Hello. Good afternoon, everyone. Thank you for being here. For the people online, also, thank you for assisting the people in person. I really appreciate that you are here with me today. I would like to start the presentation with a small overview of my research, and then based on that, try to go a little bit on the dissertation. Before I start, I would like to tell you about my experience with 3D printing. In 2016, I had the chance to work with this technology, found a company, and based on that, got the chance to come for the Masters and keep working on that for my PhD. During the PhD, I got the chance to work with a construction company, get more involved with the 3D printers, and get in touch with concrete, a different material for me, which also gave me more experience into the applications that this technology can have in cities. At the end, I decided to go for the PhD in 2020, and during this research, I had the chance to go for several collaborations worldwide in Belgium, Japan, the U.S., Mexico, here in the Netherlands, and today, that is to showcase part of the results. I would like to start with this image of Mexico. This is the way that we collect waste there. As you can see, there is no sorting practices, and it really aligns with how cultural aspects can shape the way that we recover resources. Another example here is Amsterdam City during King's Day, which is also a lot of waste in cities, but at the end, you manage to recover it and use it for new purposes. Here is where I get to know one of my supervisors, Argent Himmeren, with this project on circular cities, and the idea was to collect plastic and bring it back into cities, in this case, as an urban furniture. This technology can give us a lot of flexibility on the capacities and the things that we can do. Another example is this 3D printed bridge made out of metal, also in Amsterdam City, and I think that this gave us a sense on how flexible it can be, this technology, how much materials we can use, and how this can be adapted to the local context, which I find it really interesting during the research. To give a little bit of context on the dissertation, I try to combine new technologies or to compare new technologies with older ones and see what's this phase of replacement. As you can see during phase three, there is some optimization, and it's a point that connects with innovations and how these are applied in a bigger system, which brings me back to planning theories, in this case, multilevel perspective, where I try to identify circular practices with 3D printing and at each level to see how these technicalities can improve to recover materials and see how this can get involved into a bigger system, in this case, supply chains, but also the urban context, and how different main actors are interacting between each other. At the same time, since the technology is quite new, it was important also to keep an eye on the global context in order to really see what are the trends, what is the current state of art, and from there, try to start. For the dissertation, I use a conceptual framework based on backcasting, which I tried to come up with a vision. This vision was to use additive manufacturing in a circular way and see how we can recover resources at an urban level. Based on that, we went back to where we were and started with the chapters. So as you can see in this figure, the first four chapters are the beginning of the research and is combined with the seven collaborations that I did during the research. So basically, the blue dots there are different projects, prototypes that I developed during these five years, and that is also connected with the fifth chapter, where I share a vision on how this technology can be implemented at an urban level. To start a little bit on the dissertation, I have four chapters. These chapters are developed to create a context on how circularity new technology such as 3D printing, and the urban context can be aligned. In the first chapter, I used a conceptual paper where it allows us to have different areas linked with the supply chain and then connected later in a second chapter with the private sector. So in the second chapter or third chapter of the dissertation, I went for a conceptual empirical article where I tried to look at the current state of art of 3D printing and link it with circularity. After that, during my experience with the company, I combined my experience there with this fourth chapter in collaboration with Lead Research Institute, and the idea was to come up with a hybrid approach that allows us to use the benefits out of different construction methods for 3D printing in construction. So we end up with a new approach or a hybrid plan that allows us to showcase 3D

printing at an urban level. And in the fifth one, we used, as a context, the first three chapters in order to have a clear narrative of it and end up with a road map. After we get the road map with the seven prototypes and collaborations, we end up with a clear path that can be replicable later on. So I used to give a bit of a sense of what I did on the second chapter. Like I said, it was a systemic literature review where I focus on the urban context and then try to compare or try to identify, not compare, try to identify what are the circular practices linked with 3D printing. Based on these five main areas, I came up with a cognitive map just as a visualization on the linkage between different industries, cities, and how circularity, in addition with 3D printing, can be a good bridge, a good link between current actors and new innovations. So in the fourth chapter, I tried to go a little bit more in depth on the current practices or a practical way to showcase this technology, and I ended up comparing on-site and off-site 3D printing in concrete or in construction. At the end, to have a flexible system that allows us to have not just printers in different locations, but also be able to control the different variables or the different environmental conditions allow us to have better quality or better capacity to implement it in different regions. At the end, like I said, I tried to come up with different prototypes that allow us to link all the supply chains from the recovery of the resources to a final product. And these are part of the prototypes that we developed. The idea was to combine not just a recovery resource, but also combine modularity, circular design, different components that are used in circular economy, and end up with shapes that can help us to create bigger patterns. So let's say that we have not just a 3D printed element, but this 3D printed element can be modular, and this modularity can also help us to have bigger structures and end up with morphologies or bigger patterns that can also be included in series. Based on these core ideas, we end up having a clear pathway or a clear roadmap on how we can recover resources. And at the end, the idea was to start by having urban waste, identify actors that can help us to collect them all, and process it in order to print it, and then in that case or in that point bring 3D printing companies that can help us also to provide new products to the urban context or specific industries. At the end, the idea is to have the current supply chain or the current linear system, but with these loops try to help in order to recover some of the resources. And this ended up helping us to have a vision of a circular additive manufacturing lab, a place where we can apply all this knowledge, try to come up with local materials, and have opportunities for local actors to implement them in a bigger scale. At the end, one of the main results of the research was the lack of... I couldn't compare materials just because since we used such a different waste flow, it was hard to compare between each other, and I think that those were some... It was not a problem during the research, but it helped us to identify that to have a place where we can identify these materials and really work with them, it will be really important. So at the end, in the last chapter, we tried to come up with circular AM for cities and share this vision with... in this case, now with you, and that serve as a basis in order to create products. I think that the interesting part of this research is that since this is just a context on how this concept can be used and this technology can be applied, there are so many things that can be done later. That I find it very interesting and really looking forward to keep going with this. In a few minutes, the committee will arrive, and we will have a set of questions. Will I try to reply? And then, well, after that, we will have a drink, and then we can have a chat locally with the diploma. Before I finish, I would like to give some words in Spanish. And hola, buenas tardes, a todos. Buatar de también la. Muchas gracias por venir. Gracias por estar aquí con nosotros. También a la gente que esten linea. Le se gracias con mucho la verce toma de esta tiempo. And bueno, ah, ahora que se termino con la presentación. Vamos esperar un los minutos para poder recibiras los oponentes. Responder sus preguntas. Intenta responder sus preguntas. Y una vez que terminemos con eso bueno. Vasir un poquito el protocolo de la ceremony el sierra. And vamos a pasar a una parta el fondo para poder tomar. Una vebida. Todos con tus. Muchas gracias a todos por estar aquí o traves. And thank you, everyone, for being here. Please be seated. I hereby open this ceremony

convened by the Academic Board of Aacheninga University, in which Elias Hernandez Valera is offered the opportunity of defending a thesis with propositions entitled For a Circular Future, Implementation of Additive Manufacturing and Circularity in Cities. The defense will take place before an examining committee appointed by the Academic Board
as a prerequisite for conferring the degree of doctor. Good afternoon, ladies and gentlemen. I would like to welcome you all to this graduation. My name is Simon Busch. I'm Professor of Environmental Policy at this university, representing the Academic Board and Rector Magnificus here today. Without further ado, I would like to call upon our first examiner, Professor Melz. Professor Melz is Chairholder of Environmental Technology at our university. Professor Melz, the floor is yours. Professor Melz, that's not necessary for questions. Thank you, Chair, respective candidates. It was a pleasure to read your thesis and to dive into your research into circular additive manufacturing. It's a very intriguing proposition that key items made of materials, like plastics and concrete, can be made by 3D printing from sorted wastes at local or regional urban scale. And I should say that you really took me along in this vision towards a circular world where many of the items that we use in our daily lives could be potentially recycled through AM, maybe even at the home level. And let me then start first with a question related to a picture in your thesis, a picture on page 207, and it's actually you standing amidst what I assume is a additive manufacturing lab. Is that correct? Yeah, it is. It is correct. First of all, highly esteemed opponent, thank you for being here. Yeah, I think that that picture was for my two years' work in cyber. It was a construction company in us in the Netherlands. So I got also the chance to work with them, and the printers there and the lab is part of their headquarters. Nice, yeah. You also look very proud, and you're standing at a creation that I could not really understand what it is. I also showed it to my wife, and she also didn't understand. So we are very curious whether you can explain what actually that thing is on your right side here. Yeah, for that I had the experience to work in the company as a material developer and also working with the printers and with the projects. And the idea to have that was to test a new material. So basically we get tests from Germany. It was recycled concrete that I wanted to use, and that was a test. So as you can see, we used different shapes, different forms, and the idea was to test whether the material can resist or not. So it's a test that we do to run the printers first. Yeah, okay. And does it have a certain shape or purpose of a shape as it looks? If you can notice it, there is curve, so that helps us also to see how string will resist if we put some pressure on it. And the tiny shapes that you see inside is just to see how good the robot can move in it. It's just for that. Even we tested or we run a test before material first just to see how the robot makes. Once the performance is good, then we can do the material. So in that way, we reduce a lot of ways that can happen during the manufacturing. Yeah, okay. At this point, I will report back to my wife then. And then the... Yeah, this is already recycled concrete, I understand. Is that possible to... That this object could be recycled again, that this material could be reused? We use... The concrete was recovered in order to serve as an aggregate. So I think that once that material is used, we need to, again, shredder it, cut it and test it again. But yeah, it doesn't go as a concrete per se, but more as an aggregate. Right. Yeah, because of the quality of the materials. They are not really good if we put them together. So what we try to do is just to use it as an aggregate. That also reduces the cost for our client in Germany. So it was a win-win situation. At the end, when we work with companies, it's more about get a benefit for them and see it reflected in the cost, which, yeah, that's what we try to do there for them or for the companies that we work in. Well, the recycling question is actually also a bit of an introduction to the next question that I have. And that refers to your chapter two, one of the conclusions, and also to chapter six. And this is why you say there are still some open questions with concern of additive manufacturing in the literature, at least, around the collection and the sorting practices that could help bringing materials back and use in the urban system for better recycling. So basically, you wonder, yeah, how can we organize this recycling? You pose it as a question also at the end

of the thesis. So it also triggered me, as scientists, we like questions and we like research. Yeah, the question is, how do you see that system of organization for recycling then happening in cities? And what could we do there from the research side? Thank you. Thank you again, Haileiszcimo, for your question. I think that it's really interesting at the end, due to my expertise and also the experiences that I have during this research, I focus more on the technical side. So the idea of this research was to really combine the concepts that I thought that can be useful for me in order to apply later and show the importance of the spatial aspects of it. At the end, it was one of the examples that I have during the presentation. It's not the same collection and sorting practices here in the Netherlands and in my home country in Mexico, neither Japan, where I also work. So those things also shaped the system. At the end, I come in more from a technical side where I try to showcase that this technology can have the capacity to recover and recycle materials, but can also point on the regulation side and the policy side. So it can also be a working combination, but I think that I come from the other side. So for me, it was really, see the state of art of this technology, see what are the applications nowadays, and then see how this can be beneficial for our bank context. At the end, it's also connected with all the flows on the city. So I find it really interesting, a city scale where we can identify several materials and find also different supply chains that can be involved in those adjustments to become circular. Yeah, still, there is a lot of recycling or actually collection already, a separate collection. So you've been living in the Netherlands a few years, of course. Could you imagine that there could be some kind of a system like that also for AM manufacturing materials? In Mexico, you mean? No, in the Netherlands. In the Netherlands. Yeah, definitely. I think that there's already a lot of projects going on. Also, part of my supervisors work with them, and it ended up, this kind of research ended up being a good opportunity, a business opportunity for some of them. And the idea is that once you have tested a material, you already have a path to go. So it's just replicated. And in that way, it can have a cost benefit for them. So I think that there is a lot of research going on on that. It could be like an extended producer responsibility, maybe, even. Yeah. And serve as a bridge. I think that one of the concepts that I also use is an actor of change during the PhD. And the idea is that these additive manufacturing companies can serve as a bridge in between some industrial sectors already and the cities and users. Yeah, OK. Yeah, clear. Yeah, another question that I have, that is maybe a typical Wageningen question, but in one of your chapters, I think it's chapter six, you also suggest that instead of recycled materials, we may also use bio-based materials. Yeah. And Wageningen has a very strong vision on bio-based materials. How does your vision compare to an idea of having a more bio-based society? Do you think those two ideas can be combined? Yeah, I definitely think that those ideas can be combined. And at the end, it's important to have more sustainable products that come from organic sources. But at the end, I also notice that mostly in industry, it's hard to comply quality specifications. And I think that it will be a journey to reach that, to really go from really organic-based materials into the industrial sector, for example. But I saw some examples here, also with 3D printing mainly. Most of the materials that I use is organic source, PLA. So there is already some industries that are taking this, but I see that they are more dependent on the quality of the material rather than the origin of it. Right, yeah. Then a question building on that, I noticed that you actually are a graduate of our department. And probably you have seen our work on the bioplastics. Yeah, in Haiti. Yeah, PHAs, the polyhydroxyalkanoase. I was wondering, do you think that such a material could also be used in additive manufacturing? I mean, I think that also that one and PLA specifically, I think that they can come from different sources of organic waste. In Mexico, they used to do it with avocado, for example, avocado seeds, which I think that is really interesting. But I know that in China and other countries, they have other practices. So, yeah, I think that it's just a matter of time that those start reaching bigger industries. But yeah, I think that it's really interesting what they are doing there on bioplastics. Okay, thank you. My next question is actually related to a proposition, and therefore, a respected

candidate, I'd like you to ask one of your paradigms to read out proposition number three. Yeah, Delverdo, can you please read proposition three? Cultural differences actively shape how technologies emerge, diffuse and adapt across global contexts. Thank you. I was contemplating on this proposition actually yesterday, and I was wondering, is it not the other way around, actually? Is technology not shaping our cultural habits? And before I have your answer, I would like to give you two examples of where I feel that technology changes our lives and our cultural habits. For example, when we developed cars, our perception of time and distance started to change, and we started living much further
away from our jobs, for example. So that is a significant change in habits and the way we live. And the same is maybe with smartphones and social media, where we are communicating differently, we are behaving also differently. So, is our technology not vice versa shaping our cultural differences and our cultural habits? Thank you for your question, Mr. Boonin. I tried to see it the other way around and see how the tropicalization of the technology can be influenced. At the end, for example, certain practices are not the same in every country. So, like I said, if we focus on the process, it will be maybe hard to make everyone work as the way that I think. But if we are able to adapt or understand the system, in this case, what are the common habits from citizens in a city, then it will be easier to shape that system. That's why I'm trying to see that technology more as a way to tropicalize it so it can be adjusted to the local level, rather than how that technology can influence the practices that we have in our daily activities. So, basically, this is also a preferred way of how technology should develop, I suppose. And adapt to local context. At the end, it's like I said, I think that we leave it out when it comes to, okay, let's bring our technology. We just think that technology is good and we just put it. But the fact that we take into account the local aspect, I think that can help us to have a better grasp of that technology and use it in a better way. Thank you. With that, I would like to end my answer. Questions? And give the word back to the chair. Thank you, Professor Melz. I would now normally hand over to our second opponent, Dr.

Ramirez, at Hildago State University. Unfortunately, we've faced some technical issues. He was online, so we're unable to bring him his questions to you. So we'll move to our third opponent, and that's Professor Baudin. Professor Baudin is Professor of Circular Economy at ESEC School of Management in Lille, France. Professor Baudin, the floor is yours. Thank you, Chair. So, respected candidates, thank you for this dissertation on a timely and also original topic. And I learned a lot, so thank you very much for this. So my first question is about the territorial embeddedness and the transferability. So throughout your dissertation, you argued that circular additive manufacturing can help cities to close local resources. And obviously, cities can differ in terms of weight streams, institution capacity, industrial activities, skills base as well. So to what extent do your findings depend on these local conditions? And can your findings and can this type of circular additive manufacturing fit well in large metropolitan areas or in medium-sized cities in the same way? I highly esteem your point, and thank you for your question. First of all, I think that what you're trying to ask me is how my vision of a lab will be influenced by if it's a big city or a small city. I think that, well, that's a good question. I think that what I tried to do during the first chapter was to get a context, see a state of art. So there is some literature on recovered plastics and be used in 3D printing. There are some literature also working on how these technologies can or are already implemented in the urban context. So it was really to give a sense on what can be the opportunities of it. At the end, I also mentioned during my conclusions that it's important to have different measurements or some indicators that can help us to see. So for example, I try to put in the conclusions that Mexico can be a good location just because expertise that I have there and already some actors working in. But at the end, I think that it's important to monitor the resources first rather than to see if the technology will be applied. So do go for material flow analysis. It's something that we do during the Masters that I learned there. So the idea to connect that

later on in a bigger scale in our urban context, I think that will be the first stage. So I'll go first for that. First for that, try to see what are the resources there and the ambition that identify what can be recovered or not. I'm following on what you said about Mexico. So this country has not the same level of economic development, neither the same institutional capacity and so on. So this type of additive manufacturing can be implemented in the same way or what are the main barriers you see in Mexico to implement this type of additive manufacturing? Well, when it comes to regulation, there is still a lot on recovery of materials. So basically, we don't sort our waste. It's just done and put it in a landfill. So that's also an opportunity at the same time because we reach a point where we need to decide whether to continue with those practices or go for more practices that help us to recycle. So I think that in Mexico there is a lack of regulations, but at the same time there are companies that are also investing in this technology. For example, Semex, that is a big construction company in Mexico, is already developing materials for that technology. So you can really see both sides of the coin from one side. There is a lack of regulations, but on the other side you have private sector really trying to push for it. So I'll say that for me, in my specific case, the idea is to work with the private sector in order to bring these practices and connect them. I think that a big part of circular economy is to see how these actors interact with each other. So yeah, I think that I will be more into the networking part and trying to see what can be possible business opportunities for them. So it makes a good link with my second question because it's all about the actors involved. So my second question concerns the implementation. So your dissertation is very persuasive on technological opportunities, but the actual implementation in cities usually depends on governance arrangements, on the coordination between different actors and the public capacity. So in your view, who should lead the transition towards circularity manufacturing at the urban level? So is it the municipalities with their incentives? Is it the private firms? Is it public-private partnerships? Or does the national state should act as well to help to develop this? So who should take the lead? Well, I'll talk about Mexico. In Mexico, when it comes to municipality, they have the power to define their own regulations. They have the power to make some changes in a local level. But then, of course, there is some pressure on the national level in trying to implement this. What I see in Mexico is that we're really going to see what the other countries are doing. So once we start talking about circular economy in other places, well, Mexico is also doing it. But when it comes to results, I do believe that the private sector is the one that have this push effect that can really make things change. So I'll go for the private sector. I think that it's strong. They also have investment. They have this business or cost-benefit-oriented mindset, which makes it also good if you look for win-win situations, right? Thank you. My third question concerns the scale. So your dissertation presents promising examples, prototypes, pathways. Yet many sustainability innovations remain confined at the pilot stage. So in your view, what are the main barriers that prevent circular additive manufacturing from moving from niche experimentation to broader urban transformation? So is the main bottleneck technological, economic, regulatory, or organizational? I'll go more for infrastructure, for the capacity of the printers. I mean, the technology is evolving, so it's getting better and better. But the access that you can have to them depends on your geography, depends on where you are at. So I think that there is a lack still of people having access to printers. They do have tools to design, to do software, not to do software but to use software in order to have 3D designs. But in the moment that we want to pass it to tangible objects, I think that there is still a breach in there. So maybe question ourselves or question business if to go for half printers at home or half farms. So I think that those kind of debates can end up with the communities, which can really make a difference on the quality of life of people if you have access to these kind of technologies. So, yeah, I think that is a point in between, I'll say, but it needs to be in debate with the local actors. Okay. My next question is about the data monitoring and indicators. So you argue that better data on additive manufacturing can help also to connect

the actors and track the circular systems in cities. Let's imagine that a city is wanting to operationalize your framework. What would be the most important indicator to monitor the local impact of those additive manufacturing? So would you prioritize the material recovery? I don't know the local economic impact, emission reduction avoided, things like this? I'll go directly for materials among the material. That will give me a good sense of how can I use it, where it can go, and how much waste I will have to it. I also noticed that some researchers, when it comes to environmental measurements, they really go for CO2 emissions, which can be good if you are trying to see or to compare those emissions. But for me, it's important to have the quantity of resources so I can know how much I can do with it and connect. So for me, I think that the quantity of the materials will be the most important to monitor and to know how much goes in, how much goes out, and what happens in the system. And what about the financial aspect, like how many money you save or things like this, because at the end, it's all about business models, so you need to find the good business model. There are some articles from the AMS that work on energy, and if you compare energy usage of traditional manufacturing processes and 3D printing, there are still some saves on 3D printing. Still, not a big difference is to do it. I really cause benefit for the technology, but if you include local materials, I think that can be a good combination of both factors. And yes, probably last question about the technological promise and the material feasibility. A key theme in your dissertation is the recovery of resources through additive manufacturing, but the feasibility of that model depends heavily on the materials, right? So, in your view, is the main constraint today the technology or the quality of the material, the certification of this material as well, the availability of these materials, and the logistics to bring these materials, and so on. So, yes, what is the main constraint? The technological one or more the material-based one? The material regulation one, because you need to, like I said, try to focus on the identification of local materials, but those need to be certified in order to cover certain quality standards. So, I think that I'll go for that. Thank you.

So, with that, I would like to end back to our share. Thank you, Professor Baudin, for those questions. When I move on to our third or third-slash-fourth appointment, Dr.

Trinh is Head of Research at the Lab for Additive Manufacturing in Architecture at TU Delft here in the Netherlands. Dr. Trinh, the floor is yours. Thank you, Chair, and respected candidate. I really share what the previous opponents already said about the pleasure of reading your dissertation. Quite engaging line of thoughts. I appreciate you very much how he was bringing together views from different stakeholders how transdisciplinary it was and the span of the integration across different viewpoints. So, this, of course, I have questions. My first question regards a proposition for which I would like to kindly ask you to ask one of your friends to read the proposition number one. Can you help me reading proposition number one, please? Circular additive manufacturing enables closing material loops at the end of life status of supply chains. Thank you. What this proposition states is also highlighted in several parts of your thesis. Specifically, in chapter five, the chapter where your vision is proposed, this statement is highlighted also not just with reference to additive manufacturing in terms of technological innovation, but really as an enabler. Exactly like the proposition highlights. Can you define in your view an enabler? What really is and what do you mean with that? Yeah. Thank you very much for your question. I think that in order to come with new solutions, in this case, new materials is important to have access to technology, to have access to new tools that allow us to have the development of new materials. So, in this case, I try to use the word enables in order to— I'll say explore different materials, and to have this technology can help us to really go in depth on that. So, I use enables in order to serve as a tool, I'll say. Thank you for this clarification. And then on this line of thoughts, considering additive manufacturing as a tool that allows us to do something, let me share a reflection.

Additive manufacturing as a technology or as a tool exists since long, is of course emerging, is evolving, the trajectory is speeding up quite quickly, but nevertheless, it's been there around for several decades. And yet we are still, as your thesis indeed highlights, we are still exploring, we are still bringing together, so still something is missing. What are, if you were to name, let's say, two, three main barriers to really exploit this tool as enabler? Well, the main one is material, material cost. For example, when I work with construction, that really increases the price. So, the idea to really focus on material development, focusing for this technology can help us maybe to reduce cost and have better applications for it. At the end, that's also linked with the educational aspect, how much people know how to use printers and know how to use a tool and software is needed for it. So, I think that it's important not just to have the local materials, but to have what we call in business a critical mass, people with specific knowledge that can help us to boost this. And if I will link both, I think that is the circular aspect, the one that can really connect this and bring researcher, experts, or citizens and then try to sit and say, what are we going to do with this? What are the resources that we've got and then start making solutions or building up based on that? But, yeah, I think that the limitations are all for the local materials or development of materials. And, well, yeah, educational part or the lack of people knowing how to use 3D printers. Thank you. I will move very soon to the second aspect, the education and the digitalization, and that actually is my next question. But before we do so, let me just dive one step deeper in the first part of your answer, the material, which was already partially also discussed. So I hear, correct me if I'm wrong, two different aspects. One is cost and the other one is the availability and the quality of the availability of materials that have the quality to actually perform. Who, going back then, who is then the main actor that has the power or the view or the tools to link these to additive manufacturing to make it a real enabler? In my own experience, it's companies having this dream to do it. But like I said, I see or I notice it, there is collaboration between big material developers and people with the know-how and 3D printers. So you really have these two companies coming and try to look for solutions in a specific location. So to give you an example, we got a client in Canada that was trying to do buildings there, but the material was too expensive to send there. So what we tried to do is to check some aggregates that can be used in order to reduce the cost, and we use tire, shredded tire, in order to give some volume to the mix. And it was also a university helping us with the research in Canada. So I'll say that all these solutions came up from a group of actors, most of them on the private sector, and with a specific objective on how they want to use that technology or that specific source. So it's really a vision or a person or a group with an idea and then try to see what are the other actors that are interested in that. Okay, thank you. And I will pick up later in my question to this point. But for now, indeed, I move to the digital component, which I highlighted, which indeed is also discussed in several parts of the dissertation. When you present the cognitive maps in the interview, you highlight very clearly the role of software, together with hardware. In the interviews, several interviewers were referring to what it means, digital transformation, the availability of knowledge besides software. So several different angles emerged, utilities is. But let's say my interpretation of your point there was a strong highlight in terms of software and digital knowledge in relation to the 3D printing process, per se. You also highlighted optimization that it can allow. So this is, to me, at least all very clear. But I wonder, is this really something so specific referred to really the 3D printing process, per se, and at most the design of the component? Or could a digital transformation of the building sector or beyond the digital transformation in terms of circular economy make an impact on the larger picture that you have on these regenerative urban systems, in this availability of material in these? So can you elaborate on the role of digital transformation in a larger picture, if any? Yeah. Well, my listening, thank you for your question again. I think that what I tried to focus on during a specific chapter with the construction company was in projects. Again, I also noticed that the construction sector, it has a lot of regulations when it

comes to the material use and what you can use again, what not. And I think that that's a big bottleneck. What I think that, or what I focus now was more on to see what can be the capabilities of the printer, the design, see how this can be combined, for example, with traditional construction methods, which is all our columns, and be able to keep that, and then try to work on the design around. At the end, I also noticed and find it really interesting because I collaborate with some architects on this parametric design, how these tiny tools can really help us to go for a better design before we print. So I think that, yeah, I focus more on that, to really make sure that the process and what you are printing can be replicable because it happened a lot of times that we end up thinking, okay, this prototype is good, we print it, and the shape was not good, the material didn't work. So to make it replicable, it takes a lot of time. So I think that my focus was more on that, and really be able to replicate it instead of see how you can compare it in a bigger scale. But I noticed that when it happens, it's more focused on material recovering. So once you have material from construction that are not used and can be used as an aggregate, we have those type of cascading practices, let's say. But, yeah, we mainly focus on the design and how these tools can help us to be more efficient and reduce the waste, reduce mistakes most of the time. I completely agree that that is a key point, so I share your view. And I have a follow-up question, on acknowledging the importance of these and the value of what you were focusing on, would there be any specific advice or vision or tips or longer-term roadmap that you would like to propose to any of other of the stakeholders in terms of digital process? Open source software, I think that that can really help companies to have a standard frame, which I noticed that is not the case. Literally, in private sector, it's really jealous when it comes to technology or knowledge. So I think that to have software platforms that can be used for different companies can allow us to have the same room and then based on that, really, this cost and try to help to grow the industry instead of trying to hide things from others. So, yeah, I'll say that. And just a very short follow-up on this point. Do you see any possible link or what is your view or your critical view? Again, if any, it's a bit outside the main focus, but there's a broader picture. For example, with digital material banks. With what? Digital material banks, if you're... No, I'm not really moving on that. Which is fully fine. It's on the edge of the thesis indeed. And following up on the aspect of education, which you brought up, and on the importance of software, one specific, let's say, wonder, which I had when I was reading your thesis, especially in the description of the living labs. You're proposing this model of living labs where a distributed process of additive manufacturing could take place. And it also follows up from some of the interviewers' answers where they were highlighting how certain situation needs to be handled
with specialized knowledge. So on the one hand, we have this ambition of distributing the actions, the models, the 3D printing process. And on the other hand, we have a balance between democratizing, therefore, the tools and the software, and on the other hand, specializing the knowledge. Is this conflicting? Is this a synergy? How do you see it? I like that word synergy. At the end, I think that it's important to have local solutions, but connected with an international network. At the end, like I said, a first stage to have a lab will be to identify materials, and based on that, materials have solutions. Those solutions and materials will differ from one point to the other. So I think that if you have people getting specialized in a specific material, it can be later on translated to others. So my idea to have more specialized or more material development focused objective can help us later on to donate working or see what others are doing in the same sector. I had the chance to see in the AMS, for example, in Amsterdam, working, like you said, with bio-based material. It's also motivational. It's also good to see that others are trying to use the same technology but with other materials. So I think that that triggers that creativity. I think that I will say focus to local materials and then try to identify international networks so we can share this knowledge and replicate it later on. Yeah, I see. Thank you. With my next question, I move back a moment to the ideas that you were highlighting and

bringing together different stakeholders, especially, you said, companies' private sector as key players in activating the change. In your thesis, you refer very often to co-creation as something really needed to ensure the circularity of the full process. Now, co-creation doesn't necessarily always happen spontaneously. At least, in my observation, there can be barriers to that and especially sometimes the private sector, as you said, can be jealous and can be protective of knowledge and processes. What is your view on that? How can we fastly take co-creation? How could we engage into that? Will it happen spontaneously? I think that the spatial aspect is really, really important in that. So the fact that we can have a space, that we can test materials, provide the tools, show how the tools can be used, I'll say that it's a small prong for people to collaborate together if we are able to provide a space and provide the tools needed, because in that way, we are all in the common ground. It's not, I'm bringing this, I'm bringing that. How can we fight to have the other part? But it's more into, okay, we're learning something new. It's a new process. That's why I also mentioned several times during the research that I truly believe that technology helps us shape policy instead of policy helping shaping that technical side. So, yeah, I will say that. Thanks. Dr. June, we might leave it there. That's the reallocated time. We'll make our way around. Oh, yeah, sure. We'll see how far we get in our second round. So, having said that, I'll pass back to Professor Mills for further questions. Thank you. I respect the candidates. I would like to also continue a bit on these barriers that were mentioned, materials and education. I think you did a nice study also comparing different sectors. You looked very deeply into the construction sector and I think the other sector was more into generic sector but maybe more related to packaging if I understood it well. Looking from what you know now, what would for you be, say, the preferred sector where these innovations should spearhead? Interior design, I think that is to really go for manufacturing pieces in a small scale. It's easier due to regulations and can you give us the basis on all this needed in order to go for bigger industries like automotive industry or special, which I think that we're still not there yet. So, I think that I'll go for architectural elements, something that doesn't have a structural component on it, so more small scale products. Why do you prefer that specific sector? Because I think that it doesn't have a lot of regulations when it comes to quality control and then specification, so I think that that will make it easier in order to enter into the market. Once you are in a market, it's easier to see what can be new opportunities but as a first sight, I'll go for that. I was working, one of the prototypes that I developed was using Japanese modularity and it was really into different shapes that can be used at home. So, I find it really interesting how this scale can help us to replicate pieces and then be translated in other sectors. Just because other sectors have more regulations, it will be harder to enter just because of that. Yeah, I understand that. At the same time, I'm just wondering, if you think about an industry like the packaging industry, which is very standardized, and at the same time we see that materials are recycled more and more, the PET, all kind of plastics, do you see the potential in such industry as well? 100%, 100%. I think that packaging is also one of the main plastic sources that we use, so to have a good pathway to go can maybe bring in better products, not just packaging, but functional objects, right? Thank you. Thank you. Very well timed answer, thank you. And thank you, Professor Melz, for that final question. I now adjourn the meeting. The Examining Committee will withdraw for consultation. Please be seated. I hereby reopen this meeting. The Academic Board of Arcanine University, represented by the Deputy Rector Magnificus and six committee members appointed by the Academic Board, having noted the contents of a thesis entitled For a Circular Future, Implementation of Additive Manufacturing and Circularity in Cities, with propositions, having heard the defense of that thesis, has decided to confer the degree of doctor on Elias Hernandez Falera, born in Pachuca, Ildago, Mexico on July 10th, 1991, and to grant him all rights and privileges ensuring from that doctor by law and custom. The Academic Board assumes you accept your duty as a scientist to execute your future research ethically and with due diligence according to the I now invite the promoter, Professor Van Lelen, to present the new doctor with the

degree. You have heard the decision of the Academic Board of Arcanine University to confer on you, Elias Hernandez Falera, the degree of doctor. It's now my honor to present you with the degree signed by the Deputy Rector Magnificus, the promoter and the second promoter, and sealed with the great seal of Arcanine University. I first invite you to sign the degree as well. With this signature, you declare to act according to the Netherlands Code of Conduct for Research and Integrity in the future. Allow me, Deputy Rector Magnificus, to offer my congratulations and to add a personal address. Dear Doctor Elias, congratulations for successfully defending your thesis and for kind of ending this part of your professional journey. And I would also like to extend my congratulations to your family, to your mother, to your friends and everyone also that came over and also the people that are listening online. Because that's been a journey, no? Mostly for you, but also for your supervisors and probably also for your family and friends. I still very vividly remember that you came into my office. You were a student, you finished or you're working on the Master of Urban Environmental Management and I was relatively new to Arcanine and I don't think I ever heard of the program. And you asked, can I be part of the Urban Economics Group, can I be embedded to do my PhD research and the research and circularity in urban mining? And I thought, well, this is really interesting, but it might also be a bit far off from the urban economics topics and I'm not sure if I told you so that I was having a bit of doubts, but you insisted and you came back and then we said, well, let's give it a try. And we asked Aryan from Timur, who was at that time the scientific director of the AMS Institute and I was lucky to follow up on him and to be the next and he accepted to be your other promoter, your second promoter. And it was also a really nice way and also thank you very much, Aryan, for joining the supervision team and to have this collaboration. And then we, of course, needed to spend some time to write on a proposal also because we came from different disciplines with different backgrounds, different cultural backgrounds. And so it took a while to, what should be in the proposal? What should be the aim of the research? What kind of, how do we use the wording? But we managed and also the external reviewers were content, so they agreed upon your research and then we started working. And I think it took a while that we realized that, okay, I would say two nice supervisors, but also busy ones. So it would be good for you also to have a daily supervisor to help you a bit with practicalities and with sometimes some smaller questions. And it was not so easy to find someone, also a bit of the distance to some of the other topics that we work on in the Roman economics group, but we are lucky to have Roger coming in as a new assistant professor with a physics background, also a Spanish background. So he really sit with you to work also on the research, but also on the papers, on the writing and the structuring and jointly also got your first paper published in a really nice journal, Circular Economy. So it was a journey and from the beginning onwards, and I think it was also shown in your defense, you were really interested in connecting your research with the private sector now because you have ambitions to make the private sector more circular and more innovative, so you always wanted to learn and want to practice at the same time. And I think that came very clearly out of also this defense. You went to Japan, indeed, to the Mirai Research Institute and you learned about these modular structures in wood and they were beautiful. And you worked in us with the Saip constructions and the 3D printing with a very impressive picture. And you also went to Alaska to catch very big fish and I think you came back a bit more tired physically, but mentally you're ready to go for another stretch. And so I think it was a journey, it was adventurous. There were some highs, there were some lows, like in every PhD trajectory, but I'm very happy that you are here and also very proud on how you defended your thesis. I think I speak on behalf of many of us that we also will miss your presence in the office because when you are there, with your smile and with your care and with your enthusiasm, you bring something to the group also. And so we really hope to stay in touch, either work-related or in another way. Always be welcome also to come back to the Urban Economics Group and congratulations. Thank you.

Thank you, Professor Valleone. Dr.

Hernandez Valera, this marks the end of your defense. You've made it. It's the start of your next steps of your career as well in that same breath. And on behalf of Aachen University, I would like to congratulate you indeed on achieving the degree of doctor with us here today. You are now and will remain a doctor, but you'll also be an ambassador for our university for the rest of your life, and we look very much forward to seeing what your next steps will be. I'd also like to extend congratulations, just as Professor Valleone did, to your family and colleagues in the auditorium with us, including indeed your mother Lupita and Lucia, who is made their way all the way from Mexico. So thank you very much for coming all this way. As well as your father and sister who are watching on from home, I believe in Mexico and the United States. And also, a congratulations goes to your Portuguese exchange family who have made their way from Portugal here. An exchange family from 20 years ago, I learnt, so a very special connection. And as you said, your PhD has brought together Mexico and Portugal for the first time. Well, maybe not for the first time, but at least you've brought Portugal and Mexico together. So thank you very much for being with us here today, and congratulations. And a special congratulations goes to my two colleagues, to my left Professor Valleone and to my right Professor Van Timaren, well done on delivering the new doctor. And well done on you for dealing with two directors of the AMS Institute. That's a fantastic effort to manage them as well. So well done. Dr.

Hernandez Valera, you're a very international character by all accounts. I've just heard about fishing in Alaska too, which also sounds very exciting. But this journey, yeah, this journey in life brought you to Värkeninger for an MSC in Urban Environmental Management, as we've heard, via the Environmental Technology Group as well. We've heard all the way through to a Delft Värkeninger PhD in Urban Economics. So a really interdisciplinary and international character it appears. And of course, linked to the Amsterdam Metropolitan Solutions Institute, which I think is also very special, given that this is a key partnership between Delft and Värkeninger. It's not only interesting, but it's also a very fruitful one by all accounts. So I'm bringing together these different disciplines and these different institutions. And also has a very applied focus, which I very much appreciated hearing about today. Plastic printing and all the things that go along with that around circular, of course, printing. Very much embedded in your home cities, you were saying to me the other day in Pachuca, in Mexico. So well done on bringing all of those different elements together into a coherent thesis, really bridging practice. And what I also appreciate today, but also when we spoke, was I think I see a very entrepreneurial mind there. So the next step is really to start this lab, as you said, in Pachuca, based on the work that you're doing. And a key part of that you told me was to maintain a research link. So really a link to Värkeninger and Delft, I assume, and I hope. I'm sure it'll go beyond that. And I encourage you to look beyond that, but it's a great start, Värkeninger and Delft, of course. So well done. So it seems indeed that you're taking these next steps. And we really look forward to seeing how those next steps go. So finally, I would like to pass on a final thanks to the committee, Professor Mills, Dr. Ramirez, who unfortunately wasn't with us today, but had put on a lot of effort to examine your thesis, in fact. So we hope all is well with Dr. Ramirez, to be quite honest. Professor Baudin and Dr.

Turin, as well, thank you very much for efforts in maintaining the quality of our PhD program here at Värkeninger. So for now, enjoy the celebration with Mexico, Portugal and the Netherlands in the room together, and all the best. And with that, I close the meeting.