the regulator was connected to multiple sources of regulation and decision-making without too much reflection on its implication in a society becoming isolated. Playing with the flexibility of the story model, this problem was fairly solved by implying that such organisations are part of society at large. But the lack of connection to action probably influenced failed attempts to portray such regulators in place generation.

Transition themes depicted a wide range of helpers and barriers connected to central social transformations. Central topics of the original scenarios, such as insecurity, transport, and telematic activities were included here. Interestingly, the topic of civic insecurity was extended to other sources of insecurity in W2, such as climate change and heat waves making public spaces unsafe and abandoned. In both consultancy workshops, the negative connotation of the central change made participants to struggle with the connotations of the "helpers" (positive) and "barriers" (negative) to such change. As in the case of the regulators, this had to do with the choice of name for the actantial roles. With the facilitators' support, participants interpreted barriers as positive aspects, such as good public space design, social policies, or the regulation of tele-activities, whose absence explained the central changes.

In this phase, participants took advantage of the flexibility of the story model, allowing actors to adopt multiple roles and shapes. On the positive side, participants openly referred them as "characters" of the story, reinforcing abstracts and non-human forces (e.g. climate change) as narrative figures. Technology and society were placed as protagonists of change, which recalls the central novum of classic science fiction stories. In W2, the model also opened interesting reflections of the accountability and agency of actors in those scenarios. On the negative side, actor choices were often too abstract and symbolical, making next StS stages more difficult. This was associated with the resistance to abandon argumentative modes, particularly high in W1, instead of offering a simple narration and description of actors of the future story-world. A possible reason is that the scenario references (e.g. inequality as a source of crime and insecurity) and auto-referential concepts ("the Wall") emerging in discussions building the alternative world were mixed with multiple external referents: professional experience and dilemmas, cases from other geographical contexts, theoretical models (5-helix innovation, 15' cities…).

4.2. From Themes To Places: Localising The Scenario Narrative

The StS potential to enable the representation of future stories through real and/or virtual places was also tested in consultancy workshops during the *place generation process*. Reciprocally, our analysis pay attention to how place generation expanded and nuanced original themes, despite time limitations in workshops leave no room for encouraging this exercise. Figures 2 and 3 (middle part) summarise main locations and locales.

The location-locale relationship was more flexible that the story model and subjected to variations between W1 and W2. Firstly, participants agreed some locations giving a common perspective for the imagined photographer illustrating the news headline; then, they proposed locales (place objects, events, activities…) observable from the photographer's position, connected to central themes. Facilitators proposed a rule limiting photographer's movements, so to keep the exercise focused. Nonetheless, many locations emerged as parallel referents of

discussions. Those referents included real locations and locales in the geographical context (e.g. emblematic cites and architectural elements, places of innovation), city models (e.g. suburban models, Latin-American cities), and even fiction works (e.g. Stephen Kings's *The Dome*, the *Snowpiercer* show). Some of those places were early introduced as referents to themes as well.

In W1, the urban wall concept quickly led to the idea of private spaces and gated communities (also referenced in the original narrative as "segregated residential areas"), defining a conceptual location called: "new fortified urbanisations". The physical wall and security access control system (i.e. camera control, security guards) were the main locales defining this location. Other important locales represented the disruptive technological innovation: autonomous delivery systems based on drones and autonomous vehicles. Discussions at this stage helped to clarify the nature of the technological disruptor, described as a change in food production based alternatively on private facilities for self-supplying food (such as private greenhouses) or on pills for easily carry all nutritional needs to citizen. The class-differences theme started to gain prevalence at this point of the discussion. On parallel, urban borders of Alcalá de Henares inspired a sub-location of "transition between two cities", happening along a "segregator element" (e.g. road, change of urban pattern). This transition concept was expanded during VR experiences generation, defining locales by contrast inside and outside the residential area. Abandonment and isolation, as well as physical public-space design were added to the themes at this point, after proposing some locales reflecting urban space abandonment (e.g. abandoned children play area, degraded local retail…).

In W2, changes in social dynamics and isolation were quickly referred to an image of social meeting areas already described by the author of the selected headline. The selected location was the Alcalá de Henares' Town Hall square desolated at noon on Saturday. This specific spatial and time reference was an interesting choice if compared with W1's. Some indexes of voluntary lockdown, such as close commerce and empty bar terraces, easily represented the central action. The sub-location of an empty park permanently sealed off by police was finally included to represent the barrier associated with the lack of public space improvements and its abandonment. E-commerce's influence was represented by a futuristic image of historic streets full of autonomous vehicles and drones making deliveries, following a similar pattern than W1. These elements also signified, according to participants, distances, and digitalisation themes, together with companies as regulators related to mobility (a relationship somewhat forced during the workshop dynamic). Climate change was represented in combination to a degraded bus marquee with a thermometer showing extreme temperatures, a decision that manifests the participant efforts to make efficient choices. In this phase, a central theme of the original narrative emerged with an interesting interpretation: how car mobility dominates public space and cause its abandonment, with public insecurity as a reinforcement of this process.

The future photographer dynamic and the location-to-locales concept worked better in W2, where participants gave quick impressionistic and intuitive images after agreeing a point of observation. In W1, there was still a tendency to discuss and analyse conceptual urban settings. Challenges to represent abstract or conceptual actors (distances, disruptors, climate change…) were better solved in this phase. Some locations, such as parks, were given alternative definitive interpretations in each workshop, as a luxury (W1) or as abandoned place (W2).

4.3. From Future Stories To VR-User Stories

The potential of the StS framework to help anticipating how VR users (adopting an avatar perspective and role) might interact with places so to capture central themes was tested in all workshops. In the consultancy workshops, this final stage aimed at validating and completing previous themes and places, while the VR production workshop (W3) focused on the user story itself, improving opportunities for its communication, selecting key moments from proposed

experiences and mapping potential "game mechanics". Figures 2 and 3 (bottom part) show the main paths proposed by workshop participants between different VR experiences.

In W1, the use of the simplified routines-surprises model encourage participant to select and expand locales, this time perceived from the perspective of two avatars: a resident of the fortified urbanisation; and a visitor wanting to access inside but prevented by the wall's security measures. As observed in Figure 2 (bottom part), this unstructured array of experiences was an opportunity to stress the contrast between the luxury world inside the urbanisation and a conflictive neighbourhood in the city outskirt. Near the end of the W1, a coherent user-story idea emerged where the resident leaves the security provided by the residential area and gets lost in the conflictive neighbourhood, where she hears gunshots in the distance or sees evidence of drug dealing. An interesting experience was the need to get assistance from locals to return home, overcoming the fear of an apparent hostile environment before setting out to explore empty spaces in an old commercial street while looking for help.

In W3, after the initial reading of the story map elaborated by the research team, participants found this urban-transition concept appealing, despite the motivation of the resident to get out the "bubble" was missing. Other important aspect was the lack of markers of being in the future. "This could be United States in the 1980's" some participant pointed out. It seems that the participants did not capture the idea of the gated community as a transformed location in Alcalá de Henares. Most amendments tried to highlight the technological disruptor theme or the new technological order, both missed in the user story, by adding car and house technologies: access panels or a trademarked AI-assisted car navigation system.

W2's participants elaborated more lineal user stories (Figure 3, bottom part), encouraged front the beginning by a "Yes… and" improvisation dynamic that did not work in W1. The first story took the perspective of a journalist with the mission of making photographs, moving through selected places but finding nobody. The second story featured a delivery android trying to reach its destination, facing delays and conflicts with other vehicles, and finally breaking down due to over-heating. At the end, participants hardly distinguished from routines and surprises. As a result, most proposals depicted inflection points in the user stories, or just offered a tour through the already generated places. Both user stories stressed at some point conflicts of mobile avatars experimenting different modes of transportation, in line with the expertise of some participants. Ideas for advanced game mechanics appeared at the conclusion of the workshop, along some reflection on the dehumanisation linked to digitalisation. Participants showed some preference for the journalist story but recognised the potential of an encounter between the 2 avatars. This inspired the research team to create a story with a mixed proposal.

Conversely, W3's participants found that the journalist's mission was "difficult to translate to 2050", whereas the point of view of the android avatar was original and suggested a message of "abuse" of technology, clearly aligned with W2's themes. Nonetheless, the presence of technology reflected solitude, but also freedom, which conflicted with the core theme of insecurity. In this case, the presence of "too advanced technology" caused concerns about the overall credibility of the depicted world. The leaps between traditional city locations and advanced logistics hubs were also confusing.

Because of previous issues, W3's participants agreed on working with W1's user story. The dispersion of experiences and the problem of "where do you want the user to look at?" anticipated the need to emphasise "call to actions" for motivating exploration, which aligned with the purpose of the VR user-story model. A proposal was inspired from the experience of looking a sad child in a window wanting to go out. In this new proposal, the child is trapped inside the house after the failure of some access control system, which demands the parent to

find help outside of the residential area. This solution portrayed a moment when the resident experiments technology as a wall itself. The VR-user-story model assisted in creating a tensional sequence around the main activity (accessing the house) and the reward (saving the child). The attractor was interpreted as the "problem" or initial "call-to-action": the child calls to the avatars' mobile. Connectors deployed challenges during exploration (i.e. go out with the car and getting some technology to repair the car and the house), which quickly led to sub-stories (e.g. the broken car) not easy to structure under the story model (see Figure 2, bottom part). Even in the preparation of storyboards, when participants were expected to thematically enrich the background with new scene elements, they were still solving emerging conflicts and gaps in the narrative structure of the story. Consequently, most scene elements obeyed only to this purpose. Some technical aspects of VR, such as movement methods, and the interface format were discussed at this point.

In consultancy workshops, the VR experiences generation encouraged participants to abandon paradigmatic presentations to propose places and interactions from a more creative approach. The choice of imagined avatars helped them to build the story-world. Nonetheless, the main issue was the difficulty to contain brainstorming and counteract the path-dependency of some ideas deviating from central themes (e.g. the technological disruption theme disappearing from W1's user story). In the VR production workshop, the inversion of the StS process – i.e. reading the experience first and comparing it with the original future stories later –, created some confusion, but helped to recall central problems of interpretation. The map showing the future story models (i.e. themes and actors) was found particularly helpful by communicators for keeping the central messages, detecting the actors that were missed. The VR user-story model triggered appropriate questions along the process: "how do we point at where the solution is?", "is this a reward or not?" Although the story model was not able to capture complex sub-stories, it aligned to participants emphasis on the importance of planning the scene exploration, using narrative elements to produce it.

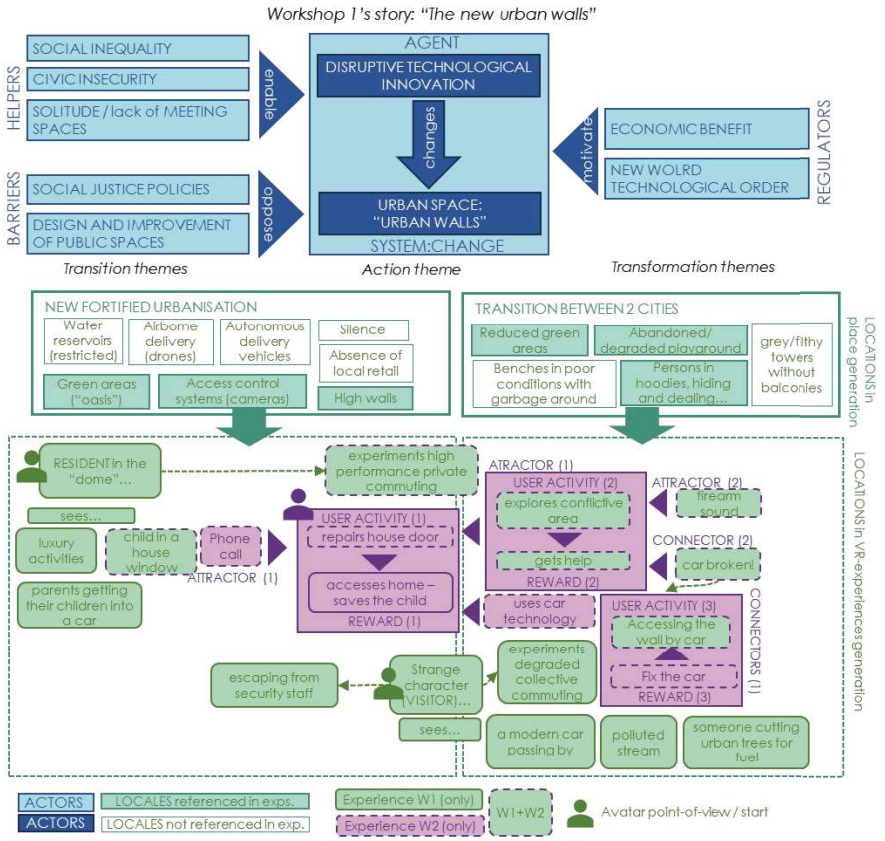

Figure 2. Synthesis of future stories, places and VR-user story models proposed by W1's participants and expanded by W3's participants.

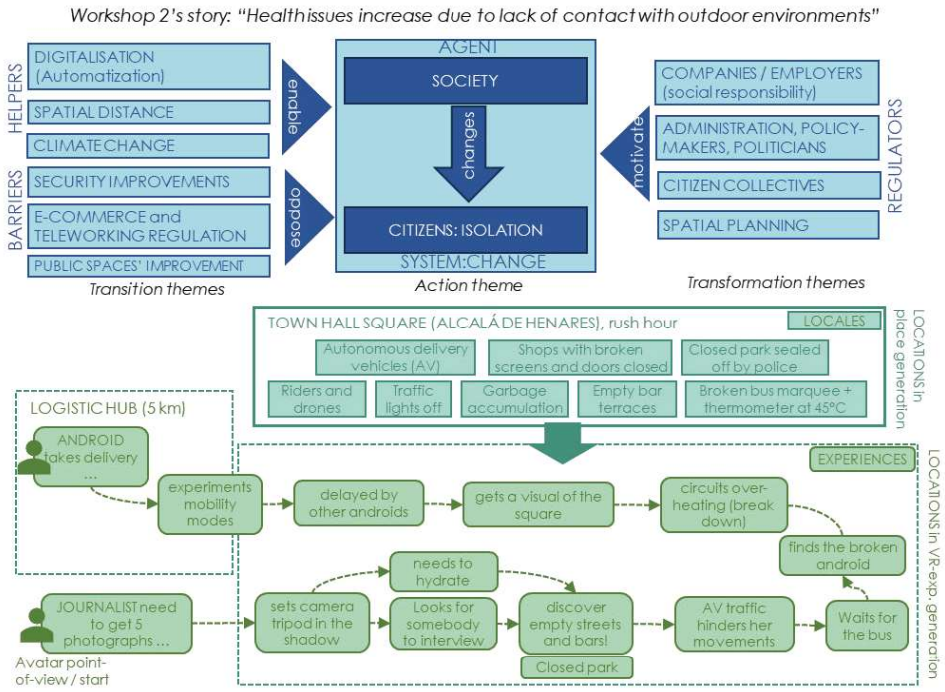

Figure 3. Synthesis of future stories, places and VR-user story models proposed by W2's participants.

5. Conclusions

This research explored how conventional scenario narratives might be enhanced and communicated by using Virtual Reality Environments through the production of 3D urban scenes. A Scenarios-to-Scenes (StS) framework was proposed as way to build scenario prototypes expanding and consolidating a narrative environment. Three expected contributions of the StS framework were tested in participative workshops with urban-planning practitioners and academics (consultancy workshops), media communicators and VR experts (VR production workshops): (1) the translation of original narratives into a narrative structure connecting scenario transformations and actors along specific themes and stories; (2) the localisations of such stories in a map of specific real and virtual places; and (3) the integration of the VR experiences and user stories in the narrative environment.

Firstly, concerning the translation of the original scenario to a narrative structure, the StS framework proved effective and flexible enough to bring out alternative interpretations of the original future narrative, materialised in participants' discussions about the nature and role of actors. These discussions, at the end, contributed to expand the original narrative and bridged some important gaps (e.g. social inequality as a cause of insecurity). Although the use of the future story model in consultancy workshops showed a slow learning curve, the effort paid off in sharing key aspects of the story-world with the VR production workshop. Both urban experts and communicators converged in underlining conflicts between technological and social actors, a narrative structure already used in other narrative prototyping experiences (Burnam-Fink, 2015). Secondly, the localisation of future stories helped in defining the nature and shape of previously identified actors, in part meeting its purpose of mediating between the previous

phase and the VR-experiences' generation. Nonetheless, places and VR experiences complemented each other to build a structured "story-map". Lastly, the VR experiences reinforced visualisation and emphasis on storytelling through the avatars' roles but failed to capture potential "model VR users" (publics, audiences….) connecting to the central message. Probably, this perspective-taking exercise should have been done earlier, along the pre-definition application contexts proposed by participants at the end of workshops: e.g. educational purposes, and urban project/plan showcases embedding narrative elements.

Some of the limitations of the StS process may be addressed by testing them in processes longer than 2-hours workshops, with frequent validation and revision of materials (as represented in the cycle of Figure 1). In the future, the StS framework is expected to guide procedures and protocols for prototyping Virtual Reality Environments by keeping track of main design hypotheses and testing them with real VR users. To that end, the story models need some amendments in the naming and its communication must be improved to understand their contribution to the VR production process.

Acknowledgements
This work was supported by the State Research Agency of Spain, under a postdoctoral "Juan de la Cierva" training grant (FJC2020- 044618-I / AEI / 10.13039/501100011033) and the National Research Project "VIR2ALL: Virtual Reality For Simulating A New Generation Of Collaborative Future Scenarios To Integrate Land Use & Transport" (MICIU/AEI /10.13039/501100011033).

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