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PROTOTYPES AS FUTURE ARTIFACTS OF TODAY: TOWARDS PROTOTYPING ALTERNATIVE FUTURES

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KEYWORDS

Prototype, future, critical and speculative design, imaginaries, urban mobility

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Prototypes as Future Artifacts of Today: Towards Prototyping Alternative Futures

_Abstract

The design of sociotechnical futures relies on institutionalized visions but also on material artifacts. In this context, prototypes are a materialized means of exploration of potential futures. This article explores interdependencies between irritations by prototypes and critical/speculative design and argues that prototypes problematize a balance between feasibility and their potential for irritation, i.e. being incited to act differently by a prototype that does not fit into familiar practices (e.g. flying cars). We investigate the significance of the feasibility-irritation tension, first, by analyzing two case studies of prototypes from urban mobility as examples of technical feasibility in marketing and testing environments, and second, by contrasting them to the notion of prototypes as deliberately irritating artifacts within critical and speculative design practices. We offer a perspective for understanding their transformative potential. Our discussion shows how prototypes, as they are used in speculative design, might open new negotiation spaces instead of limiting futures to what seems feasible. New, irritating prototypes highlight a contingency, which is necessary to openly discussing feasible and fictional futures together.

1_Introduction: Future Mobility Artifacts Today

"Mobility is entering a new age of innovation," claims McKinsey and forecloses future mobility with innovative vehicles, novel power sources, alternative transportation routines, or even fully redesigned transportation systems.[1] Other visions extend to futuristic hover-cars in the often envisioned glass-and-concrete world of the future, the gas-guzzling and people-maiming V8 engine in the not-so-ideal future of the *Mad Max* series, or the clean and omnidirectionally moving Audi from *I Robot*. These entire visions rest on the question of what practices we would want, or even could, connect to artifacts of future mobility: Would my car allow me to drive instead of it driving, presumably, more comfortably and safely? Or would cars be picking me up on demand and transporting me to a local city transport hub?

Means of future-making embodied in prototypes are linked to current expectations and future imaginaries. Prototypical artifacts imply a future, yet their promise sits at the line between a possible future and a lived present. In other words, they not only materialize what the present is but also hint at what could come next. Through their inherent unfinished nature, they provide a glimpse into corresponding future scenarios. This hinting toward a future—connecting what is known with what is not known, yet possible—is the role that prototypes take in societies, and that makes investigating them and the past futures to which they belong so interesting. When Dickel describes

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the prototype as "both [...] an epistemic object that enables learning in situ and a materialized promise of a realizable future,"[2] he sensitizes us to a concept that goes beyond an "idea to be realized."[3] Instead, it also carries an instructive component, a means to engage with a time to come in less abstract terms. This link to imaginaries is essential for prototypes. They build a bridge between representations of what is and vague promises of what could be. Prototypes invite us to imagine futures and related artifacts by creating a temporal bridge without giving exact instructions on how to get there. It is essential to point out that their manifestation may only occur embedded in prototypical situations, i.e., those constellations (design studio, real laboratory, exhibition, trade fair) in which they *can* be understood *as prototypes*. Such prototypical situations are characterized by offering a framing (pattern of interpretation) for understanding these artifacts as artifacts of the future, bridging the gap between future and present in a dedicated space (see Section 2).

From this perspective, the paper aims at understanding how an artifact of the future becomes an artifact of the present, and how this vague connection to an imagined future is translated into specific practices in the present. This paper does not try to understand imaginaries and future narratives in isolation or as abstract entities; instead, it shows how artifacts of imagined futures specifically become part of today's material practices in discourses, testing environments, and design attempts.[4]

This future-present translation process is not exclusive to prototypes in the realm of urban mobility. However, urban mobility presents a unique combination of future-oriented challenges, such as climate change, rapid urbanization, and disruptive technologies. In an increasingly accelerated and trans-local world, the construction of futures of mobility allows us to reflect on the world in which they exist.

In this article, we develop the following line of argument: Prototypes are initially material artifacts that are only brought forth as future artifacts in specific contexts, such as in design workshops, living labs, or at trade fairs. In other words, only certain spatio-temporal orders constitute the use of material artifacts as prototypes. Only then do prototypes unfold their specific potential for irritation, i.e. they challenge our familiar practices. Firstly, we explore the role of prototypes as situated future-hinting artifacts, as well as materializations of imagined futures such as sociotechnical imaginaries or visions. Secondly**,** we use two examples from the field of urban mobility: the Pop.Up (a flying car) and the Auto.Bus (a self-driving bus), to exemplify how

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such artifacts from future mobility imaginaries become mobility prototypes of today. The Pop.Up prototype focuses on the vision of Urban Air Mobility (UAM) that points to the prototype of a flying car. The Auto.Bus prototype illustrates how the prototype of a self-driving bus brings a material test object into a particular urban environment, namely that of Vienna. It enables testing what the future autonomous bus system could look and feel like directly for the citizens of Vienna. In contrast, in the third step we look at the specific practice of Critical and Speculative Design (CSD) and show not only how prototyping varies, but also how critical inquiry through prototypes supports reflection on future scenarios and how this may therefore open up new possibilities for further development. We then discuss those findings by asking how far speculative design practices explicitly challenge contemporary mobility imaginaries. By answering these questions, we develop a critical perspective on future-making regarding the interplay of material artifacts, imaginaries of futures, and specific practices from people's everyday lives. In contrast to the commonly referenced pipeline model of innovation, we argue that those testing spaces do not represent different stages in the overall process of prototyping future societies (of mobility), but that they instead represent distinct stages that are not necessarily commensurable with each other. Finally, we summarize and conclude the role of prototypes in present future-making and the advantages of opening technological pathways and future imaginaries.

2_Conceptual Framework: Prototyping the Now from a Future Perspective

This study understands prototypes as material artifacts that are intertwined in different future temporalities. As a framework for the following empirical cases, this section conceives of prototypes, first, as promises of the future and, second, as material artifacts of future visions.

Prototypes as Material Inquiries of Potential Futures

This section aims at better understanding the role of prototypes as promises of innovation. The transformative power of technological artifacts in the form of prototypes plays an important role in Science and Technology Studies (STS) and Technology Assessment (TA).[5] In these fields, visions of conceivable, possible, or desirable futures are subject to abstract debates in various fields of policy, science, and society in

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general. Some of these visions establish themselves as sociotechnical imaginaries,[6] most prominently in fields such as nuclear power,[7] national energy policies,[8] and geo-engineering.[9] When translated into specific practices, such imaginaries are shaped "through the imaginative work of varied social actors, science and technology, which result 'in performing and producing diverse visions of the collective good'."[10]

A variety of academic and practical fields deal with future-making activities to build anticipatory capacities. Examples of this include the sociology of expectations,[11] interest in technology foresight,[12] computational modeling, scenario workshops, or stakeholder dialogues.[13] These fields usually need to be adapted to the topic or issue in question.[14]

All of these scholarly attempts to study the 'not yet' have emerged from practices of future diagnosis, prognosis, and critique. The more recent studies of futures take the perspective of a rejection of technological determinism in the context of anticipation, visions, expectations, and scenarios, amongst others.[15] Here, both an important and plausible insight of systematic study of the 'not yet' is the plurality of futures. However, there are not only various futures, but also multiple perspectives on them. The "futures cone" by Voros—a geometrical shape where the tip resembles the present and the base the plurality of futures—classifies futures as possible, plausible, probable, and preferable.[16] While the first three classes largely depend on aspects such as cognitive knowledge or feasibility, preferable futures are in contrast "concerned with what we *want* to happen," which depends on people's culture, values, beliefs, mindsets, norms, or expectations. Futures, and respectively future knowledge, are therefore partial and situated.[17]

Against this background, prototypes are intriguing objects of investigation, since they are material inquiries of potential futures. They allow testing and discussion as well as opening up and foreclosing different futures. Prototypes operate as objects of irritation, as they can break with e.g., everyday ideas of specific technologies (cars, bikes, etc.), cities (solar-powered green cities, etc.), or other sociotechnical imaginaries in specific contexts (design workshops, trade fairs, living labs). Prototypes are therefore potential means mobilizing critical inquiry on a given future, supporting individuals to reflect on multiple perspectives, as well as to renegotiate notions of meaning and value, of what is preferable.

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Prototypes and their Connection to the Present: A Back and Forth of (De-)Stabilization

Prototypes have also been described as future promises as they are unfinished artifacts that point toward a future by representing a materialization of imagined states to come.[18] This paper argues that this linkage to potential futures also necessarily affects our understanding of the present. Sociologists, in particular Niklas Luhmann, have highlighted that our present life depends on an uncertain future,[19] i.e., we think or imagine *a* future, which we select out of several possible *futures*. Here, the key aspect is a contingency of futures as something that we could have imagined or done otherwise. It is in this regard that futures may be described as uncertain. From a standpoint of the sociology of risk, the insights into future risks are highly influential on various decision-makers.[20] For example, projections of climate disasters motivate a multitude of actors to take action but also orient their action to avoid negative climate futures.[21] Hence, prototypes may wield power over the present, as their material representations imply a limitation of imaginable futures, which is available in a respective setting. Empirical studies have demonstrated the power of imagined futures: Fujimura's work on "future imaginaries," for example, showed how genomic scientists employ visions of the future to gain support for their work, indicating how imaginaries affect present work.[22] Researchers put these visions into practice by constructing arguments, convincing the public, and further act on macro levels as parts of promising narratives. In a similar vein, prototypical scenarios shape contemporary visions of the future,[23] which is particularly evident at the interface of climate scenarios depicting future global warming and today's climate policy.[24]

Based on those fundamental distinctions regarding prototypes as intertemporal situated artifacts, the following case studies highlight the integration of prototypes into the realities of their users through the following mechanisms:

1. *Can dependability be created through the demonstration of feasibility?* A major effect of prototypes in the present is that they *take futures for granted*. The showcase of a mobility prototype suggests that new mobility forms are staged as feasible in the future. A sociotechnical imaginary that predated the prototype is stabilized through the material prototype. This can lead to a closing down of contingency and future limitations of future options.

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2. *Can contingency be created through irritation?* Prototypes can have *critical potential* if designed in a more speculative or even fictional way. Speculative artifacts are unfinished, as they are not embedded in present daily practices like any other prototype. However, they are not created to stabilize futures imagined by designers, but irritate more common futures to open up future-making. Prototypes and prototypical scenarios envision problems around established future visions, as well as materialize alternative possibilities. The irritating potential of speculative prototyping therefore relies on its capability to renegotiate assumptions, support perspective change, and drive the deliberate act of irritation.

Our methodological approaches to investigate the effects of prototypes are case-specific. We investigate UAM using a discourse perspective of videos as material to show the framing of a flying car in a futuristic city. For the autonomously driving Auto.Bus, we applied an ethnographic approach accompanying interviews with the lab organizers. The following two sections will explain the cases including the methods and results in detail.

3_The Embedded Prototype: Motor Shows, Living Labs, and Design Workshops as Examples of Prototypical Environments

The following three cases focus on urban mobility, yet differ in their perspective on mobility. The diversity helps to corroborate how prototypes stabilize and disrupt futures in different ways. These cases were part of a joint research project "PROTOTYP – Crafting the Future Materially. Prototypes as Communication Medium of the New," funded by the German Ministry for Education and Research (BMBF), that investigated the role of prototypes in the context of futures (see Acknowledgements).

Doing Prototypical Temporalities in UAM (Urban Air Mobility)

Although visions of flying cars date back at least to the early 20th century, their commercial visions have only recently emerged. The development of air taxis in the last ten years established such visions in a modified way by portraying a *company-specific* air taxi—be it the Volocity, the Pop.Up Next, the City Airbus, the Lilium jet, or the Ehang 216—as the primary solution for the so-called 'grand challenges' (traffic congestion, sustainability, accessibility, etc.) in the UAM discourse.[25] The global challenges that futures pose are not only discussed in sociology or STS but also in

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cultural studies.[26] Various approaches to studies of futures show that there is a need to focus on interdisciplinary and collaborative research projects,[27] especially since investigations of futures touch on different aspects such as the politicization of sociotechnical visions,[28] their negotiation as make-believe,[29] and their shaping of hegemonic master narratives.[30]

In this section, we focus on visions of people and goods being transported through cities with flying cars that often still seem fictional. The development of the above-mentioned air taxis shows that there is a competition in not only building but also in presenting a plausible future vision of an air taxi. However, this raises the question of where those "collectively held, institutionally stabilized […] visions of desirable futures" are publicly performed.[31] This question (of publicly performed imaginaries) is of particular interest as the central research object of this section.

Futuring Fictional Visions

The Pop.Up was publicly presented for the first time as a material artifact at the 2017 Geneva Motor Show by Italdesign and Airbus. Reporters and others gathered in the halls of the Geneva Motor Show to witness the event. Representatives of Italdesign and Airbus went on stage to talk about the project. After the unveiling of the Pop.Up, a concept video was shown on stage.[32] It is precisely with the images of the concept video—in the context of the fair in general and regarding the Pop.Up in particular—that certain sociotechnical visions in the discourse around UAM are stabilized. In the concept video, the Pop.Up is presented as a common technology of a 'future present.' On the one hand, it is woven into already familiar technologies such as apps, standard cars, etc., but on the other, it marks a difference from the present, as it is not an everyday technology but a prototype that is connected to sociotechnical imaginaries about, e.g., flying cars. The video shows that the Pop.Up is ordered via an app, drives to the front door to pick someone up, and continues to a parking lot ready to take off again (Fig. 1). In addition, the video shows different functions of the Pop.Up including face screening and modularity. The Pop.Up is also demonstrated in its interconnectedness with the city infrastructure and the environment. It is in this regard that the concept video shows not only the Pop.Up as a material artifact, but also the specific infrastructure and the potential future present of a society that is oriented towards this specific material artifact. In this regard, the concept video oscillates between future and

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fiction. One could argue that the visualized future present might not even be a future in the first place but an alternative fiction. The implicit question here—especially for the presenting companies—is: How can such a future vision be futurized and not interpreted as fiction? This problem is solved by showing the feasibility of the project, i.e. presenting the Pop.Up as a material artifact and connecting it to the visualized future vision. It is in this respect that the concept video functions as a connector between sociotechnical vision and materialized prototype.

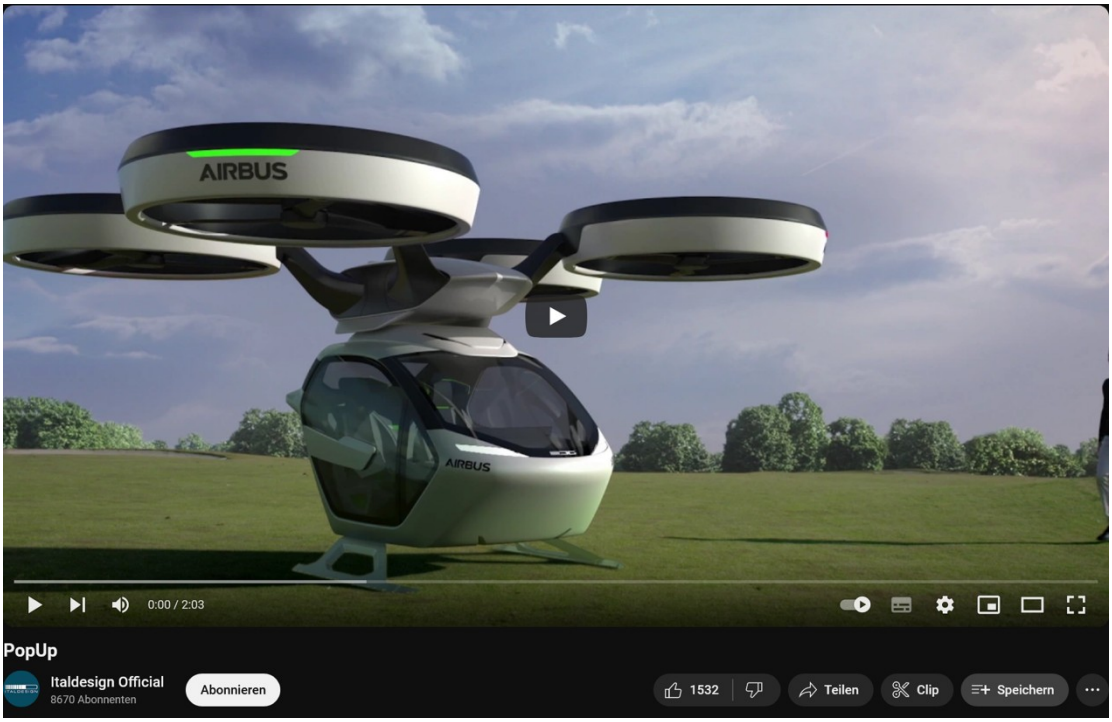

Fig. 1: Showcase video of the Pop.Up[33]

Foreclosing Futures by Demonstrating Feasibility and Showing Necessity

The presentation of the Pop.Up as well as the concept video suggest the feasibility and the necessity of the project. By unveiling the prototype, it is demonstrated that the development of such a material artifact is not impossible. In the unveiling, the Pop.Up is more than fictional images. There is a yet unfinished prototype that demonstrates a particular development and opens up a future in which the Pop.Up might be a reality. The demonstration of feasibility is also underlined by communicating collaborative action plans. The presenters mutually confirm their action plans regarding the project on stage and integrate another time dimension by presenting plans with scheduled goals.[34] By mutually agreeing on and communicating the specific action plan, they

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present a specific future and by doing that, other action plans are discarded, especially since the presenters confirm their goals in front of an audience and thereby solidify expectations. Then, their particular solutions to the 'grand challenges' (e.g. congestion relief) are communicated as action goals for UAM.[35] Therefore, at this point, two futures are referred to: one in which the problem could be solved (Z2) and one in which it is not (Z3). The solution to the problem of congestion implicitly requires a future (Z1) in which the infrastructure for the Pop.Up already exists. As Marcel Woznica argues, this means that:

> the framing of a problem projects the Pop.Up concept into a future (Z1) in which it is developed as a technology and becomes socially accepted. This point in time (Z1) is the condition for a future (Z2) in which the goal of action will be achieved.[36]

By showing both the concept video and the developed prototype on stage, the relevance of the prototype is not only underlined for *this specific* future vision, but it also forecloses future visions by showing the necessity and feasibility of the future artifact. Only in the interaction between the concept video (and thus the future vision) and the prototype does a futurization of the presented vision unfold its effectiveness as a potential future.[37] It is the linking between this specific prototype and this specific sociotechnical imaginary that rules out other future visions. It was a specific prototype (Pop.Up) that was presented in the video and not any other, the same way a specific environment (a clear white futuristic-looking city) or other specific technological practices (apps) were presented. The prototype thus functions as a materialization that reciprocally stabilizes such a given future and therefore rules out alternative possibilities.

Prototyping a Bus or Prototyping People?

The second case, a project situated within an Austrian Living Lab, focuses on a prototype of the so-called Auto.Bus (or "AUTONOM SHUTTLE"), an autonomously operated bus that, during the time of this research project, was tested in the general area surrounding the lab in Vienna. As a potential future mobility solution, the Auto.Bus serves as an insightful example of a technological prototype still evolving in terms of the technology keeping it on the road. Before its arrival in the lab, however, it has seen very little 'actual' testing involving human subjects. The testing in Vienna pre-

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sented an opportunity for citizens to engage with an artifact of the future in the context of their everyday lives.

Prototyping the Auto.Bus

The autonomous bus that underwent testing in one of the mobility living labs in Vienna is a small people carrier (10 seats, one buggy space) brought to the city by the consortia partners to test its application in an urban context.[38] Even though technical aspects, such as the improvement of sensory systems, were an integral part of the testing, this was just one part of the story. The other part—the one that is of particular interest to us—is that of technological innovation being intertwined with the lives, and therefore contemporary everyday practices, of ordinary citizens. Testing the autonomous shuttle service moves beyond the evaluation of technological concepts and into the realm of techno-social innovation, where contingency not only applies in a technological sense, but also is manifested in the lived, everyday contingency in the lives of Vienna's citizens.

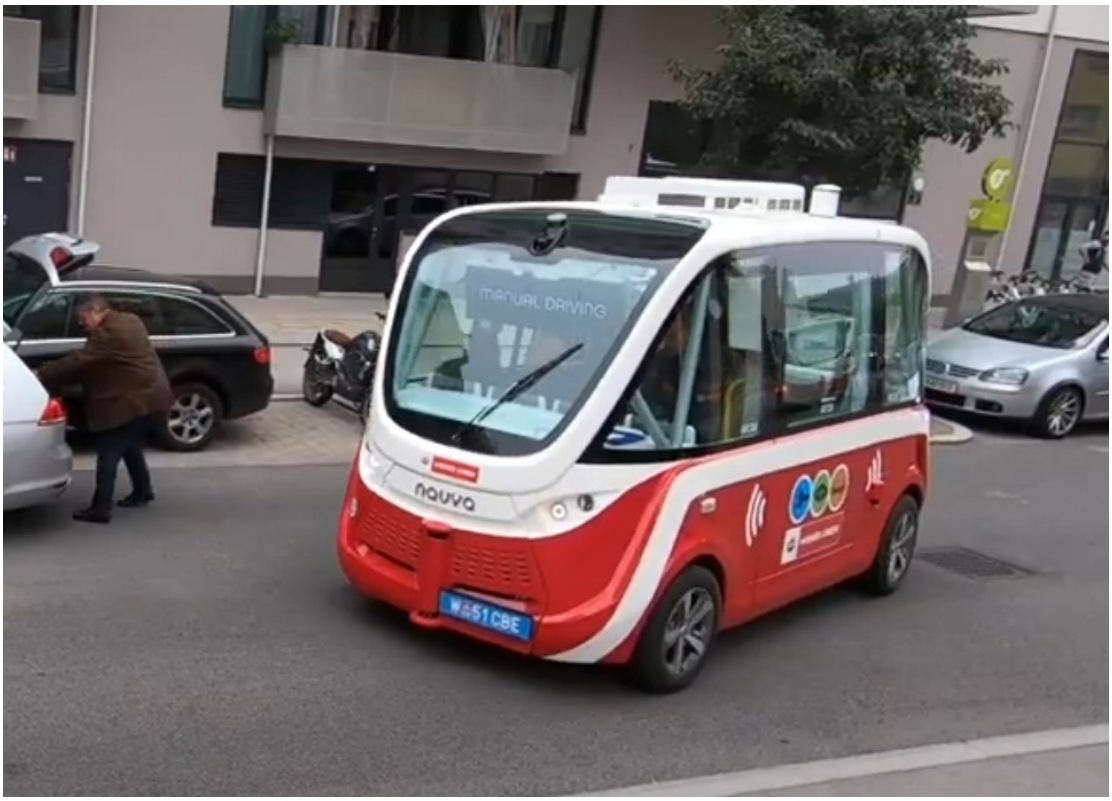

Fig. 2: The Auto.Bus in Vienna[39]

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A Long, Coffee-Fuelled Path to Street Testing

In the interviews we conducted,[40] one term that kept popping up in regard to the first stages of testing the Auto.Bus was 'Trockentesten' or 'dry-testing' the bus before it could move on into public testing. While undoubtedly a significant part of the overall project of bringing the bus to Vienna, those 'Trockentests' were conducted on non-public roads, necessitating the provision and maintenance of additional infrastructures that usually would not be associated with an autonomous bus at all. For example, the project leaders pointed out that they needed to ensure a steady supply of coffee and smoking breaks for the test audiences invited to ride on the bus in secluded areas. In addition, unlike in later phases of testing, financial incentives were handed out to citizens willing to participate in this first stage of testing. This is of particular interest since the entire goal behind the dry tests was to minimize complexity, however, through this approach, complexity was merely shifted away from the bus itself into the testing environment, requiring the provision of additional infrastructures that otherwise would not have been required. When describing these 'Trockentests' in general terms, the lab organizers kept pointing out that they were establishing a baseline of what the bus can and cannot do by eliminating external factors such as traffic; changing road requirements (including random obstacles); and minimizing the probability of carrying passengers that might interfere with the bus in any unexpected way. In this sense, they served the purpose of reproducing the bus' baseline function of 'test vehicle' as established by the factory. In the context of tests-to-come, this first stage of testing puts strict spatial and temporal constraints on the prototypical experience of bringing an artifact of the future into the present. Conducted far away from the everyday needs of bus users and in a compressed period of time, this first step of testing was necessary but only somewhat comparable to the 'real life' testing that followed and reintroduced contingencies into the operation of the bus.

After the project managers established the fundamental functionality and safety of the Auto.Bus prototype, it was introduced to the roads of Vienna. For safety and insurance purposes, a human operator was still required at this stage. However, the bus was supposed to operate on its own, with the human operator only intervening in emergencies. Thus, it was considered crucial that the bus not only had to navigate its routes adequately, but also announce upcoming stops, when to leave or board the bus, and overall, communicate its movements. The bus was therefore modified by in-

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stalling additional hardware such as screens for passengers to better understand what the bus was doing and why, as well as to develop trust in it. This phase of testing not only concerned the vehicle and its function but also extended to the passengers. Not only were the bus and the onboard human operator the obvious test subjects but so were the passengers, by partaking in what one might consider 'wet' tests. Passengers involuntarily became part of the 'future bus in the present,' engaging with an artifact of the future by being asked to integrate it in their individual routines and thereby bringing it to the present.

From the participants' perspective, bringing the bus prototype into the present meant 'learning to live with the bus,' adjusting one's own expectations and routines along the way. This process of translation is exemplified by the additional displays installed by the living lab team. Initially, only a traditional screen displayed upcoming stops and the route. This was expanded to information regarding the bus' operating mode (see Fig. 2) and the current actions performed by the bus, such as departure from the bus stop, evasion of obstacles, etc. Those adaptions are particularly interesting when contrasted to standard, human-operated busses: Whereas, for example, a bus driver standing next to the bus, taking a smoking break would clearly indicate that there was no rush in getting on or off the bus, the Auto.Bus did not afford such means of indirect communication. Subsequently, the emerging gap between established everyday bus-taking practices and those associated with an autonomous bus service required adjustments and the inclusion of further means of communication to allow citizens to understand the bus on a more technological level. Installing the screens may be understood as a means of limiting an excessive amount of contingencies between future and present. As potential bus users are not expected to be familiar with the Auto.Bus or any autonomous bus, this additional infrastructure explicitly aims at translating the experiences and expectations of taking a standard human-operated bus into taking a little autonomous bus of the future.

Furthermore, despite the high expectations of the Auto.Bus—such as quicker responses and safer travel than with human-operated busses, as formulated by both the manufacturer in their advertisements as well as the living lab organizers—we observed a sense of understanding and consideration by early users. It was implicitly agreed that, despite its irritatingly slow and sometimes tedious movement, participants considered this perfectly acceptable as the Auto.Bus was "not quite there yet,"

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as stated throughout short interviews with local bus-riding citizens, both technologically and temporally, as an artifact of the future. Here, it is particularly interesting how, in practice, those expectations seemed to result in tensions that were resolved by referring to the 'not yet' of the Auto.Bus prototype. The additional promises such as increased safety and convenience were strongly acclaimed, although they are a standard feature of autonomous transportation. It seems many people implicitly agree that being an artifact of the future comes with the expectation to be better than what we already know, while still recovering from being thrown into a very non-futuristic world where, for example, the supporting infrastructure might not be up to par, yet. This was reflected both in interviews with citizens as well as interviews with the organizers. On the one hand, it was stated in the interviews with the local public transport organizers that "you need to be able to trust the bus blindly."[41] On the other hand, one of the key organizers behind the initiative used this metaphor to introduce a more humanizing perspective: "The bus is like a blind person entering a room and has to navigate this new environment. Where are the corners of houses? Where are the public walkways? Where are rods at the roadside that it can use to orient itself?"[42] Finally, the term "the poor bus" from the passenger interviews mirrored this humanizing perspective on the prototype. The future bus is torn between promises of autonomy and safety and the reality of the highly complex world of human transportation. The merely-a-few-months-long test represented a key step in collaborative prototyping of a form of future mobility in the everyday lives of citizens.

Introducing Contingency through Speculation: Prototypes in the Critical and Speculative Design Practices

The technology-driven futures represented by the previous case studies are stabilized in sociotechnical imaginaries.[43] A sociotechnical imaginary refers to society's collective perceptions and expectations of how technology interacts with society. It encompasses beliefs and values that influence how technology is developed, deployed, and integrated into daily life and therefore varies significantly across societies, cultures, social groups, and historical periods. Sociotechnical imaginaries can be largely considered top-down visions developed and proposed by the technology industry and innovation-oriented disciplines. These are rather *mainstream futures* that, strongly focused on technical feasibility and economic growth, envision a continuation of the

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political, economic as well as technological *status quo*—futures that guarantee 'business as usual.'[44] Even when considering the lived realities of their future users, as in the presented case studies, mainstream futures still 'fit the mold' and reproduce a contemporary logic of innovation, which is iterative and incremental. This form of incremental technological development is described by Auger et al. as the "future nudge."[45]

As technologies are increasingly embedded in our lives, questions regarding the visions behind such concepts as well as the justification of their visions should be fundamental to any development process. Moreover, while it is often difficult to imagine how given developments could affect our environments and day-to-day lives, opening such critical inquiries to those most impacted by future scenarios (e.g., citizens, diverse groups), and conducting them outside corporations and corporation-impacted consortia, could help in shaping preferable futures.

Towards Alternative Futures: Prototypes for Interrogating the Mainstream, Prototypes for Materializing the Other

The promotions of commercial mainstream futures open a gap for alternative scenarios beyond tech-optimism. Addressing and exploiting this gap is the purpose of Critical and Speculative Design (CSD), a framework of practices that use design as a medium for critique, problem finding, provocation, and debate.[46] Critical and speculative practices have developed strategies for interrogating established technological trends and visions, making their consequences tangible and able to be experienced through prototypes embedded in everyday scenarios. When it comes to interrogation, most of the case studies in early CSD practice materialize an ironic and pessimistic depiction of a given problem in rather gloomy, dystopian scenarios. While these aim to create counterpoints to the idealism of official institutionalized future visions, the creation of counter-narratives and "counter-utopias" is still needed. Critical yet positive future narratives make alternatives tangible and believable.[47] However, is it possible to construct alternative yet discursive future narratives? Moreover, what is the role of prototypes in these future narratives? While CSD is often related to futures, the creation of speculative futures—or 'alternative presents'—is approached as a key strategy for leveraging changes in the present.[48] Within this context we find that discursive practices focused on crafting *alternatives* to the mainstream—with prototypes

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and prototypical speculative scenarios deliberately designed to depict the "other" as a means of fostering critical reflection—encourage public debate, and in the best-case scenario leverage a mindset shift.

Crafting Alternative Futures with Design Fiction

At this point, it is important to make clear that critical and speculative practices do not aim to provide a 'working alternative.' They rather aim to materialize possibilities or preferable paths that are multiple and diverse, and that show different notions of meaning and value. By questioning the connection between traditional modes of problem solving, innovation, and commercial profit, CSD questions the idea of technical feasibility. In this sense, prototypes in CSD practice are not demonstrators—in the present—of what is or could be technically doable—in a given future. Conversely, they are irritators that explore *alternatives* to the mainstream *status quo* through practice, regardless of whether or not they are technically feasible. Thus they operate as a mechanism for triggering dilemmas and prompting an audience to reflect upon and debate current practices.[49]

Prototypes in critical and speculative practices materialize open and simultaneously closed-off snapshots of a given vision through "design fiction,"[50] which is the object of inquiry accompanied by a narrative that creates a prototypical scenario. These practices do so by creating a conceptual space for the use of fictional objects (prototypes) in fictional yet everyday situations that provide "a conflation of design, science fact, and science fiction."[51]

From the perspective of this paper, prototypes in CSD create a temporal tension between *future* and *present*. They fulfill their purpose in the (imagined) futures within which they exist and are placed as everyday objects, as mechanisms for fulfilling their purpose in the present. This ultimate purpose is to irritate and provoke a reaction from the audience, inviting them to reflect upon, debate about, and create pressure to (re)act. Prototypes here do not promise given futures but rather create the space for inquiry to challenge and question these futures, as a means of redefining notions of meaning and value for imagining and crafting preferable alternatives.

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Alternative Mobility Futures

In this section, we present a case study that illustrates how the topic of future mobility can be addressed through critical and speculative design practice. *Our Symbiotic Life*,[52] a project by Katja Budinger and Frank Heidmann, presents an alternative speculative scenario that takes the concept of autonomous mobility a step forward from a more-than-human perspective.[53] Through multiple media such as prototypes, photos, maps, or a routing app, the project visualizes an urban environment in which mobility is not provided by self-driving cars or buses, but rather by self-driving landscapes (Fig. 3). Self-driving landscapes are moving gardens that are energy-autonomous: they collect energy from the sun, the wind, and from the plants. The scenario includes different types of landscapes for different needs and speeds. On the one hand, commuters in a hurry can take "direct units" that focus on efficiency and take the shortest way to a destination.[54] "Direct units" are moving gardens "inhabited by shorter, more resistant plants that are not as affected by acceleration."[55] On the other hand, "contemplative units" support joyful, slowed down commuting experiences by adopting botanical gardens that "offer citizens the opportunity to take a walk while approaching a destination" (Fig. 3, middle).[56] With these different options, commuters can decide if they prefer to arrive quickly or enjoy a longer ride. The scenario is supported by multiple prototypes and storytelling elements, containing physical artifacts that materialize multiple versions of the self-driving landscapes (Fig. 3, left); concepts for an augmented reality application for journey planning (Fig. 3, center); and a generative map of the system (Fig. 3, right). By creating visions that are unfeasible and that may seem absurd at first glance, it offers glimpses of novel alternative ideas. For example, it includes the integration of different modes of transportation (faster and slower) that build on different values related to social discourses (e.g., efficiency vs. deceleration). These visualize new relationships between nature and technology and between humans and their environment toward the vision of more sustainable and decelerated cities. While the 'bigger picture' of how such a mobility system would impact other aspects of the urban setting still remains open and ambiguous, the prototypes and narrative illustrate how particular elements of everyday life (e.g., route planning) would function and appear, for example, through an augmented reality application for route planning (Fig. 3, middle) or the design of a map for the urban transportation system (Fig. 3, right). This interplay between open-endedness and con-

cretization successfully illustrates how critical and speculative practices function. The concretization of the vision through familiar yet alienated artifacts offers the audience a material anchor to the present. Although having some irritating characteristics, speculative artifacts are close enough to something we know, something we can relate to based on our present perspective. At the same time, the unfeasibility or even absurdity of the scenario aims to convey that the main vision is still unfinished, and therefore still open to further discussion and development. This represents an invitation to debate and to (inter)act.

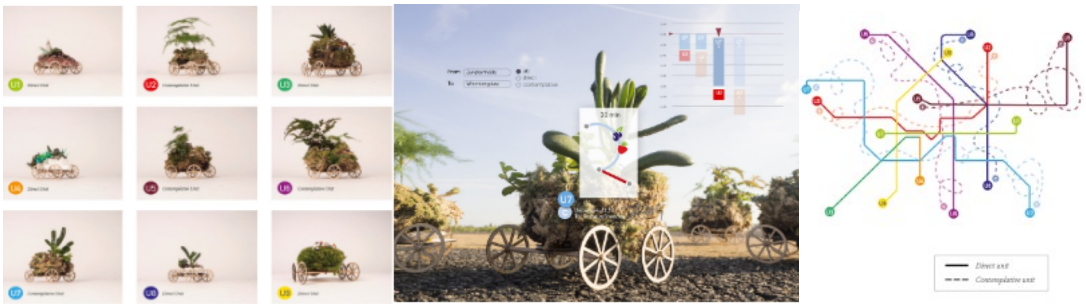

Fig. 3: *Our Symbiotic Life* by Katja Budinger and Frank Heidmann, 2017.[57] Different types of vehicles enable different modes of transportation (left); the contemplative unit U7 and the augmented reality journey planner (center); a map of the mobile urban transportation system (right). © Katja Budinger and Frank Heidmann.

4_Discussion and Conclusion

The three cases above demonstrate distinct approaches toward integrating prototypes into present imaginaries of the future. The Auto.Bus prototype enables testing the 'look and feel' of the future autonomous bus system for the citizens of Vienna. In contrast to this integrative, practical approach, the Pop.Up does not enable testing in an operational environment. Instead, it connects to sociotechnical visions such as the grand challenge of sustainable on-demand mobility solutions. Unlike the Auto.Bus, the conditions to justify possible tests have yet to be established for the Pop.Up. In addition, CSD offers a concept that is different in its aims and practices. Whereas the first two cases show a difference in approaches to how prototypes may be integrated into dominant imaginaries of the future, the third example provides a counter-perspective by questioning those very latent, dominant imaginaries. One might rightfully criticize the lack of plurality in contemporary future imaginaries,[58] yet it is exactly this lack of plurality that such a critical design perspective may address. Plurality can

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be enhanced by balancing between creating stable futures and their careful disruption by way of alternatives.

We contribute an interdisciplinary comparison between the three cases, regarding their perspectives on feasibility and contingency through irritation, as follows.

Creating dependence through the demonstration of feasibility: Prototypes offer more than what engineers call 'proof of concept' that demonstrates a certain idea or method to be feasible in the lab. Prototypes are made to be publicly presented in an operational environment. In the case of the Pop.Up, the concept of the prototype is a car-like vehicle that flies and, for the Auto.Bus, a self-driving bus. A prototype does not have to prove its efficiency and marketability yet. Prototypes appear relatively late in the stream of development at Technology Readiness Level (TLR) 6–7 (on a scale of 1–9) and suggest a tangible future.[59] CSD differs fundamentally by denying proof and omitting feasibility. Prototypes in CSD open up new futures that may or may not be plausible, but they are alternatives to what are commonly accepted futures. The futures taken for granted in the development, testing, and presentation of prototypes for urban mobility might narrow down future pathways. Speculative approaches instead open up creative thinking about alternative futures. The creativity unleashed by unfeasible speculative objects seems to be unique to CSD, as shown by the speculative design project *Our Symbiotic Life*.[60]

Creating contingency through irritation: All prototypes irritate common practices as they are not embedded into everyday lives. Prototypes promise something new and unheard of. Therefore, even feasible and marketable prototypes suggest practices different to what is commonly accepted. These prototypes come with a future vision—in our case, for urban mobility. The Pop.Up carries the vision of urban air mobility with people commuting and traveling in air taxis. Similarly, the Auto.Bus suggests that future public transport would be driverless. Prototypes from CSD such as *Our Symbiotic Life* irritate common practices and expectations as well. However, their vision is no extrapolation of already accepted feasible futures. Their irritation affects not only how new artifacts influence future practices, but also opens up new, possibly even highly fictional futures that at the same time challenge current assumptions (in *Our Symbiotic Life*, the notion of what shape the future of autonomous mobility could also take). In the context of science and technology governance, this opening up of possible futures requires more appreciation in analytic and participatory appraisals and in

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practical implementation.[61] Conversely, political, preferably democratic, decisions give closure. However, prototypes have a closing effect too. Prototypical interventions—as we presented with our empirical examples—imply a future vision which forecloses at least some of the contingency of innovation pathways. This closing effect does not have to be evaluated negatively, such as when prototypes promise a more sustainable future. However, this technological closing effect should be considered when democratic decision-making and participation is in question. Consequently, CSD can foster a critical approach beyond the focus on pure feasibility, while opening up a debate in participatory settings.

Prototypes create both a functional and social estrangement, implying completely new mindsets that are projected and supported by fictional scenarios.[62] They are mediators engaged in debate about alternatives to the *status quo*. They do not imply a timeline but a disruption. They are not proposed as futures to become a present reality. An open question of critical importance remains: Can prototypes help open up futures for democratic deliberation and engage with values such as social and ecological sustainability? Or will they fall back into technocratic visions?

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