SUBJECT:	**Urban Innovations in the City**
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	Co-Founding Director, WOHA
	Prof. Thomas Schroepfer,
	Professor and Associate, Head of Pillar Singapore University of Technology and Design
MODERATOR:	**Michael Koh, Fellow, CLC**
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Note:

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EMCEE	In today's session, we are honoured to have with us Mr Richard Hassell, Co-founding Director of WOHA, and Professor Thomas Schroepfer, Professor and Associate Head of Pillar at the Singapore University of Technology and Design. Mr Hassell will share more about the Kampung Admiralty, Singapore's first integrated public development that brings together a mix of public facilities and services under one roof. Prof. Schroepfer will cover the "Future of Us" Pavilion at Gardens by the Bay, an innovative climate responsive structure which reinvents the experience of a public space in the tropics. The format for today's lecture will start off with a presentation by Mr Hassell and Professor Schroepfer, followed by a Q&A Session with the audience moderated by Mr Michael Koh, Fellow of CLC. We would now welcome Mr Hassell to deliver his speech on stage. Mr Hassell, please.	
RH	We've been really interested in this idea of Urban Innovation and recently put out a book called *Garden City, Mega City*, where we've basically listed out a lot of the strategies that we've been thinking about for what cities need to do in the coming century. And as a sort of broad over-arching thing, the idea of the self sufficiency that Singapore is, I think, a particularly unique case as a kind of canary in a coal mine that future in the planet in that Singapore doesn't have a hinterland that it can rely on for many things, so the idea that the city has to be self sufficient in food, energy and water is something that makes a lot of sense for Singapore in terms of its national security as well as its control over its own	

	destiny.
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RH	And so in this project, we … so to look more for … first, principles, we now look at the city which has to do things like make the best use of the sunlight, so it's natural energy coming in, how do we use that for power and water. And so in this city, we proposed that as a sort of major urban master plan and thing, we think we have to work out how you basically don't waste your solar energy. And so in this project, we have something where it's 100% use, either energy, the stuff we don't use, for agriculture and agriculture is used for urban greening. And we sort of put together a vision where people could really live in a city, that was sort of 100% nature as well as doing all these things from performative a point of view from … and power and food on the roof, and then energy, you see it in the layer above. And we think there's a lot of possibilities in these ideas that I think that as we have new requirements based on new knowledge, that we should have new urban forms that are actually derived from these, and to us, that's not a sort of the imposition of something difficult, but the tremendously exciting stimulus for what we should be doing. So as part of this vision of this overall city, that is sort of self sufficient, we came up with this term "prototypology". So I think architects talk about

	typologies of certain kinds of buildings, and we thought it was interesting to look at our buildings as prototypes for this new kind of cities.
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RH	So if you imagine a city built out of buildings that were like the buildings that we've been experimenting with, it would be a city that could perform towards this self-sufficient goal. So in the talk, I'm going to just show you two projects in a bit more detail, which is Kampung Admiralty. And in the book, we assessed the projects under these different categories, so green plot ratio, community plot ratio, civic generosity, ecosystem contribution and self-sufficiency. And this is something we've started doing as an ongoing thing because we think these are important aspects of a building that are maybe not being measured by the government departments at the moment. But for us, it's a way of tracking and measuring and seeing how we can get our buildings to perform in this way. So we're thinking about: At high densities, how do you make sure that you keep this very worthwhile aspects of maybe a less density in a very high density environment? So SkyVille[@Dawson] is the other project. And I can go into details shortly. So SkyVille, we really saw it as … I think by the time we were working on SkyVille, we were very consciously thinking of prototypes and we were thinking how can we really make a really dense project, 960 apartments, have

	a real sense of a lower-scale and a very enjoyable environment.
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RH	Typically social housing in Singapore is 15 to 20 storeys high in the newer areas mainly because of the airport, but in the older areas, we do have a chance to go higher. And when we were talking to a lot of people about HDB [public housing], there was a real sense of nostalgia for the common corridor blocks; that these had a real social space along the common corridor. So people loved the fact that they knew their neighbours, but they hated the fact that their neighbour could stick their head in the window and see what was going on.

So we were quite curious whether we could somehow bring back the sociability of the common corridor without the disadvantage of it. So here're some old blocks with the kind of life along the common corridor.

After that, in response to those issues about privacy and the heights of the buildings, the point blocks was evolved, and these were great from the privacy point of view, but that whole social aspect disappeared. And these basically got taller as time went on.

So our move with SkyVille was … we were thinking, the sidewalks was nice and both from the common corridor and also the fact that they were so tall so people could sort of wave to their friends on the ground, and there was a sense that you were connected to the neighbourhood or kids playing |

	basketball downstairs.
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RH	We wanted to retain the point block privacy but…so we thought that if we were to chop that down to around 10 storeys, and then we pulled it apart, we could create kind of the social space in the middle, and see this as a kind of component where it made the Sky village, and as well, in only had 80 homes in each of these modules, so we thought there was much more likelihood that you would know your neighbours if you were sharing a common space and there were only 80 families there, rather than 960. So on the side, we have a linear park on one side and the relocated Margaret Drive, where we had these great old rain trees. And in some ways, the rain trees also helped justify the project to HDB because we could then go much taller, otherwise, we would end up cutting down all the trees. And so in a fairly simple way, we just assembled these villages, one on top of the other. So we have three villages on plan and stacked four-high, giving us 12 villages of 80, or 960 homes. And you can see here how we really just ran a new ground level, so it's like as if we just stacked up four of those old slab blocks right on top of each other. Then this idea that we would actually intensively use every area, so the north of the side, the top has a … because of the old rain trees, we could make a really big public park, we then have the band of all the housing, and then the

	car parking block has a sociable area facing the linear park; it's a recreational area on top.
	00:08:46
RH	And then something we thought was really important was to create more of an urban space within the HDB development. The tendency at the moment is to place few facilities, elements all along the HDB estates, but we feel that's really in a way dispersing a sense of activity in life, and so here we fought very hard to make a very lively node. It's also a good spot because it's along the linear park, so there're lots of people coming past it, and it's where there's one of the few traffic lights where you have to stop and so people do have a … it's easy to just turn your bike and go in here and have a meal.

This slide shows where … how we created these sky gardens. So basically [in] the typical plan, there's eight units per core on four bridges, the blocks have been pulled away from the lift lobby so when you stand in the lift lobby, you're actually looking into a volume and a space that is part of your sky village, so everybody, when they come out of the lift, passes through this public space. And then at the bottom of the stack of 11 storeys, we dropped out two levels of storeys of units, so we have a double volume public space that runs through the block. And that's about 150 metres long from one end to the other.

And so there's quite an interesting game going on where, sort of … when you experience it horizontally, you feel a very comfortable, village-y [sic] sort of

	scale, but when you look over the edge, you get this quite dramatic, vertiginous, exciting aspect to it.
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RH	And we thought that's something really interesting that's kind of a possibility of a super dense metropolis where you can have this simultaneous experience of domesticity as well as sort of mega-structure at the same time. And again the idea that you are both close to the ground and you are high up in the sky and that's something that's quite interesting as well. So your kids can be playing happily just a few floors below, but you also have a panoramic view over the city. And I think this is great that in a way, the experiences of density can be more than just congestion and people very close together, but you can start having experiences that you couldn't have in a lower-density city. So this is the community living room, how you can see the … although it's very repetitive, we played with the form and light and shadow and different elements, so when you are experiencing it close up like this, it's not … it doesn't feel overly repetitive or too much. And the park at the top is open to everybody including the surrounding neighbourhood. The inhabitants, always quite keen to close it off to everybody else, there's always ... when we asked, there's something going on at the moment, we are asking for feedback, where some of the feedback says "Lock up the park, like the Pinnacle." But it's actually … it's not overly invaded by outsiders and I think, and it's not meant

	to be a private space for the inhabitants of SkyVille only.
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RH	So after that, we're really interested in what's going to happen with SkyVille, because this idea of community space seems to be working, and … but it's something that takes time. People haven't grown up in a building like this, so nobody really knows how to use it. And we don't really whether we provided too much space, you know, maybe it could be less and it could be as effective. Or as … maybe as people sort of grow into the building and get used to this adjunct space as their living space, they are going to start using those areas more and more. So we're planning to do some follow up with … NUS has expressed interest, and but maybe SUTD (chuckle) will be good, and to really find out about this. What is nice though, that we've seen now, is that I think because of Singapore's policy of young couples being eligible for the unit, it's now … already when I've been there for the last few times, there are so many babies in these areas and so parents are playing with their babies in the gardens and the parents are chatting, and I think it looks like it's working, which is something very exciting to us. In a way, it was a sort of a risk to experiment, but the worst we thought it was that, you know, they're not well used, it wasn't a … there's no real terrible downside to the risk and I think the upside is that if it creates really sociable areas or a really social community, and if people, you know when they look back at their childhood at SkyVille, and they said, "Oh I had such a great

	bunch of friends, we all grew up there, and we used to meet on the roof after school…" these sort of thing … I think that, in the end, that's the point, I think, of trying to create, really vibrant liveable cities and so, we'll monitor it and I think we're hoping to learn from it, and incorporate that in our next project.
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RH	The next one, which I'll need to go through quickly, I think, is Kampung Admiralty, and for us, this was really an exciting project too, because it was another chance to make a kind of prototype for the future and it houses quite a few different users in one group, which is very … in one building, which is very unusual for Singapore where there's a tendency to separate different uses into different groups and to different buildings, particularly with HDB. So the site is in a mature housing estate. It's next to a commercial block of shops and it's very close to the MRT station, which is right in front of it. It's also located along a park connector and it's … there's existing pedestrian and cycling routes that run through the site. So a very great spot to make a kind of urban focal point and I would just show the design moves as we go along. So these are the new scripts, or the things around it, the MRT right in front. There're some big and busy roads very close by as well, routes through the site for pedestrians and bicycles. So for our key moves, the site is about 9,000 square metres, so these are the four components that are inside the project.

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RH	And a typical approach would have been to build a separate building for each entity. But we felt this would be a waste because it wouldn't make the whole greater than the sum of the parts, we would just have a cluster of parts.
	So instead, we thought we would look at it more three-dimensionally, so we put the supermarket, retail shops and food centre on the ground. The medical centre we treated as a very large plate that went across the whole site, and created a kind of parasol or umbrella for the public space, because the public space, we thought, is really the most important part of this project although it's not in the schedule of accommodation. And by doing this, creating a shady, covered space, we could unlock a lot of community potential for the site.
	So you can put the childcare and eldercare on top, run a park over the whole thing, so we also have a huge park to contribute to the public domain. And then the social housing for the elderly will then sit on top of that. So instead of these individual buildings, which don't do much to each other, we think here, we've got a whole set of sort of interesting spatial and three-dimensional arrangements. And definitely the whole is greater than the sum of the parts in what it can contribute in terms of quality of life to all the end users of the building.
	So basically although we are building over the site, we are almost giving the entire site back to the public as a public park and we achieve, in fact, a green

	plot ratio of actually 110% but in addition to that, we also have a community plot ratio of about 120%, so it's … despite the fact that we are doing quite a dense development on the site, we're actually releasing more amenities for the public than if we had left it empty.
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RH	So this is the ground floor, so you can see that it's actually substantially about 50% open to the public in this people's plaza. That we preserved, really, a whole range of routes through the site, so people can continue to cut across the site and through the site, and this should add to the vibrancy of the public spaces. So this is the tropical urban space and this is where we think we do need new models in Singapore that … you know if you make an open plaza, we are very hot and sunny during the day, if it's covered, it's not so … maybe if it's covered, you know, it's all weather use, so you can have good commercial uses, and if it's designed right, so it's very breezy and we get natural light inside, it's probably much better use than an open-air plaza. So on the upper level, we have the food centre, which looks down into the public space. So we call this a community dining room, overlooking community living room. And then this is the big umbrella floor. So where in Park Royal, we used the car park to create a big tropical umbrella, here, we had a whole series of rooms that didn't really need, necessarily, light and air to all of them. So we could use the same kind of space to do the medical

	centre.
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RH	But even the medial centre interacts with the room down below, and with the park on top. And so you can see that it's … by being orientated around this green courtyard, it's also feels like it has its own ground plane, and it doesn't feel institutional; it feels very much about a healing and wellness environment. So upstairs, we have the community centres. So here we've got childcare and elderly care together and we're hoping again, this creates the kind of synergy by being together, that the kids enliven the old people and the old people can contribute to the education of the children. So we have playgrounds and places for the elderly to sit, [and] it's a very informal mix of generations. And finally, the greenery extends all the way to top of the park and here we have some urban farming as well [space] for growing vegetables. So this is the view from the elderly housing looking across to the park. And the elderly housing, we arranged these little buddy nooks. So next to everybody's front door, there's a little place where you can sit, so if you are lonely, you can sit in this nice cross-ventilated passageway and see what's going on or overlook the gardens below. We have sun shading over the whole façade. It's all done in pre-cast concrete. And for the landscape, we actually work with our landscape consultants to

	make this cascading garden, a series of vertical swales that treat the run off of the water. Solar panels on top of the elderly housing, and a very bio-diverse garden.
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RH	So we're starting to look at not just greenery but making sure our greenery is actually contributing a habitat for birds and animals and insects. So, some of the testing of the pre-cast concrete, and where it is at the moment. It's topped out and should be finished by the end of the year. Yeah, so this is the idea that we really bring back the community spirit where people chipped in and did things together. So that's the completion of my plan. Thank you.
TS	A very good afternoon, everybody. Thank you to CLC for including me in their "Urban Innovations in the City" Lecture. It's quite an honour to be here and of course quite an honour to speak after Richard — beautiful presentation. So I'm going to switch gears a little with what I am going to talk about now, which is the making of the "Future of Us" Exhibition Pavilion. So I hope that many of you had the opportunity to visit the actual exhibition in 2015. It was actually a great opportunity for SUTD to test some of the kind of advanced things that we work on in the university context in a rather large-scale context.

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TS	So, to introduce the topic of the talk, let me frame it a bit more broadly. Over the last 10 years, we can see that our computational design has impacted architecture in multi-faceted ways. I would say most noticeably through the rise of algorithmic and parametric methods. So in conjunction with these advances, new fabrication tools and techniques have made customisation of architectural components easier and we believe that this allows for new languages of architectural forms to be explored. And that's something we do at SUTD, but of course many other universities do this too, but I think we have a bit of cutting edge when it comes to this.

Particularly the proliferation of so-called CNC, or Computer Numerical Control machinery such as laser cutters, 3-D printers and universal robots, increasingly allows for custom components to be produced quickly and at a relatively low cost, and therefore they become interesting also for architects.

So again, this makes mass customisation of components a viable option for our field, and as I said earlier, the design of the "Future of Us" Exhibition Pavilion, for us, presented a really great opportunity to explore the potential of these advances in the context of SG50's capstone event in 2015.

The project is located — it's actually still located there even though the exhibition is gone for quite some time now …. The project is located between Marina Bay Sands and Gardens by the Bay. In a way, the Pavilion follows the grand tradition of the demonstrative expo-structures by exploring a new |

	dialogue between built form and nature for the tropics.
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TS	It's … I should say, it's the result … it's not just our project, but as any kind of project in architecture, it's the result of teamwork. In this case, it was an intense collaboration between the Faculty of Research, as in students from the Singapore University of Technology and Design, engineers from S. H. Ng [Consultants] and Passage Projects, the builder Protag Tetra [Group] and the general contractor Pico Art International, which are also responsible for the overall exhibition, which was really not under us. We really did the kind of metal structure that you see in this image here.
	So the project consists of an overarching roof and a linking canopy, and it conjoins a cluster of temporary exhibition domes underneath. Let me just show you a short video, not as perfect as the ones that Richard showed, but it was actually produced by some of our students who develop drone technology at SUTD. But as I've said before, our project essentially linked all the temporary exhibition domes together and provided a kind of a central space for the exhibition as a whole.
	So here you see the layout, so the piece that I am going to refer to in the rest of the talk is essentially this one. But this shows you how everything held together as an exhibition space. So the intricate form and composition of our part of this project, which consists of a double layer perforated aluminium panel structure is based on an investigation that began already in 2013, with

	SUTD's winning competition entry for a temporary structure for Dhoby Ghaut Green.
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TS	Before I get there, a few more recent photographs of the projects, these were taken not at the "Future of Us" exhibition but at a later exhibition — the Singapore Garden Festival. But really, where it all started was here in 2013, when we developed similar ideas for a different context — again, for Dhoby Ghaut Green.
	So this project was based on extensive environmental and structural analysis, and our design for Dhoby Ghaut Green, proposed an open structure that would densify in certain areas where it is exposed to the sun or rain for example, and open up in areas where, for example, prevailing winds enter or where particular views from within the structure are of interest.
	So you see here, these are all the kinds of computational methods we applied to the structure, and essentially, the result is a building that reacts, for example, to a tree that stands next to it. The tree provides shade, therefore the structure underneath can open up more, where you want to protect the structure more from the sun … the interior more from the sun. You kind of densify the structure more. So if you flatten this out, this idea, you get something like this, it's based on an algorithm, so the structure can get very dense again where you want it dense, and you can open up in areas where you

	can have it open.
TS	And this is how it's then translated into a series of triangular panels, because it's a very complex geometry, therefore triangulation is the best way to achieve it.

And you look at the roof or plan of this structure, for Dhoby Ghaut Green, already it has some of the characteristics that you see then later in the "Future of Us" Exhibition Pavilion. For the first time here, we also tested this in a physical model, so this is a 3-D print in a 1:50 [ratio] and again, we won this competition, so we were quite encouraged to push this project forward in one way or the other.

Then we had a great opportunity to kind of bring it to the next level, which was an invitation to the 2014 Venice Architecture Biennale, where we were asked to essentially bring this to the next level by building a prototype of this kind of wall, and the result was an approximately five-by-three metre wall that you see here — aluminium wall. In this case, exhibited in a space in Venice, that is part of the Venice Architecture Biennale. That then, also triggered interest here of Design Singapore Council and they invited us to develop an even bigger prototype for the National Design Centre that we worked on just after we have completed the prototype in Venice. And this is what you see here in this image, it's bigger. As I've said, it's about 12 metres long and of course, what was wonderful in this context, we could also test it |

	against the glass façade of one of the galleries and see kind of some of the … study some of the more aesthetic effects of this kind of approach.
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TS	Of course there's always an interesting reversal of light at night, so this is the same condition taken from a different angle in the National Design Centre, a shot taken at night of this prototype. So you also see here in the foreground, we essentially displayed the idea behind it, the simple idea of densification, or opening up of the structure depending on wind, light, programmatic requirements, et cetera. But this project was also very interesting for us because typically what we do, and what I've tried to explain in the introduction to my talk, that there are really great opportunities for architects to directly prototype things nowadays, to kind of like in a way, cut out the middleman by going directly from the computational design into the fabrication, and that of course is something that we are quite interested in at SUTD.

So in our case, we developed not just the design for this, but we developed then a method to make this three-dimensional. Of course when you do a 3-D print, that's fairly easy, but the moment you scale things up in architecture, it becomes a very different problem and usually, when you deal with a complex geometry like this one, it's like a lot more thought has to go into how you do this in a cost-effective way.

So what we did is we developed a system where we could essentially produce |

	this wall from sheet materials — aluminium in this case — and we produced the so-called cut sheets. So you see all of the pieces are different, and they are packed into standard-sized aluminium sheets that could then be processed by a large-bed laser cutter, what you see here. All of this done at the university.
	00:33:26
TS	So here you see the results, still a kind of two-dimensional sheet material. The sheet material is then put together, so there is a top and a bottom that behaves differently, according to the environmental simulation that we ran in advance. And here you see what happens next, you fold the sheet material into three dimensions, you combine it and voila, you have one of those panels. We do this typically … researchers, faculty, students, here you see this happening in our lab, actually here you see one of our post … one of our doctoral candidates, who was quite instrumental for this project.

We tested it, we put it together, you have to label it because each piece is different. Essentially you ship it to Venice, or later to the National Design Centre, and then again you need the workforce — the students — to put it up at this stage. But essentially, what this does is that you run into all the issues that you can potentially run into when you scale it up to an even bigger building scale, like in the case of the "Future of Us" Pavilion.

So here you see the last preparations before the opening of the show at NDC [National Design Council] and again, another shot of the final result at NDC. So we were very lucky. We have on the very last day of the exhibition of |

NDC, we had the curatorial team, including Mr Khoo [Teng Chye] who is sitting at the front row here, stop by at the exhibition and they were quite interested in that. And one thing led to another and voila, we were asked, "Can you do this some 10 times bigger than this in a very short time?" And of course you know, when there is an opportunity you know, you say "Yes! Of course we can!" You know, not thinking about the consequences. But we said "yes" and it was the beginning of a very exciting time for my team and myself.

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TS And to kind of shorten the story a little bit here, you see already the next step, a 3-D printed model of the actual structure that we put up. And this is already the final result, that you can still see it at the Gardens by the Bay.

And to illustrate the size and the complexity of this structure, let me just share a few numbers with you. The "Future of Us" Pavilion incorporates what we think is a phenomenal 11,000 unique perforated aluminium panels; 12,040 bolts; more than 11,000 plates; and close to 5,000 elements for the main steel structure. The roof spans a width of almost 50 metres and reaches a height of 60 metres. In terms of thickness, the structure is a very slight 20 centimetres and this is something that we are actually very proud of in the context of Singapore because you know, some of you might be architects, [and you know] safety factors in Singapore are usually a killer, and they make everything look very heavy right? So, that you can actually span with a kind

	of complex geometry, 50 metres, and do this with a 20-centimetre deep structure — I think it's quite an engineering success.
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TS	Again, there's a very clear mathematical logic to the design, which is determined by extensive environmental analysis and simulations as well as a whole series of structural optimisation. We think for the visitor, the project offers a climatically comfortable outdoor environment, but also quite a stunning visual experience akin to walking under the foliage of lush, tropical trees, which was really kind of the driver of the driving idea behind this.
	And why we could do this so fast from the Dhoby Ghaut Green project, translate this into a different context, to a different size, is really because this project was, from the get-go, driven by a computational parametric model that allows you to change the parameters — and the whole structure will essentially magically adjust to [the] different conditions that it sits in.
	So I'm going to share with you quickly just a few images of the effect. Here you see the kind of … what we think is a very beautiful play of light and shade on one of the exhibition domes. Here you see the day of the actual opening, which was in late November 2015 with the Prime Minister and Gene Tan, the main curator of the exhibition. I think it was very well received. There were thousands of visitors over the course of three months that came to see the show. And here you see the playground just outside of our structure. Of course at night, you have a very nice kind of reverse effect, the lighting,

	which was not done by us but by Pico, but they did a very interesting play of light and this is artificial light.
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TS	After the end of the capstone event in 2016, prominent location and the quite practical performance at the "Future of Us" Pavilion allowed for a range of community and cultural opportunities, and this is why I am very happy to share that the project will continue to be there as a public asset to Singapore in the years to come. So this is the article that came out on the first of January this year. It essentially confirmed that this will be kind of a permanent landmark and will be used for all sorts of other things. Okay, so now, I'm going to talk a little more about the technical aspects of the project. Despite the project's geometric complexity, and the resulting uniqueness of most of its parts, the team working on the Pavilion, which means us, plus all the others I listed before, we were able to realise it in less than six months from design to completion, which I think is really quite astonishing. This was largely due, as I said before, to the extensive use of advanced computational methods that allowed for the parallel design of the project's steel structure and the aluminium cladding as well as the just-in-time prefabrication of most of its parts. The computational analysis of the Pavilion's free-form shape led to its

	structural rationalisation into welded arms and a central triangular shell.
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TS	Let me just point it out to you, so these are what we refer to [as] the "arms", and this is the triangular central piece. This enables the structure to work as a fully triangulated series of arches and to behave like a hybrid grid shell. And you know, ultimately, to allow for the kind of minimal thickness despite the large span. The vertical orientation of the arches and the arms and their radial orientation in the central shell subsequently allowed for the pre-fabrication of all members and the installations on site using only a single easy-to-measure dimension to control everything.

The structure's strength, primary and secondary purlins, normal orientation to the cladding surface, also allowed for easy connections between the aluminium panels and the underlying steel members. The primary purlins' connection to the arches provided lateral stability, while secondary purlins deliver lightweight support for panels. So let me show you. This image already shows you the structural system. So here, this is the main steel structure, here you see, in this kind of exploded axon, you see again the main steel structure, and you see the lower arch cladding, the inside interior cladding and the exterior cladding on top, and again, they behave differently, according to the environmental analysis that we ran.

So quite interestingly, our team, which is of course the architect's team, we produced drawings for the steel structure, the cladding, the cut sheets and the |

	installation of the cladding aluminium panels. So this is in a typical, in a kind of traditional way of working. Completely unheard of, right? That the architects did all these things. And I'm not saying we did everything but we did it in close collaboration with all the other members, and we were able to … just like in the example where I showed you, where we conceived something and then we pushed it all the way to prototyping, testing and so on, in this case, we really did the whole chain of things that needed to be done in the context of a project like this.
	00:43:03
TS	So, the very close collaboration that was required to deliver the project in such a short time was achieved through the use of a shared, lightweight, platform-independent computational master model that everybody worked on at the same time. Also quite unheard of in the building industry. Everybody has their own model, despite BIM [Building Information Model] right? BIM efforts [are] still not quite there. The master model was also used to evaluate the resulting triangulation of the overall structure in terms of its structural, environmental and aesthetic performances. So again, this use of the master model for the team collaboration proved to be highly effective and efficient and was continued throughout the project from the very beginning. What you are looking at here, a series of screen captures just to illustrate the method of working on this. The top one is essentially the structural model, the

	second one, sorry, it's really a bit washed [out]. The second one shows you the structural orientations and the last one, the bottom one, is the coordinated model where everything was put together.
	00:44:14
TS	Here, an example for cross-section, is a detail showing the steel structure and the aluminium cladding on top and below. But you see the geometry is rather complicated, right? In terms of process automation and pre-fabrication, again, remember we had more than 11,000 different kinds of cladding pieces. So the use, and the use of the computational design and the resulting high level of automation in the pre-fabrication, of particularly the aluminium panels for the cladding, allowed us to deliver both fabrication-ready geometries and annotated construction drawings in less than two months' time for the whole project. The accuracy of the drawings was checked using the shared master model, and one the accuracy was verified. We applied an algorithm to annotate the cut patterns with information about their location in the overall project. Because, you know, because ultimately, it's like a giant puzzle right? So you have to let people know actually where this piece goes and then you can put it in with great precision into the actual steel structure. So this one is another example for an aluminium cut-sheet where we used again, the power of the computer by laying out all the 11,000 plus panels and then the computer helps us to put them into standard size aluminium panels

with the least waste right, because you want to pack them in a way that not much is left, because you cannot use what's left of the material. So in a way, that's also an idea of material efficiency that comes into the picture — that without the use of advanced computational models, would probably not be possible.

00:46:19

| TS | In terms of the actual sequence then, the construction sequence, the project was constructed in four overlapping phases. In Phase One, which is what you see in purple here, in Phase One, this is a self-supporting mock-up that we constructed in advance, and it was re-constructed on site. We used to previously, before that off-site, to test the structural soundness, construction methods and also of course, the aesthetic aspects of the whole thing, so once we were happy, we just shift it there, and put it up. |

The second part was the triangular central piece here, and then followed by the arms. The first one is the one in the north and the other one is towards the southwest.

So for all of this, we used, again, pre-fabricated elements that were manufactured off-site in Vietnam and China, and were brought to the construction site just in time, just like in car manufacturing. There was no need to store raw materials on-site; everything that was brought there was put up instantly, so again, no need for large areas for storing construction

	materials.
	00:47:44
TS	The power of the computer also helped us to identify what we refer to as problem panels, which are those where the computer cannot find that kind of optimal solution for the geometry, the complex geometry. So what you see here in this drawing is the typical kind of drawing about the work that we did. So you see here, they are very few, and we were able to deal with them on-site.
	I am going to show you just a few quickly a few images of the project under construction. Hopefully, you'll see some of the things I was just describing in the images here. Here, you see the installation, in this case of the exterior aluminium panels, while the work continued also on the inside of the project and here you see some … one of the workers, also checking the location of the panels.
	The design, pre-fabrication and construction efficiency, effectiveness and accuracy that we were able to achieve in the realisation of the "Future of Us" Exhibition Pavilion, I think, testify to the great potential of advanced computational design for architecture. They also bear witness to the new possibilities we have when using novel tools to enact change on established methods of design and construction. I think this allows for whole new paradigms of exploration, not only to achieve innovative aesthetics and environment responses and hopefully they go hand-in-hand of course, but

	also resource efficiency, precision and structural tectonics and open up new and exciting realms of architecture.
	00:49:38
TS	And maybe I can share with you … since we completed this project, we've received quite a number of awards, including the International A'Design Platinum Awards in architecture. We also received the World Architecture Festival High Commendation. We received the Singapore Structural Steel Excellence Trophy Award, as well as the SG Mark in Singapore Design Gold Award last year. So thank you very much.
	[Cut to next section of video]
MK	What is one other thing that you'd like to change or innovate or disrupt in Singapore? Architecturally speaking.
RH	Actually, well, we've been realising that lots of the things we want to do need to really be done at the … at least the district level, and so we're really keen … one reason we put the book out was to think of these issues beyond architecture and into urban planning. Because it's like if Singapore solves the water problem nationally, you know, the buildings don't have to solve the problem and many of these problems actually do need … they are much more efficient and they are much easier to deal with at the national level. So we're sort of keen to extend this expertise from the level of architecture into urban design, and I think there's a lot of exciting urban design possibilities in this

	interweaving of sustainable infrastructure through our environments, which have fantastic possibility. So that's what we're interested in.
	00:51:19
MK	Thomas?
TS	I mean, I can subscribe to a lot of things that Richard said, and maybe I should be wearing my other hat. But since I've presented the "Future of Us" Exhibition Pavilion just now, what I would like to see is … you know that maybe the local scene is a bit more adventurous in testing some of these new technologies that are available. And I think they have great potential, not just for cool form, but for form that actually means something that is driven by particularly in the tropical context, by environmental factors, not always … it's not always the box that is the best design. So you know, I see tremendous opportunity to change the discourse or kind of you know, open the discourse for what these tools can do for architecture, but not just for architecture, also for urban design, because if we tap on sources like big data and so on, all of this can essentially be part of the architectural and urban design proposition that we make for Singapore and beyond in the future.
MK	Well, how very exciting, what Richard is saying is: Could we get this whole series of buildings, perhaps not only singular blocks at Dawson, but just a whole series at the district level, interconnected gardens, interconnected greenery? And for Thomas, I would say, even venture to create that "Future of Us" Pavilion over the whole of Orchard Road? Why not? We could

provide that tropical sun shading, screening, et cetera.

Just a question now for each of you. First and foremost, maybe Richard, and this is a technical question, because I think a lot was talked about the common corridor as one of the key social ideas, social spaces in the block. Now, I'd like to ask, can this actually be repeated in private developments?

00:53:24

MK	I think you've done the Metropolitan in Bangkok, which is a model that you've also experimented with. But in the private world, where efficiency ratios are crucial and where developers and architects are instructed to sell every bit of GFA [gross floor area] and literally the lift lobby and the roof as well. So how could this model actually be translated to private sector developments?
RH	Actually, what's been really interesting for us, is that we've had private developers who see sky roofs, but not Singaporean ones because they are so obsessed with the efficiency. So for instance say, we are doing a project in Brisbane where they said, yes, this idea of sociable common spaces is something that we think is really good and appealing to people here. But so, I think interestingly, Singapore is a particularly extreme case because of the cost of the land and the way the GFA regulations are written. It's something that's easy to fix with the change in regulation, and it's not something that … well, for Bangkok for instance, it's much more about construction floor area [rather] than gross floor area, because the land cost is maybe 30% of

development cost. So I think it's … the only real barriers to doing it are because of a particularly tuned set of regulations, and I personally think that the regulations, if they are shown to be anti-social, or I think there's many aspects, too, coming up where some of these sustainability strategies may also be in conflict with GFA regulations? You know say, older sales have closed covered area and that becomes GFA, that sort of thing. Well, we just have to tune it and make sure we are not thwarting things.

00:55:27

RH	The regulations are very good, they are meant to achieve a certain end, but if they start thwarting our a possibility, then the only thing preventing us doing it is changing and amending the regulations as situations change and needs change.
MK	Right, and just onto a question on Kampung Admiralty. I think we've seen the concept of integration of community facilities with commercial spaces and public spaces, and the projects are being realised. Unfortunately, I understand that some of the spaces are being left as white spaces and not fully as conceptualised as what you had on screen. So what were some of the major issues or obstacles that you faced in terms of funding, coordination, dealing with authorities, agencies, et cetera, in the realisation of the project? And why did you end up with white spaces?
RH	Oh, actually [Wong] Mun Summ is really running this project, so I'm probably not the best person to answer the finer details of the project. From

	my overhearing [laughs] of frustrations of the project, wasn't that bad. I think most people were really on board with the idea. The biggest difficulty I think was getting the various separate agencies to agree to be housed in a single building, rather than having their own building where they felt they would have more control over it all.
	00:56:54
RH	And I think this idea that the commonality … somebody's organisation contributes to the common good rather than being something specifically part of their brief is just something that everyone has to get on board as stakeholders, that the common … the success of the common areas is equally as important as the achievement of each separate parties.
	But I don't think it's substantially going to be any different to what we saw on this and we're really excited for it to be finished because we think based on our experience with SkyVille and others that these kind of spaces are going to be really successful, both sort of socially, from a community point, as well as environmentally.
MK	Thank you Richard. Now a quick question for Thomas. How do you think technology, and what you experienced in building this Pavilion is going to have wide-reaching consequences or positive responses in the building industry as a whole? From what you show, there's the ease of replicability [*sic*] and the applications are wide and can that just change that idea that pre-

	fab may not be boring?
TS	Yeah, I think that that is one of the main points that I was trying to make in the talk. That nowadays because of the tools we have at hand, computational tools, mass customisation has become affordable.
	00:58:43
TS	It's not the kind of 20th century mantra that to build cheaply, you have to have a high level of standardisation, which I think is still kind of looming around a bit in Singapore with some of the agencies. But a project like this essentially … I cannot tell you what the budget was, but it wasn't big budget that we had for this project. And you can actually show you can build fast, you can build, what we think, interestingly. You can build with a lot of control as a designer, and know what is the actual outcome of the process. So I think there are great opportunities there and we're just seeing the beginning of it at this point. But particularly to escape from, you know, that everything has to look the same, you know, that things can have more identity, they can vary not just according to style, but they can vary according to environmental conditions for example.
	So, again, where this envelop that I've showed, where it opens and where it's more dense, is determined with a high level of accuracy, based on how do the wind flows through the structure. If there is a tree next to it or not, right, all these things can be taken care of in kind of a new way of design.

MK	Wow, how exciting it would be if both WOHA and SUTD could actually collaborate on something like this. Just putting two and two together.
	01:00:11
MK	Now, I'm going to be naughty and ask one other question before I open up to the floor. What do you think, both Richard and Thomas, did the agencies learn and what do you think they can apply, say in the public housing model or in the pre-fab world?
RH	I think that well … what we've learnt anyway, with agencies, is that each agencies have their own very strong KPI [key performance indicators] which they need to report back to ministry and the government, and I think the thing that we … not so much that the agencies need to learn, but I think that Singapore as a system, would be fantastic to evolve what is already one of the most integrated sort of public sector systems of the world, but that you know, this idea that by putting things together, you can achieve something … the whole that is more than the sum of the parts, that agencies can identify some of these common goods and embrace them even if they are outside their KPI. So I think it probably needs to gain some kind of formalisation or structure from them, but I think if we really going to move to a really sustainable future, what we learn from nature is that things do many things, you know? Your skin performs many functions, in a very efficient way, and to get to a level of efficiency where we could really be self-sufficient, we need everything to be doing double triple or quadruple duty, and that's something

	very hard to achieve when you split everything into parts that are trying to operate at maximum efficiency themselves, it might mean that something operates as a component at only 60% efficiency, but as a whole it's operating at a very high level of efficiency, and that's a real challenge I think because the way a lot of our thinking and organisations and systems are set up as sort of 20th century production line efficiency where components are separated and then optimised on their own.
	01:02:37
MK	Thomas?
TS	Which is of course the whole idea of the shared model, you can take it straight to technology right, and I mean of course there are all this efforts in the building industry to bring everybody together through BIM, right, but I think a big project like ours is a good example for … you know, if you work together as a team, and you share actually the power of these tools, what you can achieve in a fairly short time. So, you know, I should also say that things like this project are possible in Singapore right, and they were pushed by the curatorial team and you know, some very enlightened people here, so I think all of this is actually the right way to move forward.
MK	Thank you. Now I'd like to open up to the floor. Questions?
Q1	My question for Professor Schroepfer and I was interested in … I think the

| | timeline for your presentation has talked about, reinventing tropical public space through this project and I really enjoyed visiting the Pavilion when it had the exhibition in it but I haven't been back since. And so they are two-part questions for you which is, A, how are people using it now, that it doesn't have the exhibition inside; and secondly, what do you see is the social potentials for these new models of parametric design? |
| | 01:04:14 |
| TS | I showed a few images of what happened after the "Future of Us" exhibition, so the project was essentially handed over to the Gardens by the Bay, and they used it for a couple of events including the Singapore Garden Festival which took place last year. And they changed completely the interior, you know, you saw, it was kind of lush and green, and it was kind of a beautiful environment also, which was quite different from the "Future of Us" exhibition. So for us, this was very exciting to see, that the structure that we had provided for a different context could accommodate different kinds of events, right? It worked very well in this case, it was the central kind of meeting space for the Singapore Garden Festival. And of course this whole idea that there's a new kind of dialogue of architectural form, aesthetics and so on with nature, is completely in line with our ideas about the project.

So we've seen how the project performed on a couple of occasions, including the one I just mentioned. So we're excited that it can be used for other things, we're also excited about the fact that now, the committee in charge of making |

	decisions about projects like this has decided to keep it. Obviously they see the value of this project for future events in the context of Gardens by the Bay, and from what I understand from the management of Gardens by the Bay, they are also quite excited to have this space available for them, and they are planning to make this available for future events that they have.
	The second part of the question, remind me. You know, I talk too long, it was about the social potential? Or ....
	01:06:09
Q1	You spoke very convincingly about the engineering and economic and just-in-time benefits of this sort of design, and indeed, from collaboration amongst the project team, just wondering, thinking more broadly what social potentials there might be for parametric design tools?
TS	The project is … I mean, right now, it's just the kind of a big kind of covered public space, right? When you come from Gardens by the Bay, you walk under the structure, immediately you feel that it's pleasant. It's a little bit like you come out of the sun and you go under the shade of a [lush/large?] tropical tree. I used this analogy in the presentation. So this is very much what we were after, also the kind of aesthetic quality of exactly that, that you walk, you know, in a forest, where you kind this quite interesting play of light and shade. I think all these things were drivers for our ideas for the project.
	So to make public space successful, I think you have to operate on many

	levels, it has to be a space that is exciting, right, that's interesting — people like to go there — that's pleasant. Of course in tropical environment that's very important so it has enough shade when the sun is out. And of course, our project does a little more, it channels, essentially, the prevailing winds in a way that you feel even more comfortable than you know, being under a tree that probably doesn't do that to the same extent.
	01:07:45
TS	So I think with the use of technology, we're kind of pushing as much as we can to have a successful space. In this case, it can accommodate many, many different things, and I think I have to leave it there, that's as much as we could do with this one. We hope we have a say as this space is developed into.
RH	Actually we don't think our building looks bad. But I think it's interesting the topic is the innovation in cities, and I think both our projects were very focussed on particular innovations and to innovate something, it's always a bit of a risk and it also takes a lot of resources. So we made quite a conscious decision that with SkyVille, we were very focused on this community and public space as the key innovation. We knew dealing with HDB [Housing & Development Board] on this … I mean they were behind it, they were the agency that stimulated it, but they also have a huge apparatus of standardisers that they are trying to make sure that no one is going to complain about anything. So we knew getting it through the system would be challenging and

	take a lot of energy, so we made a very conscious decision: that's where this project will be different, and everything else, in a way, we would do it in a fairly simple way and a fairly standard way, so that we could pick our battles and our resources to where they would have the effect.
	01:09:25
RH	And I think it was one of those ones that, when it came out, it was more from the rendering stage and the initial models and things because it is a project which is much better experienced in person than looking at [it] as an elevation. And I think … I don't think that discussion is still going on now that people have seen it and experienced it. And in fact, some people we chat to them in the Sky Gardens, and their babies are playing, and we go, "Oh how are you enjoying living here?" And they go, "Oh actually I don't live here, I live next door."
MK	That's a good testimony to the success then!
RH	Yeah, but I think it is really crucial and I think that's the power of … I mean that it's one of the risks of innovation is that you can't do everything and you know, you can say why wasn't the SkyVille parametric as well, oh it's because parametric is something new and takes a lot of energy, so to do a simple building like a pavilion, you know, allows you to 100% to devote energy to it. I think both of them are important, because once it's being done, and the people … you take away that objections of saying that it's an impossible dream, other people can then move onto the next level of

	innovation, you know? This is no longer controversial or difficult. So that's where to actually achieve a real life built example of something new is, I think, fantastic. And that's the way things move forward.
	01:10:59
Hee Limin	What is the role of that client in allowing for innovations to happen in a project?
TS	Well, you need an enlightened client who is willing to take the risk, right? Which particularly, in the building industry, it doesn't happen too often. So, you know, in our case, we were really quite lucky that a lot of things came together, and of course the enlightened client in this case, was instrumental, otherwise, this would not have happened. It would have stayed at the level of a prototype in the National Design Centre, we would never have the opportunity to realise it on such a big scale, and also prove all the structural parts that I was referring to in the talk, that you can actually do a life-sized building of quite substantial dimensions in this kind of technique in a very short time. So without client, no project, frankly.
RH	I think the really important thing is the innovation and the potential risk has to be aligned very closely with the client's needs and desires of where they want to go. HDB came to us and said, "We were really interested in the future of public housing." And so the project was something which had the end result of experimenting and seeing which direction they should take public

	housing in.
	00:12:37
RH	So they were highly engaged and excited about the outcome of the experiment, I think it's really difficult to propose innovation and risks where the client feels like the payoff doesn't align with their objectives. In that case, they feel like they have been used for something that you want rather than something that they need. So for us, when we are trying to do something innovative, we always try and find that alignment of the payoff from the risks with the clients' own drivers.
MK	So, gentlemen, having seen the projects and your achievements on the screen, what more do you think can be done to head Singapore, push Singapore towards being a city in nature?
RH	Yes, I think the garden thing is exciting, but I think that it has associations mainly with recreation and decoration and maybe a certain thin-ness of experience. So I do think slowly changing it to a city in a eco-system, or a city in a productive landscape, you know, maybe we need to broaden the definition of the potential of green space. And then I think it can take it to the next level. Because what we've realised is that the cost of putting planting through the city in a building is fairly fixed, but the outcomes between a clipped hedge and a diverse piece of forest or a productive agricultural garden are quite different. And so I think it can be very helpful to identify much stronger performance objectives from our green space. And certainly,

	enjoyable recreational gardens will continue to be one of the most highly in demand things for an urban population.
	01:14:48
RH	But you know, I always talk about the otters in Singapore, the gang of otters, which I think have just delighted so many people over the last couple of years. Just seeing them and being tweeted on Instagram and shared, I think if you multiply that by 10,000 to all kinds of species in life in the city, I think you know, it can make it equally huge contribution to people's quality of life to have a super diverse eco-system in the city as well.
MK	So you think implementing the idea of the green plot ratio will help that?
RH	That sets the potential, and then I think there's a whole layer of skills involved in terms of if you are actually designing an eco-system, and you start having to think about, well, what food sources am I providing? Are the food sources available through the year? How do animals that don't fly get to this garden? How do we link them up? I think it's so many fantastic and exciting things to think about, how you actually design for eco-systems, that this could really be a growth area in consultancy and Singapore as a knowledge base. And whenever we give talks anywhere around the world, people are so excited about it.

When I talked to Brisbane, someone came up and said, "We want to create a koala suburb where our suburb is also a sanctuary for koalas." So it's not as |

	wacky an idea as some people seem to think. I think it seem to have struck at the core of our human desire to live in paradise is that we'll be always surrounded by teeming abundant nature.
	01:16:36
MK	Well, I've smelt koala pee before, and I'm not sure I want to live in a koala suburb. Thomas, your views?
TS	I agree with all things that Richard said, I think that you put it very well as usual. Maybe thinking about the built environment, again coming back to the same point I have been making the whole day today. I think we can think of architecture and urban design as something that's more malleable, you know, more fluid, and maybe, you know, these…the kind of focus on performance of buildings or urban design, you know, can be driven by ideas of performance in the context of nature, right? So we can study in a lot more detail now, the impact of let's say suntan on buildings, on prevailing winds, many, many things, right? And they can find their way into the actual urban design and architectural proposition.

So in other words, future buildings might look quite different from today's buildings, which I think very often, they are still stuck in a kind of, you know, 20th century paradigm. But if we allow these kind of performance aspects to take over to a certain extent, and of course we control them aesthetically also to a certain extent, I think we could imagine cities that look radically different from today's cities. And cities are at the same time, they are exciting, they are |

aesthetically exciting but they are also in greater sync with nature, and I see tremendous potential for really exciting explorations in architecture and urban design for the future.

[Video ends at 1:16:25]