The expert view: creating better more resilient homes

Interviewer: Gareth Byatt – Principal Consultant, Risk Insight Consulting
Interviewee: Melodie Yashar – Space Architect | VP of Architecture & Building Performance at ICON

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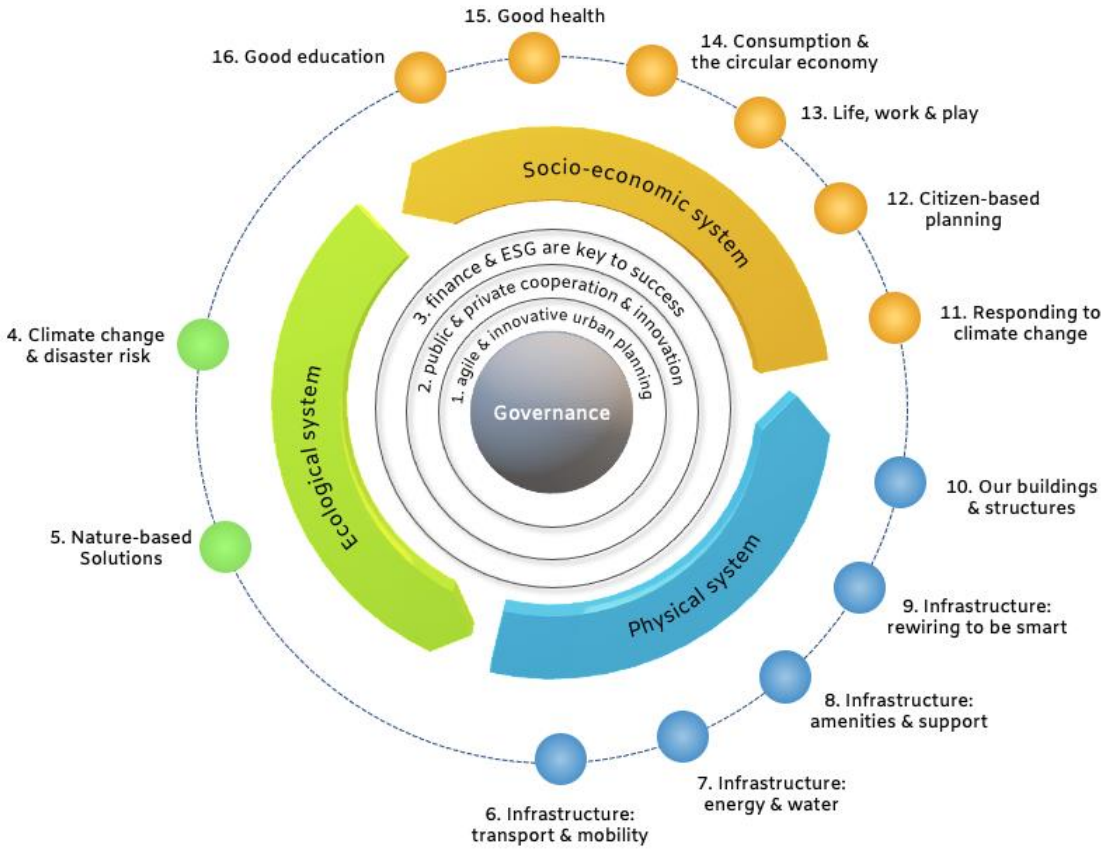
Image: ICON website

Melodie,

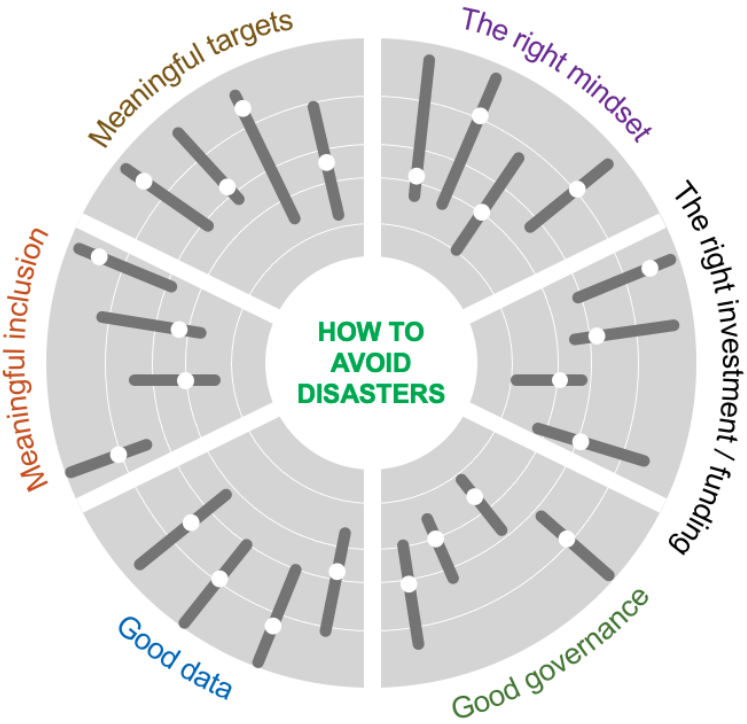
Thank you for making the time to talk with me about the work of ICON – for planet Earth and beyond, and how it can support the development of resilient urban environments and disaster resilience. I found it very interesting to attend your talk about space architecture and its application also to what we do on planet Earth at an event hosted by the Powerhouse Museum in Parramatta, just outside of Sydney, Australia, on 17 September 2024.

I'd like to link our discussion points about new forms of housing to some aspects of a system I have developed called the Urban 2.0 system (outlined in the diagram below), which links to the 17 UN Sustainable Development Goals (the SDGs) and the 2030 Agenda (point 7 – infrastructure: energy & water, and point 10 – our buildings and structures – are of particular relevance to our discussion in this interview).



Urban 2.0 system image – by author

Plus, I will also refer to a separate (and related) initiative that I am involved in called Disasters Avoided, in which a team of three of us (myself, Ilan Kelman and Ana Prados) have developed a six-point model:



Gareth: Could we start with a brief overview of your background and the activities you are involved with (which I know include some linkages with academia)?

Melodie: *I am the VP of Building Design and Performance at ICON, where I oversee the architectural direction of ICON's built work as well as the performance of ICON's building systems. I joined ICON in 2020 to establish and build the Architecture & Building Performance department. In prior roles, I was a Senior Research Associate with the Human Systems Integration Division at NASA Ames within the Human Computer Interaction Lab. I was also a co-founder of Space Exploration Architecture (SEArch+), a research group developing human-supporting designs for space exploration, as well as a Professor within the Architecture department of Pratt Institute. When time allows, I also teach undergraduate and graduate space architecture studios at Art Center College of Design.*

Gareth: Thanks for this context, Melodie. Perhaps we can start with a general overview about ICON – what the business does and your vision / mission?

Melodie: *Yes — ICON is a construction technologies company focused on large-scale additive manufacturing for Earth and in space. At ICON we develop construction technologies using artificial intelligence, robotics and sustainable materials engineering to address the global housing crisis. We are developing construction robotics to be able to introduce rapid growth within the housing sector and provide housing solutions to those that need it most. The construction industry has failed to meet demand for accessible housing solutions worldwide and moreover has not managed to advance throughput using digital or production-scale manufacturing technologies. At ICON we develop accessible, dignified and resilient housing solutions using automated construction robotics.*

Gareth: It was fascinating to hear that ICON's work is supported by NASA, who have awarded ICON with funding in a few instalments over the past few years if I understand correctly, including in 2022 a contract under Phase III of NASA's Small Business Innovation Research (SBIR) program for nearly $60 million, which builds upon previous NASA and Department of Defense funding to research and develop terrestrial and space-based construction systems that will one day support planned exploration of the Moon and beyond.

A video you presented at your talk in Parramatta in September 2024 showing the 3D printing / additive manufacturing techniques that are being developed by ICON was fascinating and it got me thinking about a range of possible applications it could have.

Whilst I could easily spend this entire interview talking about the possibilities for Moon and Mars bases (!), I would like to understand how you think the technologies you are working on and developing at ICON could have potential for planet Earth.

I appreciate that your team at ICON is already involved in housing developments in North America. For example, Wolf Ranch in Texas is, I think, as of September 2024 the largest 3D printed home development in the world, with 100 homes that are priced at market rates. ICON is also building homes for the formerly homeless at Community-First Village in Austin which includes 17 homes 3D-printed to date for the formerly homeless, with another 100 homes planned.

Equitable and energy-efficient housing is a challenge everywhere. What do you think the possibilities could be for urban developments around the world using the types of techniques that you are using at ICON, linking to points 10, 11 and 12 in the Urban 2.0 system I mentioned earlier, and SDG 9 (resilient infrastructure, inclusive and sustainable industrialisation and innovation) and SDG 11 (sustainable cities and communities)?

Melodie: *In our opinion, 3D-printing using our Carbon-X material introduces a new way of imagining the future of resilient and sustainable homes, contributing to a future in which our cities and communities are designed and built not only for longevity, but also for beauty, dignity, and energy efficiency as well. CarbonX is our new low-carbon extrudable/printable concrete formula. When paired with our wall system and robotic construction methods, CarbonX is the lowest carbon residential building system ready to be used at scale. Additionally, homes in ICON's Codex collection are designed to achieve EnergyStar certification to reduce homeowners annual energy utility costs. The ICON wall system reduces energy consumption with above code minimum insulation and the increased thermal mass of the wall compared to conventional stick framed construction.*

Gareth: Just to touch on the Sustainable Development Goals (the SDGs), one of the points you mentioned in your talk in Parramatta was the relevance of these global goals to how we approach the establishment of human settlements beyond the Earth. You described how a number of goals such as SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy) and SDG 13 (climate action) amongst others are as relevant for extraterrestrial human settlement design and development as they are on Earth. I'm wondering if there are examples from your work on extraterrestrial human settlements that we can apply to developments we undertake on Earth?

Melodie: *Designing and thinking through the conceptual operations of a Mars or Lunar habitat is truly an exercise in sustainable systems development—as we are designing for the most extreme, remote, and resource-constrained environment imaginable. Passively protecting astronauts from deep space radiation, integrating renewable energy resources, leveraging local materials and resources, and even considering bioregenerative closed-loop systems are some of the considerations and strategies taken when thinking through how to sustainably support a human presence on the surface of the Moon and eventually Mars. Technology development initiatives in each of these areas are entirely applicable and introduce dual-use benefit for Earth as well. It is important that we adopt a similarly resource-constrained design methodology when designing infrastructure-scale solutions here on Earth, as doing so will almost certainly introduce greater innovation and accelerate new solutions for renewable energy, clean water, and much more.*

Gareth: I mentioned an initiative that I am involved in called Disasters Avoided (which has received funding from NASA for case studies). The resilience of people's housing is part of the interconnected aspects we are looking at. Can the 3D printing / additive manufacturing technology that you are developing at ICON support good disaster resilience, for example for housing for vulnerable communities anywhere in the world? I recall you mentioned that you have been involved in disaster relief structures with the General Land Office of Texas on the US gulf coast to create more resilient houses for this coastline, to give one such example.

Melodie: *Yes, we are very invested in further exploring how our technology can be deployed in disaster-relief scenarios to introduce solutions where they are most direly needed. We are eager to develop projects that introduce resilient housing solutions in a just-in-time fashion.*

Gareth: Myself and my colleagues, Ilan and Ana, have been fortunate to be involved in the development of some global reports for UNDRR, the United Nations Office for Disaster Risk Reduction, such as their latest Global Assessment Report (GAR), Special Report 2024. Amongst other things this report discusses the importance of injecting resilience into infrastructure investments. Could 3D printing have potential for other types of disaster resilience against hazards (be they storms, flooding, wildfire, earthquakes or something else), such as different types of infrastructure?

Melodie: *Absolutely; one of the most salient attributes of cementitious 3D-printing and use of our CarbonX material in coastal regions that are prone to flooding and hurricanes is the inherent fact that our material is mold-resistant and fire-proof, and our structures are resilient to potential impacts from high winds and tornadoes as well. The inherent durability and longevity of our structures offers a new definition to designing for resilience in disaster-prone areas.*

Gareth: One of the things I found interesting in your talk about space architecture and establishing bases off this planet was your point about the importance of engaging in participatory land use and consensus building to agree how to form such developments, for example on the Moon and on Mars. These principles are key for development on Earth as well – and we don't always get it right, or not as good as it should be on this planet. They are very much aligned with some key principles I link into the Urban 2.0 model (*meaningful involvement*) and the Disasters Avoided model (*meaningful inclusion*).

Melodie: *In my opinion, very few private actors and industry stakeholders are actively considering how to leverage participatory activities and consensus building with the public for the development of shared infrastructure solutions on the Moon and Mars. It's entirely true that a future Lunar economy will be inherently competitive in nature; however, I do find it heartening that most private sector companies with complementary capabilities or technologies are actively considering how to collaborate and integrate systems so that we can all get back to the Moon and deliver on the upcoming Artemis missions.*

I do believe that NASA will take a leading role in the next decade to outline participatory frameworks for collaborative infrastructure development and requirements for said infrastructure moving forward.

Gareth: Materials management was a key point that you mentioned in your talk, to use materials that are immediately available to create structures. When it comes to structures on this planet, does that mean using Nature-based Solutions (NbS) and seeking to be in harmony with a local natural environment?

Melodie: *Yes, aligning project initiatives to best integrate with local environments and design vernaculars is central to our design methodology. We continue to explore the potential of utilizing local materials as feedstock for 3D-printing in multiple contexts. I also believe one of the benefits of additive manufacturing is the ability to create bespoke and site-specific architectural and infrastructural solutions that can adapt to local conditions in ways that are more cost- and time-efficient as compared with traditional means and methods of construction (stick frame, masonry, or steel construction, in particular). The thing that really distinguishes additive manufacturing as a construction process is that it represents a completely digitally native workflow, and thus introduces new potential for design in various contexts, landscapes, and climates.*

Gareth: Are you liaising with other researchers / businesses that are working on 3D printed / additive manufacturing, and / or research into housing design and construction (for example, I think of the Energy House 2.0 research project ongoing in the UK to look at how to make housing more energy efficient)? I am wondering if there is an international network for 3D printing / additive manufacturing, whilst appreciating that there will be commercial sensitivities to consider.

Melodie: *We have a number of initiatives with academic and other research partners exploring the durability of our material in freeze-thaw conditions, exploring how to build robust BIM workflows as we develop designs to be print and construction-ready and which explore 3D-printing using local materials in expeditionary contexts, to offer some examples. Research is a driving force for our progress as a technology company, and we are always looking for and interested in collaborations that advance the state-of-the-art of the 3D-printing industry forward.*

Gareth: Thank you very much for your thoughts and perspectives, Melodie. I am very much looking forward to following the progress of ICON.