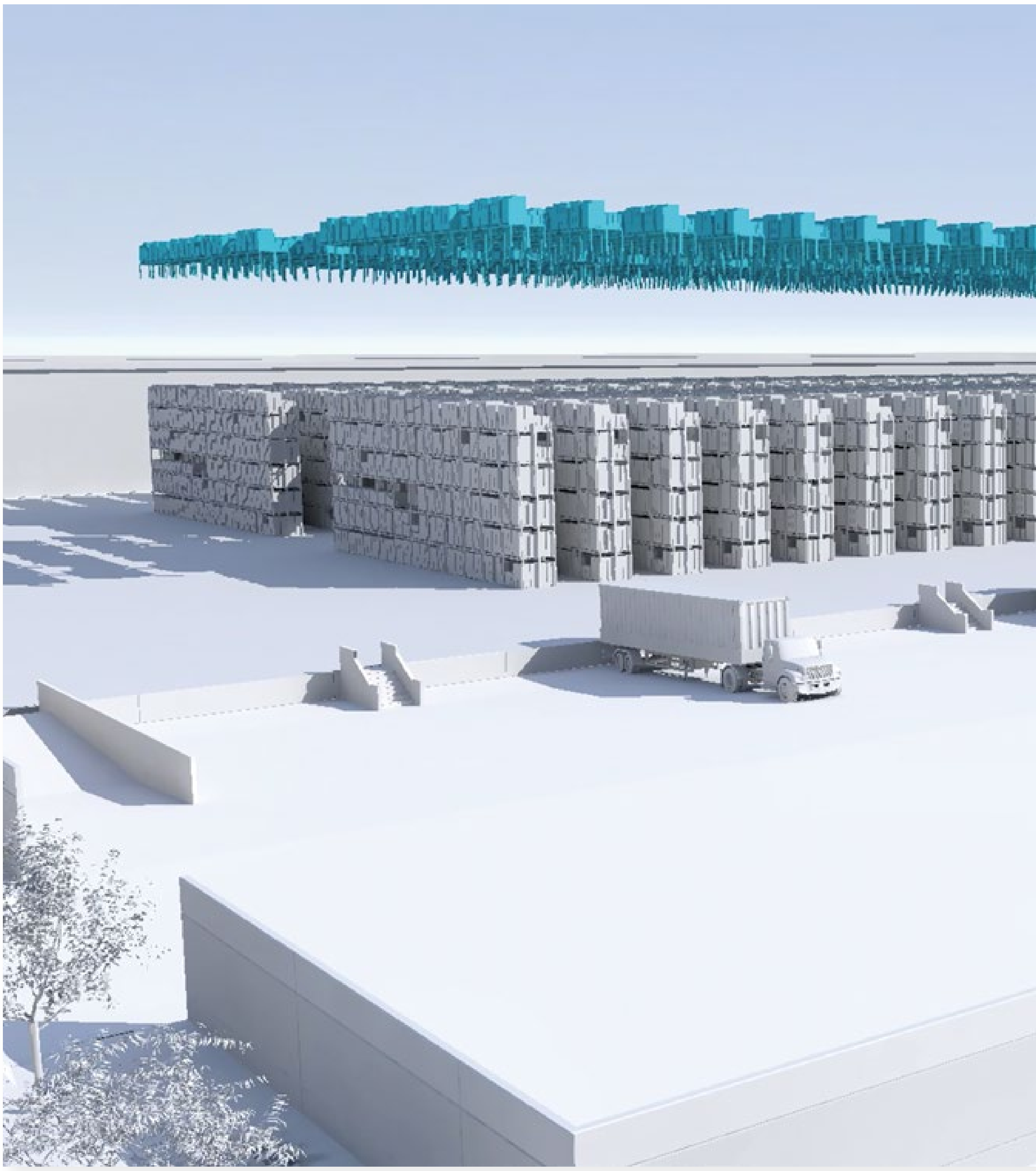
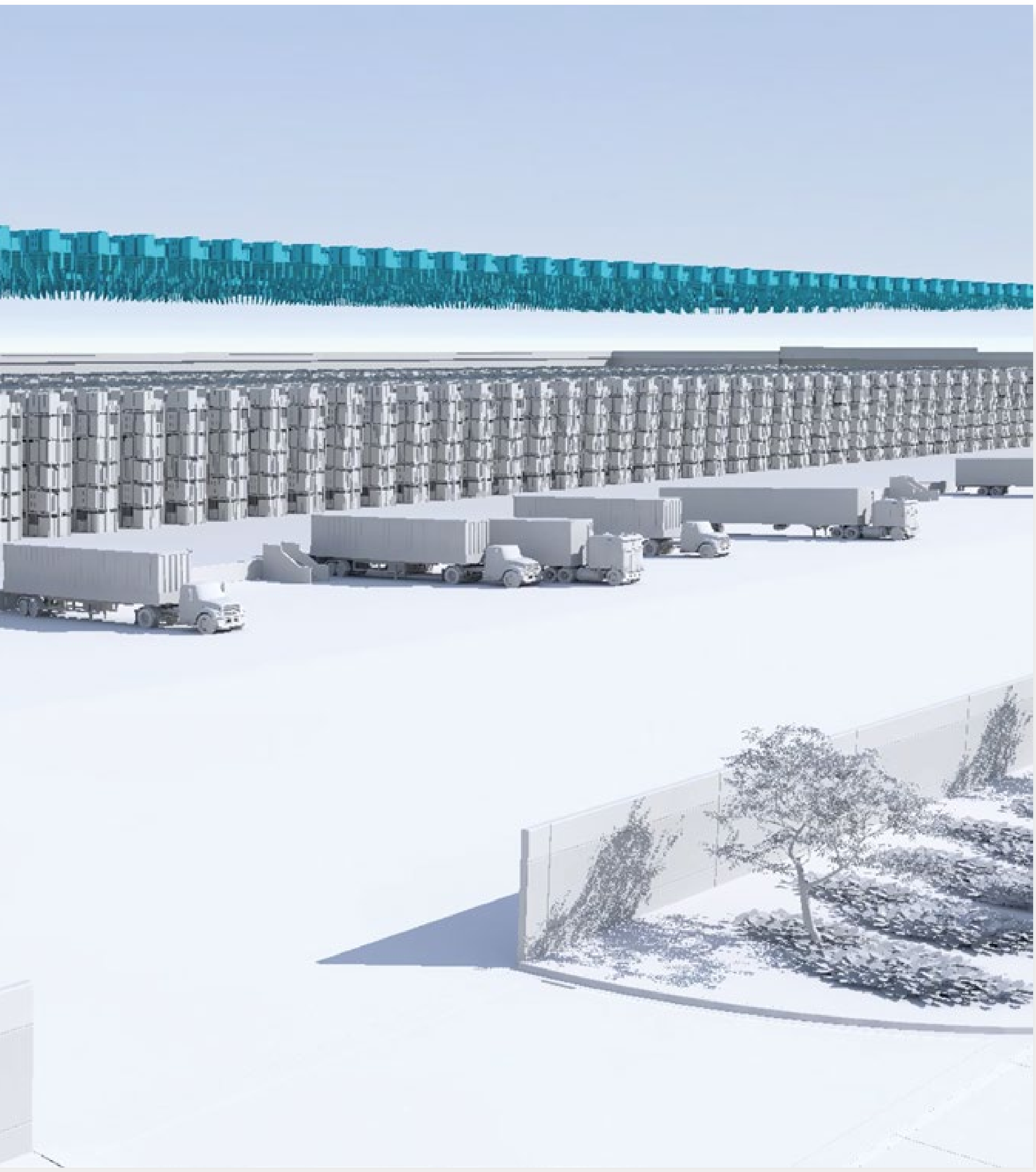
HUMAN EXCLUSION ZONES

Jesse LeCavalier



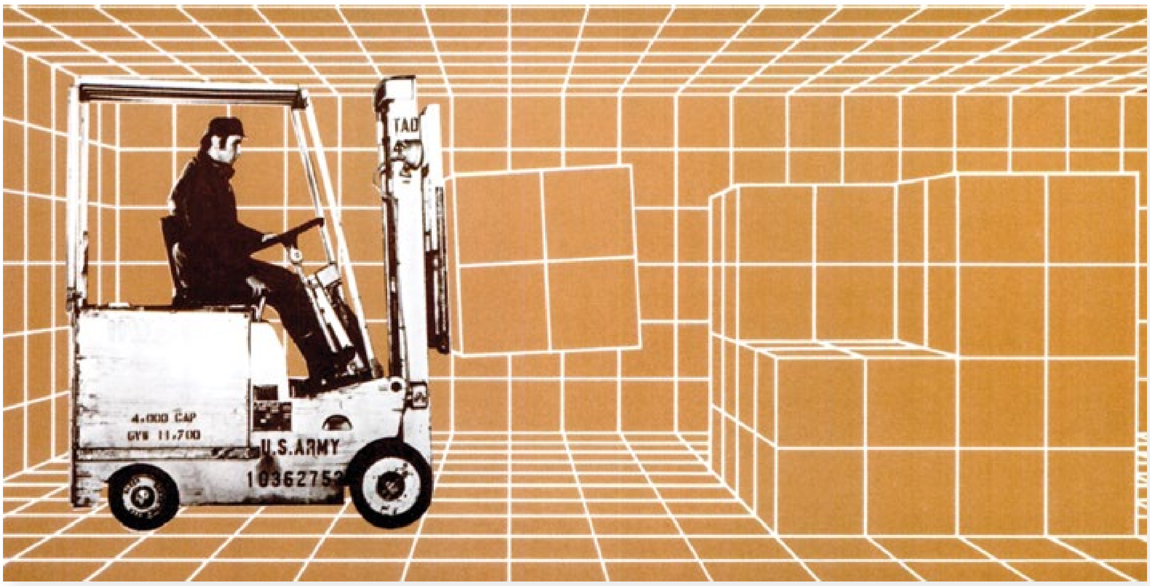
LOGISTICS AND NEW MACHINE LANDSCAPES



Watson Land Company,
Still from promotional video
'Watson Reveals 36' Clear!',
2017

In warehouse real-estate, storage capacity is a primary concern. This still from a promotional video for Watson Land Company, a California developer, shows an additional 4-foot (1.2-metre) layer of storage added to a typical warehouse.

From automatically guided vehicles (AGVs) to robotic drive units (RDUs), warehouse operations have advanced apace in recent decades. **Jesse LeCavalier** – Assistant Professor of Architecture at the New Jersey Institute of Technology in Newark, and Daniel Rose Visiting Assistant Professor at the Yale School of Architecture in New Haven, Connecticut – recounts the development of the latest generation of adaptive, environment-reconfiguring machines, such as those created by Kiva Systems and its successor Amazon Robotics, and discusses their effect on architecture itself.



Charles B Einstein,
'Modeling the Wholesale Logistics Base',
Army Logistician,
November/December 1983

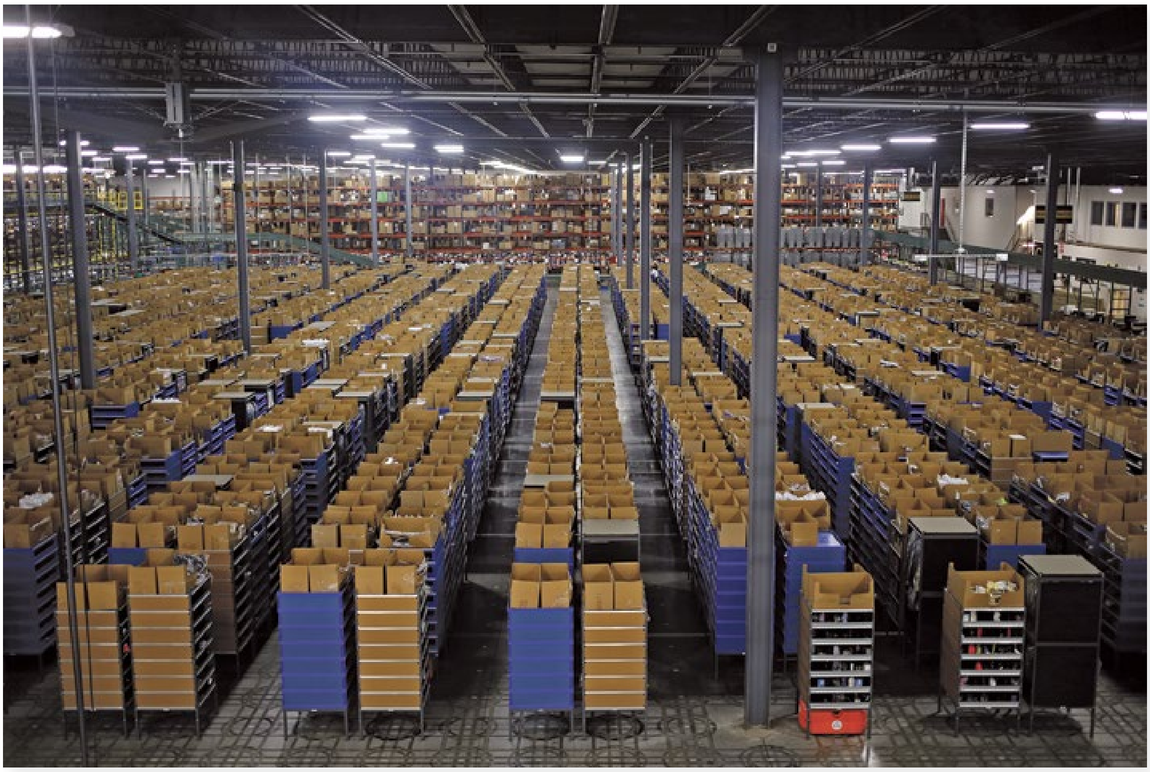
This illustration from *Army Logistician* describes a warehouse building's enclosure and its inventory in the same manner, suggesting they are conceptualised in similar terms.

One of the great stomachs of American consumerism sits east of Los Angeles, in the adjacent cities of Chino and Ontario. Processing and redirecting relentless quantities of inventory, this landscape encloses staggering amounts of 'cubic' feet – 'cube' in materials-handling argot. Architects might see this emphasis of volume (section) over area (plan) as a positive turn to experiential and spatial qualities. Materials-handling managers, however, see this simply as a question of capacity. These distribution and fulfilment zones create a machinic landscape all their own and one that, as it becomes more autonomous, poses challenges of both intelligibility and recognition to its human occupants.

Watson Land Company, one of the developers at work in Chino, distinguishes itself by offering a warehouse model that has a clear dimension from the top of the floor to the bottom of the ceiling of 36 feet (the more common height is 32). Multiply those 4 feet of height by one million square feet of area to understand what is at stake even in these small adjustments. A promotional video from 2014 (see the still on the previous spread) makes a case for choosing a warehouse with a 36-foot (10.9-metre) clearance by first introducing viewers to a digital model of a typical 32-foot (9.7-metre) example before a new 4-foot (1.2-metre) layer of blue 'cube' lands like a blanket of snow.[1] In the otherwise monochrome rendering of the warehouse, the envelope is left out, creating the impression that the racks, the ground and the trucks are all part of the same system. Though partly a product of visual necessity (it would be difficult to see the transformation of the 32-foot pallet racks otherwise), the choice resonates through the visual culture of materials handling and logistics because of a shared tendency to conflate the architecture with inventory or to omit it entirely.

For example, an image from the November/December 1983 issue of *Army Logistician* renders both warehouse interior and warehouse contents in the same fashion. The image's single-point perspective merges the gridded walls and floors with the stacked boxes of inventory and presages contemporary preoccupations with cubic feet by rendering generic inventory volume as physical substance. This material is made stackable and transportable through standardising functions necessary for the industries of logistics to operate. The storage pallet, for example, is a key element of standardisation because goods can be 'palletised' into rational units of measurement, a crucial step for the total management that came with the 'logistics revolution'.[2] This palletised unit of inventory has architectural implications because it has a physical dimension and so becomes a determining factor for warehouse construction.

In the *Army Logistician* image, all seems to be in its place except for the human forklift operator. The implied autonomy of a human operator is at odds with the otherwise regular logic of the warehouse environment. Indeed, the human aspect of logistics has resisted industry drives towards standardisation and automation even as the automatically guided vehicle (AGV) has emerged as a dominant attempt to overcome the expense and fallibility of human operations. Often serving specialised tasks and moving along fixed circuits, AGVs suggest a whole new set of organisational and spatial conditions.[3] Despite these technologies, the specific tasks of logistics, particularly the packing speed and picking dexterity required for assembling an order, continue to frustrate attempts at automation.



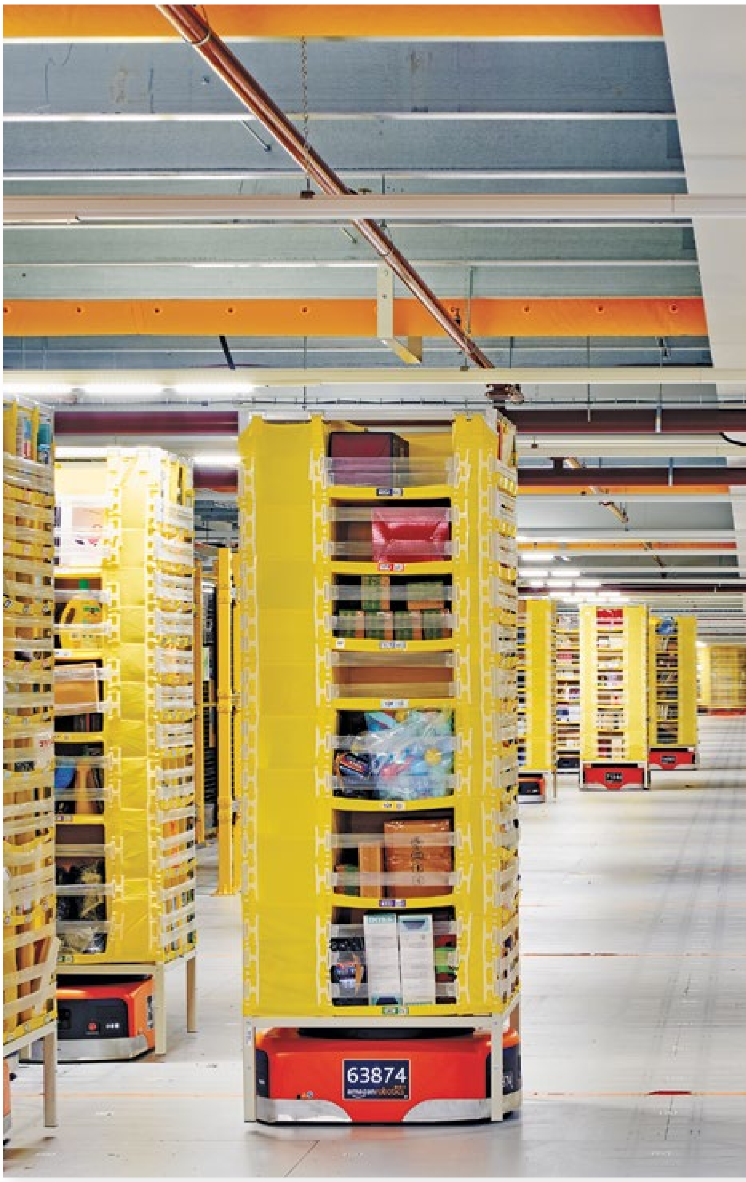
The Kiva system in use at a Gilt.com distribution centre, Shepherdsville, Kentucky, 2014

The Kiva robot system uses orange robotic drive units to deliver mobile inventory shelves to awaiting human pickers. Once the item has been picked, the shelf is returned to the closest available space.

THINGS TO PEOPLE

Broadly speaking, the initial concerns of automation were primarily those of position, location and movement.[4] Early AGVs from the mid-1980s would follow fixed looping paths, often controlled by networks of transducers. By comparison, the system developed in the early 2010s by Mick Mountz and Kiva Systems does not require a predetermined path, but relies on a host of robotic drive units (RDUs) operating in unison and with common goals.[5] The RDUs go where they are needed and then return to the most convenient location. Kiva's innovation is significant because, despite numerous attempts, automated mobile fulfilment processes had not found a mainstream hold in the logistics industry. More typical approaches, by contrast, rely on fixed conveyors to move goods through a distribution centre. Automation still plays a significant role in these cases, but primarily in the sortation and routing of totes and packages. Humans walk (sometime miles in a day) to inventory locations to pick items and assemble an order before placing it on one of many automated belts.[6] Kiva's dramatic development, echoing EM Forster's *The Machine Stops* (1909), was to figure out a way to bring things to people instead of the other way around.[7] The Kiva system was purchased in 2012 by Amazon for $775 million and has become the cornerstone for the company's new venture, Amazon Robotics.

The small orange RDUs developed by Kiva are equipped with a threaded cam to lift inventory shelving units (pods) just enough to transport them to an available picking station and worker, all controlled by a warehouse management system (WMS). In order to have an item delivered for picking, a request is sent to all of the RDUs on the floor. According to the language of Kiva's patent, after this happens: 'The mobile drive units respond to the order request with bids that represent the amount of time each mobile drive unit calculates it would take to deliver the requested item.'[8] The 'winning' bid then delivers its charge to the awaiting station. Once the items have been picked, the RDU brings the shelf not to its original position, but to the closest open slot. Through this process, the warehouse is continuously reconfiguring itself.



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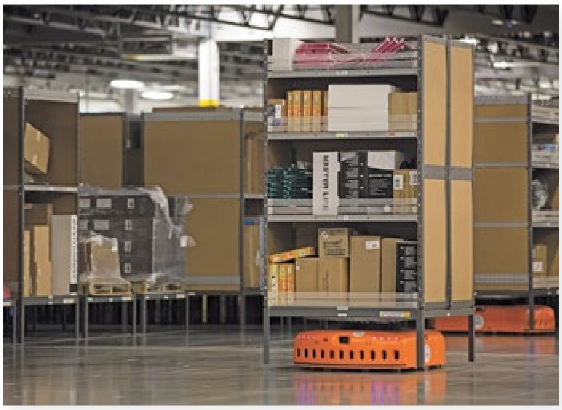
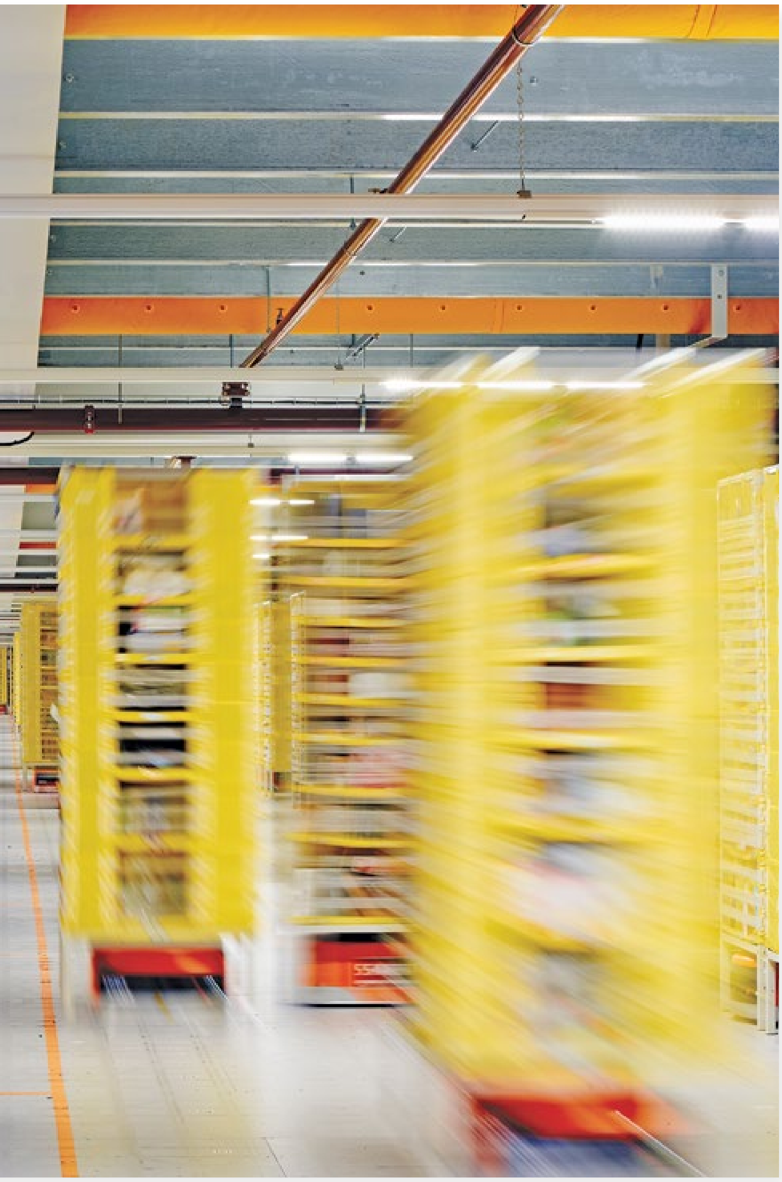


A Kiva robotic drive unit in use at an Amazon fulfilment centre, DuPont, Washington, 2015

The robotic drive units move the shelves by lifting them slightly off the ground, reorganising the building each time.



Kiva's breakthroughs were to granulise the system, to make storage and inventory the same thing, and to make storage mobile. Storage historically was often assumed to be a fixed element of distribution systems. Indeed, some storage racks serve double-duty as actual structural support for their building's roof system. In these cases, the storage becomes the architecture itself, fixed in place and stable. Kiva undoes this by not insisting that storage elements remain static and by animating them with a certain kind of intelligence. Instead of machine buildings populated with robot-like humans, as familiar science-fiction tropes might lead us to anticipate, Kiva creates a machine landscape of building-like robots.

The Kiva system's form of internal communication creates an overall organisation in which the racks with frequently requested items 'drift' closer to the packing stations. Mountz describes this as a 'complex adaptive system [that] demonstrates emergent system behaviour'.[9] His cites references like Steven Johnson's *Emergence: The Connected Lives of Ants, Brains, Cities* (2001) and Kevin Kelly's *New Rules for the New Economy: 10 Radical Strategies for a Connected World* (1998), texts also popular in architectural discourse, especially in the mid-2000s.[10] 'Emergence' and swarm behaviour remain tantalising for the discipline of architecture, and in this context Kiva's contribution is noteworthy because, rather than producing an image of a swarm, it uses small robots and pieces of buildings to create an actual emergent condition. Instead of a fixed form that suggests a field, here is a dynamic set of elements, each controlled by simple local feedback yet collectively creating a shifting whole whose form reflects a content we cannot understand. The map of a Kiva warehouse is a picture of our own collective consumer desires and impulsive quests for fulfilment, encrypted and presented back to us through a machine language that we cannot read. However, we would be mistaken to think that we are not part of this landscape.

Robotic drive units moving shelves around Amazon fulfilment centre, Manchester, 2017

above: Amazon's robotic drive units occupy an exclusive part of its fulfilment centres in which they can move without interference from humans.

right: Amazon workers must check the inventory locations during the 'stowing' process. From there, the shelf will await delivery to a human picker who will select a product and add it to an order to be packed and shipped.

THE NEW UTILITY

Once Amazon acquired Kiva, evidence of its activities became difficult to find. Amazon Robotics absorbed Kiva Systems and ended the sales of its products to other companies.[11] Since making Kiva part of its operations, Amazon has incorporated its technologies in a new generation of fulfilment centres that combine human picking, packing and shipping with automated inventory delivery. Much of the inventory is managed and processed in a multi-level area of each fulfilment centre known as the 'human exclusion zone'.[12] As goods arrive from suppliers they are 'stowed' in the inventory pods, which are then moved into the storage area. Since the RDUs get their directions from a grid of 2D barcodes on the ground, and since the local wireless network governs their location, the bots only need a small light to scan the codes on the floor. As a result, the human exclusion zone is dark. Dark and quiet. It is large enough that the rows of racks receding in the distance, when viewed from the outside, disappear into the blackness beyond. Periodically, an inventory pod on its way to a new location silently interrupts the long cross-aisles.[13]

Amazon has roughly 30,000 robotic drive units in operation and even though the company's automated fulfilment centres are increasingly full of machines, they remain part of a human condition. These buildings provoke a crisis of legibility in that we cannot understand the behaviour of their machines even though we created the instructions that guide them. When observing the RDUs in action, one is tempted to assign a kind of intelligence to these machines because they seem to operate with such unpredictable purpose. In 1984, the Italian cyberneticist Valentino Braitenberg created similar conditions by orchestrating a series of thought experiments in which simple 'vehicles' are assigned sensors (stimulus) and motors (response). By creating a series of mechanical feedback systems, apparent behaviours, emotions and even intelligence appear to emerge. Braitenberg posits that there is a tendency to conjecture that the vehicle 'does some thinking before it reaches a decision, suggesting complicated internal processes where in reality there was nothing but a threshold device waiting for sufficient activation. The patterns of behaviour described in the vehicles … undoubtedly suggest much more complicated machinery than that which was actually used in designing them.'[14] For him, more a psychologist than an engineer, the question is one of methodology and assumption; that sometimes to study something one needs to simulate its operations from the inside out. He reminds us that, 'when we analyse a mechanism, we tend to overestimate its complexity'.[15] And yet, while the operation of the individual RDUs is somewhat simple, the complexity that ensues over the 30,000 in Amazon's system suggests a different order of magnitude, one in which the individual vehicle is absorbed by a system with a propulsive technological force.

Architecture has always been a machinic landscape. Our challenge now is to offer suitably seductive responses, to proliferate typological inventions and to generate dispositional modes of practice that see the political problems of logistics as fundamentally architectural.

The apparent autonomy of the Amazon Robotics automated fulfilment centre floor suggests, if not creates, a sense of historical inevitability. The 'how' of the mechanism supersedes the 'why' and the spectacles of autonomous fulfilment landscapes justify the system that they propagate. In other words, the underlying assumptions and values about the consumer society upon which Amazon is built become more and more normalised through a set of technologies that creates greater and greater distance between action and consequences. Langdon Winner suggests that such technological momentum withers political agency because of the difficulty of comprehending systems beyond immediate experience: 'Most persons are caught between the narrowness of their everyday concerns and a bedazzlement at the works of civilization … With the overload of information so monumental, possibilities once crucial to citizenship are neutralized. Active participation is replaced by haphazard monitoring.'[16] In the case of Amazon, participation in a consumer process is rendered remote and instantaneous. We can 'track' the progress of our items, a process that reduces the efforts and complexities of the supply chain to a series of checkpoints. If we were to try to do more than 'haphazardly monitor' the process of order fulfilment, our frustration would continue because of the unintelligibility of the fulfilment landscape. A wilderness of machines of our own making that, while not autonomous, maintains a diffuse momentum of self-propagation.

Like electrification, fulfilment is on its way to becoming a new utility and a new expectation of contemporary life. And like electrification, it is changing us in the process. The degree to which we collectively depend on these systems then becomes a key question. In the context of an increasingly technomorphic landscape, companies like Amazon thrive if we are isolated as individual consuming subjects. But in that isolation, to return to Winner: 'Seemingly valid excuses can be manufactured wholesale for anyone situated in the network. Thus the very notion of moral agency begins to dissolve.'[17] If we accept that automation has a technological momentum that will work to shape the built environment to its own expedient ends then, rather than stepping aside to let technology run its course, there is an opportunity to treat this as an architectural issue, or at least as a spatial one. Architecture has always been a machinic landscape. Our challenge now is to offer suitably seductive responses, to proliferate typological inventions and to generate dispositional modes of practice that see the political problems of logistics as fundamentally architectural.

NOTES

1. 'Watson Reveals 36' Clear!', Watson Land Company promotional video: https://youtu.be/H3P8d1_pVgg.
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3. Keller Easterling, *Floor*, in Rem Koolhaas/AMO/ Harvard Graduate School of Design (eds), *Elements*, Marsilio Editori (Venice), 2014.
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5. Michael C Mountz, 'Material Handling Method Using Autonomous Mobile Drive Units and Movable Inventory Trays', US Patent 6,748,292 B2, 8 June 2014: https://patentimages.storage.googleapis.com/cf/19/af/f4db8f47c28bd0/US6748292.pdf.
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7. EM Forster, 'The Machine Stops', first published in the *Oxford Cambridge Review*, 1909: http://archive.ncsa.illinois.edu/prajlich/forster.html.
8. Mountz, *op cit*.
9. *Ibid*.
10. Steven Johnson, *Emergence: The Connected Lives of Ants, Brains, Cities*, Scribner (New York), 2001. Kevin Kelly, *New Rules for the New Economy: 10 Radical Strategies for a Connected World*, Penguin (New York), 1998. For examples of the discussion of emergence in architecture, see for instance Michael Hensel, Achim Menges and Michael Weinstock, AD *Emergence: Morphogenetic Design Strategies*, May/June (no 3), 2004, pp 6–10.
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16. Langdon Winner, *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*, MIT Press (Cambridge, MA), 1989, p 296. First published 1977.
17. *Ibid*, pp 303–4.