Komatsu's Smart Construction and Japan's Robot Revolution[1)]

Andrew DeWit

Japanese multinational construction giant Komatsu is a front-runner in the development and deployment of renewable energy, efficiency, automation and robotics. It is also a repeat winner of the coveted Deming Prize and numerous other awards for excellence, innovation and environmental protection[2)]. It is important to stress that Komatsu has a history of impressive achievement as preface to suggesting that, on January 20, 2015, it held a possibly landmark press conference in an era of climate and energy crises.

At the conference, Komatsu unveiled a new paradigm of "smart construction" that brings the robotics revolution into the USD 7.4 trillion (2010 data) global construction industry[3)]. Komatsu staged its announcement in Tokyo district Shibuya's capacious Hikarie Hall, a focal point and showcase of Japanese rail and real-estate

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1) This paper is a revised and updated version of Andrew DeWit, "Komatsu, Smart Construction, Creative Destruction, and Japan's Robot Revolution," *The Asia-Pacific Journal,* Vol. 13, Issue 5, No. 2, February 2, 2015.

2) On the Deming Prize for Total Quality Management, established in 1951, see the Union of Japanese Scientists and Engineers (JUSE) page describing its history, awardees and other pertinent information: http://www.juse.or.jp/e/deming/

On Komatsu's 2014 selection for the Deming Prize, as well as concise information on why Komatsu wins prizes for innovation, see "Deming Prize," Komatsu Newsletter, No. 24, March 2014: http://www.komatsu.com/CompanyInfo/views/pdf/201403/Views_No24_DemingPrize.pdf

Komatsu's environmental awards are listed in the "Recent External Commendations and Evaluations on Komatsu's Environmental Conservation and Social Activities" section of its corporate website: http://www.komatsu.com/CompanyInfo/csr/others/03.html

3) For data on the global construction industry, see "Global Construction Market Worth $10.3 Trillion in 2020 (50 Largest, Most Influential Markets)," PR Newswire, February 17, 2015: http://www.prnewswire.co.uk/news-releases/global-construction-market-worth-103-trillion-in-2020-50-largest-most-influential-markets-292235981.html

conglomerate Tokyu Corporation's smart city strategies[4]. With a GPS and camera-equipped drone hovering overhead, Komatsu CEO Ohashi Tetsuji declared that, from February 1 of 2015, his company would begin offering smart construction options at its 123 sales outlets within Japan. Komatsu calculates that its smart approach can cut project costs by at least 20–30 percent through the use of robotics, including the multi-sensor drones; cloud computing through its "KomConnect" platform to process the massive flows of information; and further automation to displace reliance on scarce labour while increasing precision and decreasing the waste of energy and other resources. Komatsu, the world's second largest manufacturer of mining and construction equipment (behind Caterpillar), and the biggest in Asia (including China), also intends to make smart construction a global product by March of 2016.

Komatsu's project is part of a business－government "Robot Revolution Realization Council" report released on January 23, 2015[5]. Japan is unfolding a policy mix and public-private collaboration to recapture some of the outright dominance the country held in robotics during the 1980s. Both Komatsu and Japan's ambitions seem unlikely to be impeded by concerns about job losses and other potential downsides from automation and robotics. The labour shortages already plaguing construction and other projects in Japan's ageing and shrinking society are in fact a major reason for Komatsu's new business model. The suite of technologies composing Komatsu's smart construction also aim to bolster the climate-resilience of roads, bridges, and other core infrastructures, while reducing the escalating costs of their maintenance and repair. Komatsu's smart construction may therefore add a new aspect to the proliferating elements of Japan's smart cities and those evolving elsewhere.

This paper details Komatsu's paradigm and then suggests it could be one facet

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4) The role of Hikarie Hall is described on pages 4-6 of (in Japanese) Tokyu Managing Director Watanabe Isao's 2013 presentation "Concerning the City-Design Concept of Tama Denen Toshi as a Community that can Cope with Epochal Change," to the Ministry of Lands Infrastructure and Transport : http ://www.mlit.go.jp/common/001025682.pdf

On the global significance of the "Tokyu Method" of building Tama Denen Toshi, see the short note "Tama Denen Toshi New Town (Tama Garden City), Japan" : http ://www.amchamvietnam.com/5654/tama-denen-toshi-new-town-tama-garden-city-japan/

5) See "Robot Revolution Realization Council," Japanese Prime Minister's Office Homepage, January 23, 2015 : http ://japan.kantei.go.jp/97_abe/actions/201501/23article3.html

of bringing big capital into political coalitions to accelerate resilience and sustainability through smart communities. In work on the externalities of climate and energy crises, taken up below, it is common to encounter the contrary assertion : that resilience and sustainability are primarily a matter of grassroots activism. Big capital is often depicted as an antagonist, and smart technology at best secondary if not delusionary or even dangerous. But timely mitigation and adaptation to climate change appear to require massive and rapid shifts in energy-related infrastructure enabled by technological change, organizational discipline and powerful incentives. The imperative of acting with appropriate haste indicates that building coalitions among civil society, the state and the market are essential. Against this backdrop, Komatsu's example perhaps illustrates some of the collaboration and creative destruction required to construct smart communities centred on renewable energy, efficiency, new materials, and other technologies.

Komatsu and Dantotsu" Renewable Energy and Efficiency

Komatsu takes its name from the city of Komatsu, Ishikawa Prefecture. The company was founded there, in 1917, by Takeuchi Mining Industry as a subsidiary to supply industrial tools[6]. Komatsu became an independent corporate entity from May 13 of 1921, but struggled to survive through such shocks as the 1923 Great Kanto Earthquake and the 1927 Showa Financial Crisis. It held on by finding markets, in the 1930s, for construction and farming equipment in the Japanese colonies of Manchuria and Korea[7]. It also branched out into weaponry—such as tanks and howitzers—during Japan's long years of war until its defeat seven decades ago in 1945. Komatsu truly gained traction in the postwar rebuild. It received an enormous boost from the reconstruction of Japan's devastated cities, especially Tokyo, introducing the workhorse D50 bulldozer in 1947. Like Toyota, Honda, Fujitsu and other non-zaibatsu firms, Komatsu emerged as one of the new Japanese industrial giants that blended

6) Komatsu's corporate history is available at its corporate home page: http://www.komatsu.com/CompanyInfo/profile/outline/history.html

7) Komatsu's history and innovative strengths are deftly described by Yozo Hasegawa in *Rediscovering Japanese Business Leadership: 15 Japanese Managers and the Companies They're Leading to New Growth* (translated by Anthony Kimm), John Wiley and Sons, 2010 : 145-56.

entrepreneurialism with a zeal for innovative technology and thus reaped immense opportunity in Japan's postwar growth miracle[8].

Komatsu relocated its head office to Tokyo in 1951, while remaining the major employer in its corporate birthplace of Komatsu City. Its product line centres on construction and mining equipment, forestry related machinery and industrial machines, with a significant R&D investment in robotics, automation, and energy-related technologies[9]. Komatsu is also a global multinational with 143 consolidated subsidiaries and over 47,000 employees (as of March 31, 2014), but it is neither a household name in Japan nor recognized internationally as representative of the "Japan Brand" as such firms as Sony, Panasonic, Toyota, and Nissan. This general lack of awareness concerning Komatsu seems largely be due to what it makes. For example, Sony Group's global employment of 140,900 is thrice that of Komatsu, but its brand recognition many multiples greater[10]. The key difference may be that Sony built its fame on the basis of fist-sized devices like the Sony Walkman, consumer items that have direct personal utility for hundreds of millions of consumers as well as enormous cachet. Komatsu, by contrast, makes 70% of its income from hydraulic shovels and other heavy earthmoving and construction equipment— "yellow steel," as one author aptly puts it[11]. Most people experience these machines from a distance, as nearly generic tools that labour in the midst of noisy public works or the destruction and construction of homes and condominiums in the urban landscape.

Komatsu is well-known among business analysts and other specialists because of the outstanding success of its *dantotsu* ("unrivalled") business model that stresses continued organizational and technological innovation, where it sharply contrasts with ailing Sony and other household names. Komatsu is also a leader in the aggressive de-

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8) Gary D. Allinson, *Japan's Postwar History* (*Second Edition*), Cornell University Press, 2014: 104-5.

9) For example, on Komatsu's robot-welding R&D see (in Japanese) "Komatsu Deploys Robot Welding Domestically and Overseas to Maintain Quality and Cut Costs," *Nikkei Shimbun*, February 17, 2014: http://www.nikkei.com/article/DGXNASDD120UH_S4A210C1000000/

10) See Sony's employee data at: http://www.sony.net/SonyInfo/csr_report/employees/info/

11) William R. Haycraft, *Yellow Steel: The Story of the Earthmoving Equipment Industry,* University of Illinois Press, 2000.

ployment of renewable energy and efficiency in its factories and equipment, bringing to market the world's first hybrid electric forklift trucks in 2007 and hydraulic excavators in 2008[12]. Komatsu's role in information and communications technology (ICT) is also unmatched in the industry. Its Komtrax wireless equipment monitoring systems remotely monitor, in real-time, myriad such parameters as fuel consumption, location, and productivity. Together, these items tell the customer whether their machine is making money and whether it is safe, and whether it is in good health[13].

Moreover, in the wake of Japan's 3-11 disaster on March 11, 2011, Komatsu doubled-down on its commitment to efficiency and renewable power, spending YEN 74 billion in 2014 to refurbish domestic facilities towards its corporate goal of halving its power demand[14]. Komatsu draws on its long-institutionalized innovative strengths to achieve this ambition. For example, Komatsu subsidiary Kelk was part of the New Energy and Industrial Technology Development Organization (NEDO) 2002-2006 initiative to attain high-efficiency thermoelectric generation, which uses waste heat to produce electricity[15]. This and other NEDO projects helped Komatsu become a world leader in advanced thermoelectric generation.

Komatsu used this and other renewable power-generation and efficiency technology, together with ICT and automation, to cut power demand by a staggering 92% in a refurbished assembly wing of its Awazu factory[16] in the precincts of the firm's

12) The hybrid equipment is reputed to achieve at least 45% reduction in fuel consumption. See "Komatsu Introduces the World's First Hydraulic Excavator : Hybrid Evolution Plan for Construction Equipment," Komatsu Press Release, May 13, 2008 : http ://www.komatsu.com/CompanyInfo/press/2008051315113604588.html

13) See "Komtrax : Komatsu machine monitoring a tracking system" : http ://www.marubeni-komatsu.co.uk/komtrax.html

14) See (in Japanese) "Komatsu to complete refurbishing of 2 domestic facilities in 2014, with Awazu factory completed by May," *Daily Engineering and Construction News,* May 1, 2014 : http ://www.decn.co.jp/?p=11165

15) See (in Japanese) "Renewable energy for effective CO2 cuts : Developing and distributing the world's most efficient thermoelectric generation modules," Komatsu Press Release, January 27, 2009 : http ://www.komatsu.co.jp/CompanyInfo/press/2009012713421026622.html

16) The thermoelectric generation applications at the Awazu factory are described (in Japanese) in "Dealing with climate change (goods and service that combat climate change) : thermoelectric generation," Komatsu CSR report 2014 : http ://www.komatsu.co.jp/CompanyInfo/csr/environment/2014/pdf/14.pdf

starting point in Komatsu City. Demonstrating *dantotsu*, fully 20% of the reduced power demand is derived from increased productivity (i. e., reorganizing production to save energy), 32% from more efficient equipment, and 40% from solar, biomass and other in-house generation. Komatsu is also collaborating with local businesses in order to expand the benefits to the local community[17]. Moreover, Komatsu is undertaking similar projects at its other facilities, explicitly aiming to free itself from reliance on power firms as well as cut its total corporate peak summer power demand by 50% by 2015 compared to 2010[18].

Komatsu's ambitious projects have long caught the attention of technical specialists in Japan. They are also an increasingly visible benchmark for city planners and others devoted to transforming the energy economy. The most recent evidence of this attention was a January 24, 2015 symposium "Aiming at Green Energy in Tochigi," at Tochigi Prefecture's Utsunomiya University, in Utsunomiya City (population : 510,000) roughly 100 km north of Tokyo. Representation from area academic and research institutions was supplemented by the University of Tokyo (through its "Green ICT Project"). But the event was framed by Komatsu's Oyama factory (30 kilometres from Utsunomiya) production-technology division's presentation on the details of their aggressive deployment of environmental measures[19].

Komatsu's deep power－demand cuts are surely essential to any realistic programme for sustainability, so for that reason alone the firm deserves to be made a benchmark. But as we describe next, Komatsu is also central to Japan's new National Robot Strategy.

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17) On this, see (in Japanese) "Komatsu collaborates with area industry to achieve 90% cut in purchased power for factory," *Nikkei Electronics*, May, 2015 : http ://techon. nikkeibp. co. jp/ article/MAG/20150408/413148/

18) See Tsunashima Yuta, "Komatsu shows off progress in 'energy independence' at plants," *Nikkei Asian Review*, May 31, 2014 : http ://asia. nikkei. com/Business/Companies/Komatsu-shows-off-progress-in-energy-independence-at-plants

19) See (in Japanese) "Thinking about the environment and energy, business, academe, government symposium at Utsunomiya attended by 120," *Shimotsuke News*, January 25, 2015 : http ://www. shimotsuke. co. jp/news/tochigi/economics/news/20150125/1850981

Komatsu and Japan's National Robot Strategy

Japan's ambitious National Robot Strategy was unveiled on January 23, 2015. It was developed by the "Committee for the Implementation of the Robot Revolution," which had its first meeting on September 11, 2014. Its membership included heavyweights straddling business and government, such as Kuroiwa Yuuji, Governor of Kanagawa Prefecture (just south of Tokyo with a population of 9.1 million and its capital in Yokohama City) and a strong proponent of renewable energy. Its chair was Nomaguchi Tamotsu, senior advisor to Mitsubishi Electric and former director of the quasi-governmental National Institute of Advanced Industrial Science and Technology. The committee met five times in late 2014. At its final meeting on January 23, it formally presented its report to Japanese Prime Minister Abe Shinzo[20]. Abe then declared 2015 to be "year one" (*gannen*) of moving towards a "robot society."

The strategy outlined by the committee's report aims to quadruple the current domestic robot market from YEN 600 billion at present to YEN 2.4 trillion in 2020. Seed money for basic R&D and related activities will total YEN 100 billion of public and private-sector financing[21]. The strategy itself, released by METI on January 23, identifies developments in other countries as threatening Japan's lead in the deployment of robots (see accompanying figure on "industrial robot sales" for 2013 sales and operational stock in 2012). The challenges highlighted by the report include the Chinese robotics programmes, the US "Industrial Internet Consortium", as well as the German "Industry 4.0" initiatives that seek to revamp industrial processes throughout the economy. The Japanese documentation conveys deep concern that their annual take-up of robotics peaked (in terms of shipments) in 1991, and that the robots are concentrated in automotive and electronics factories. The Japanese authorities want to expand the use of robots in other industries such as elderly care, services, construction, disaster resilience, and farming. To promote this goal, they aim to reduce the

20) See (in Japanese) "Japan's Robot Strategy," Committee for the Implementation of the Robot Revolution, January 23, 2015: http://www.meti.go.jp/press/2014/01/20150123004/20150123004b.pdf

21) See "Govt to expand robot market to Y2.4 tril.," *The Japan News*, January 24, 2015: http://newsonjapan.com/html/newsdesk/article/111109.php

size of robots (compared to current industrial robots) and enhance their connectedness (via ICT) so as to make them more readily adaptable in small and medium-sized firms that at present have no alternative to scrambling for scarce human labour.

The Japanese Robot Strategy explicitly uses the above competitive challenge as well as the upcoming Tokyo 2020 Olympics as spurs to action. As to targets, the strategy aims to increase deployment of robotics in manufacturing by 2020 from the 7% prevailing in the auto industry in 2010 to 25% for large firms overall and 10% for small and medium-sized firms. To help achieve this aim, the strategy will identify and promote at least 30 cases of best-practice use. In services, such as hotels and the food sector, the strategy aims at a diffusion rate of 25% by 2020 for sorting and checking functions, as well as the selection of about 100 best-practice cases in wholesale, retail, foods, hotels and other areas.

Elderly care is also a large target for robots and automation. Policymakers aim at expanding the elderly-care robotics market to YEN 50 billion by 2020. Japanese workers employed in nursing the elderly totaled 550,000 in 2000, a figure that by 2012 had increased to 1.49 million. By 2015, employment is estimated to increase to about 1.7 million, with a further increase to roughly 2.4 million by 2025. These numbers imply great stress on tight labour markets as well as on the workers themselves. The robot strategy aims to alleviate both problems, using robotic assistance to displace labour demand and to zero-out the current high risk of injury to care givers from handling the sheer weight of the elderly. Thus robotics will be used to help in moving the elderly from beds, in assisted walking, in bathing and use of the toilet, as well as in care of those with dementia. Survey data indicates that 59.8% of caregivers would like to use robots in elderly care. Moreover, among recipients of care, the desire to be assisted by robots is already higher, at 65.1%. The strategy aims to raise both these figures to 80% by 2020.

The strategy highlights startling facts about the fields of infrastructure, disaster-relief and construction. Total employment of 6.85 million in 1997 has declined to 4.99 million as of 2013, with a profound demographic shift. The 45 year and above cohort in these fields comprised 40.1% of employees in 1997, but by 2013 had swollen to 55.3%. Conversely, the demographic under 34 years declined from 30.2% in 1997 to

19.2% in 2013. The strategy thus aims to automate maintenance checks and otherwise back up technical staff. Robots such as drones are seen as means to more quickly identify the location and scale of disasters as well as aid in facilitating rescue. The strategy proposes to raise productivity in these sectors as well as reduce human labour, by achieving a diffusion rate of ICT construction equipment to 30% by 2020. It also aims to outfit 20% of Japan's backbone infrastructures (such as roadways and waterworks) with sensors and robotic devices to perform routine inspections to assess areas of stress and other indicators of impending failures. Robotics will also be deployed to assist in repair work. Similar devices will also be adopted for assistance in such severe natural disasters as mudslides and forest fires.

Robotics is also to be expanded in farming and forestry as well as food processing, where ageing and declining population have also led to severe labour shortages. The average age of Japan's 1.74 million people employed in the farming sector is already 66.5 years, with only 10.2% (178,000 workers) being 50 years and under. The strategy is thus quite aggressive and explicit in its ambitions of deploying automated tractors and other farming equipment to raise productivity to hitherto unthinkable levels. The use of power-assist (exo-skeleton) equipment will also be used to mechanize and automate as much as possible of the sector's heavy work. The strategy aims to have automated tractors and other equipment in place and operating by 2020 and to have over 20 different kinds of new robot processes in place in the primary industries as well as food processing.

Japan's ageing, while more pronounced than most of its competitors, is also common to all of them. Demographic studies indicate that China will catch up to where Japan is at present in under two decades, one of the consequences of the now abandoned one-child family policy. Should Japan get a head start on creative and competitive uses of robotics in age-related fields, it may build itself enduring export opportunities[22].

22) See, for example, Figure 15 B "Average age of population aged 20 and more, 1950-2060," in "Policy Challenges for the Next 50 Years," OECD Economic Policy Paper, No. 9 July 2014.

Back to the Future, on Competitive Advantages?

We noted earlier that the Committee for the Implementation of the Robot Revolution included some very senior representation. One of its members is Komatsu Chairman and Executive Director Noji Kunio. On January 23, Noji gave the committee, meeting at the Prime Minister's Offices, a presentation on smart construction. This presentation came three days after Komatsu CEO Ohashi explained smart construction at the above-noted January 20 event in Shibuya. Noji brought no drone for his discussion of smart construction. Perhaps the theatrics were not necessary : the attached photo and video clip show us that the full committee—with PM Abe in attendance—had already beheld a disaster-relief drone fly about the room, during their first meeting on September 11 of 2014[23]. But Noji's short talk on January 23, 2015 did unveil additional metrics concerning Komatsu's new model[24].

Yet another committee member is Tsuda Junji, Chairman and Executive Director of Yasukawa Electric Manufacturing Company. Tsuda delivered a presentation on industrial robots to the committee on January 23[25]. Along with Komatsu, Yasukawa is one of the star firms discussed by Michael Porter in his *Competitive Advantage of Nations*, wherein Porter masterfully details the Japanese business-government cooperation that created the world's leading robotics industry three decades ago[26].

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23) The context for the drone display is a presentation on the disastrous August 20, 2014 mudslides in Hiroshima City. See from 3 : 30 of the video (in Japanese) "Committee for the Implementation of the Robot Revolution : September 11, 2014" : http ://nettv.gov-online.go.jp/prg/prg10456.html

On the mudslides, see Andrew DeWit, "Hiroshima's Disaster, Climate Crisis, and the Future of the Resilient City", *The Asia-Pacific Journal*, Vol. 12, Issue 35, No. 2, September 1, 2014 : http ://japanfocus.org/-andrew-dewit/4174

24) Noji Kunio's presentation (in Japanese) was given on January 23, 2015, and is available at the Cabinet Office web site : http ://www.kantei.go.jp/jp/singi/robot/dai6/siryou2-1.pdf

25) Tsuda Junji's presentation (in Japanese) was delivered on the same day as Komatsu chair Noji Kunio's, January 23, 2015, and is available at the Cabinet Office web site : http ://www.kantei.go.jp/jp/singi/robot/dai６/siryou2-2.pdf

26) See Michael E Porter, *Competitive Advantage : Creating and Sustaining Superior Performance*, Free Press, 1998, 384-421.

Porter argues that one of Japan's advantages in building up and diffusing robot technology during the late 1960s and the 1970s was cooperative trade unions that did not have to worry about their protected employees being displaced. He also highlights the strong role of engineers in Japanese firms as well as "the emergence of Japanese companies as the premier manufacturing companies in the world in a wide range of industries. Through high levels of automation, reorganization of work flow, and extreme attention to quality, Japanese companies redefined manufacturing practice." That description certainly fits the postwar corporate history of Komatsu, reviewed earlier. Porter goes on to relate how these and other factors worked together to make 1980s Japan "the earliest, largest and most sophisticated market for industrial robots in the world."

That was then, and this is now. But Japan's manufacturing elite and public sector are clearly trying to stage a repeat performance, with different assets and a different cast of characters. As with Komatsu, some of the same innovative firms, still vibrant, remain at the centre of the mix, and a few rising stars were also represented on the committee. But in contrast to four decades ago, Japanese policymakers and business elites are now hoping to use labour shortages, ageing, environmental crises and other constraints as spurs to action and innovation. And they wield the 2020 Olympics as a deadline for achieving a wide variety of targets.

The Japanese do not appear to be unrealistic in their estimation of the competition. One example is seen in Taiwan's Foxconn Technology Group, the world's largest contract electronics manufacturer. Foxconn is a major supplier not only to Apple, Microsoft, Samsung and other global electronic giants, but notorious for suicides due to "mundane and grueling work[27]." It will automate to cope with shrinking revenues from cheapening of the electronic devices it supplies parts for in tandem with steadily rising labour costs, which have doubled since 2010. Foxconn currently employs 1.3 million workers in China alone during peak production periods, but seeks to restrict fur-

27) Eva Dou, "After Suicide, Foxconn Worker's Poems Strike a Chord," *Wall Street Journal,* November 7, 2014 : http ://blogs.wsj.com/chinarealtime/2014/11/07/after-suicide-foxconn-workers-poems-strike-a-chord/; Jenny Chan and Pun Ngai, "Suicide as Protest for the New Generation of Chinese Migrant Workers : Foxconn, Global Capital, and the State," *Asia-Pacific Journal,* September 23, 2010 : http ://japanfocus.org/-Pun-Ngai/3408

ther growth of the workforce through plans to deploy a million robots over an as yet unspecified time-frame[28]. Moreover, the Korean Ministry of Trade, Industry and Energy announced in early January of 2015 that it would work with business to build a 1 trillion won (USD 929 million) robotics industry to help domestic businesses deploy largely automated "smart factories." At present, Korea's largest smart factory is at LS Industrial Systems (LSIS), Cheongju City, North Chungcheong Province, about 110 kilometres from the national capital in Seoul. LSIS is one of Korea's largest cable makers, and about 95% of the production processes at its Cheongju factory are automated. The factory has reportedly achieved an incredible level of precision, with only 97 defects per 1 million units, together with impressive cuts of nearly 60% in power costs[29].

Whether corporate Japan can move fast and nimble enough to regain the momentum in this strategic industry remains to be seen. Komatsu's smart construction went on-line domestically as of February 1, 2015, and it will take at least a few months to see if the model merits the obvious pride on CEO Ohashi's face. Among other salient initiatives, Japan's Huis Ten Bosch theme park in Nagasaki Prefecture will, in mid-July, open a hotel with robot staff and face recognition technology rather than room keys. Huis Ten Bosch reportedly plan to have 90% of their hotel services run by robots "in the future[30]." Japan's official programme to restart and reboot its robot revolution bears watching over the next five years to the 2020 targets and beyond.

The Politics of Komatsu's Smart Construction

The above has only skimmed the surface of items that deserve to be explored in Japan's new commitment to accelerate a technological revolution. In particular, there

28) Michael Gold and Yimou Lee, "Apple supplier Foxconn seeks to reduce 1.3m workforce, eyes robots," *The Age,* January 28, 2015 : http ://www.theage.com.au/it-pro/business-it/apple-supplier-foxconn-seeks-to-reduce-13m-workforce-eyes-robots-20150128-1309mb.html

29) "'Smart' factory touted as an industrial model," *Korea Joongang Daily,* January 26, 2015 : http ://koreajoongangdaily.joins.com/news/article/Article.aspx?aid=3000113

30) "Huis Ten Bosch theme park to get hotel staffed by robots," Japan Times, January 28, 2015 : http ://www.japantimes.co.jp/news/2015/01/28/business/huis-ten-bosch-theme-park-get-hotel-staffed-robots/#.VM2xPToq9jE

are legitimate concerns about the implications of such swiftly unfolding paradigms as smart construction. The many well-informed critics of the overall smart city concept, including the LSE's Adam Greenfield[31], a former sergeant in the 7 PSYOP Gp (psychological operations group) of the United States Army's Special Operations Command, might see Komatsu's smart-construction model as an amalgam of gimmickry or perhaps yet another threatening portent of unbridled technological change[32]. Regardless of Japan's labour shortages and declining population, some progressive scholars and activists might be dismayed at Komatsu's deliberate destruction of jobs[33]. Many will surely be concerned at the further deployment of drone technology that is elsewhere being used in spying and deadly airstrikes, with Arab, Asian and other children among its collateral damage[34]. And those concerns hardly exhaust the potential horrors from business models that mix and match items from the rapidly growing menu of automation, robotics and related advanced technology[35].

Muddying the moral water ever more, Komatsu's products still include military equipment, built by its Defence Systems Division. Most notable among these items is Komatsu's Light Armoured Vehicle, first used by Japan's Ground Self Defence Forces in 2007. This deployment was in Japan's cooperation with America's still-unfolding disaster of invading Iraq on the pretext of a tissue of lies floating on a sea of oil[36].

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31) On Adam Greenfield's work and background, see his profile at Urbanscale : http ://urbanscale.org/about/adam-greenfield/

32) See Adam Greenfield, "The smartest cities rely on citizen cunning and unglamorous technology," *The Guardian*, December 22, 2014 : http ://www.theguardian.com/cities/2014/dec/22/the-smartest-cities-rely-on-citizen-cunning-and-unglamorous-technology

33) On the issue of automation and employment, see The Editors, "Will Automation Take Our Jobs?" *Scientific American*, July 15, 2014 : http ://www.scientificamerican.com/article/will-automation-take-our-jobs/

34) One of the most informative and credible institutions that details the use of weaponized drones, such as the Reaper and the Predator, in Afghanistan, Pakistan, Yemen, Iraq, Syria and elsewhere is "Stop the War Coalition," founded in September of 2001 in opposition to the post-9-11 "war on terror." (http ://stopwar.org.uk/officers). For their most recent report on drone strikes, see Chris Cole, "The dirty consequences of 'clean' US/UK drone wars that trash international law," Stop the War News, January 5, 2015 : http ://stopwar.org.uk/news/the-dirty-consequences-of-clean-us-uk-drone-wars-that-trash-international-law

35) On the nightmarish scenarios, see the work of the Centre for the Study of Existential Risk, University of Cambridge : http ://cser.org

36) The endurance of the deceptions about then-Iraqi dictator Saddam Hussein's active programme to build "weapons of mass destruction" (WMD) is evident in the fact that 40%

Against this backdrop, as well as our era's unprecedented inequality, it is small wonder that many of us oppose the smart city, or at least having big business in it. Yet we appear to need technology, and even more of it. And we also seem to lack robust and ready alternatives to incentivizing corporate actors, like Komatsu, that innovate and deploy it. This remains true even if much of the basic research is funded by taxpayer money or (especially in the US) by the direct military demand Mariana Mazzucato detailed in her *The Entrepreneurial State*[37].

Let us look at the politics of this from a different angle. Few of us display any qualms in boarding a Boeing 787 jet, save for lamenting the cramped size of our economy-class seat. Yet the 787 is built with automated orbital drilling and other technologies that presumably kill jobs through greater speed and precision[38]. And the myriad innovations in the jet itself include ICT sensors in its composite-material skin as part of the "smooth ride technology" that keeps us from losing our in-flight dinner during turbulence[39]. The jets also generate as much as half a terabyte of the much-maligned "big data" per flight, as its multiple systems monitor components to spot potential failures in the engines that carefully sip the fuel for which we fight wars or frack away the water[40].

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of Americans believe there was indeed a WMD programme and the US media continues to debate it. See Kevin Drum, "No, There's Still No Evidence There Was an Active WMD Program in Iraq," *Mother Jones*, October 15, 2014 : http ://www.motherjones.com/kevin-drum/2014/10/no-theres-still-no-evidence-there-was-active-wmd-program-iraq

37) On the roots of technology used in smart phones and other devices, see Mariana Mazzucato, *The Entrepreneurial State*, Anthem Press, 2013 : http ://marianamazzucato.com/the-entrepreneurial-state/

38) See the SAE International excerpt "Boeing advances automation with smart and portable orbital drilling tools for 787," from Wesley Holleman, Eric Whinnem and Madeleine Wrede "Smart Portable Tools : The Practical Solution to Agile Assembly," SAE Int. J. Aerosp. 6 (1) : 180-187, 2013 : http ://articles.sae.org/12811/

39) See James Wallace, "Aerospace Notebook : New technology gives 787 a smoother ride," *Seattle PI*, May 22, 2007 : http ://www.seattlepi.com/business/article/Aerospace-Notebook-New-technology-gives-787-a-1238203.php

40) Matthew Finnegan, "Boeing 787s to create half a terabyte of data per flight, says Virgin Atlantic," Computerworld UK, March 6, 2013 : http ://www.computerworlduk.com/news/infrastructure/3433595/boeing-787s-to-create-half-a-terabyte-of-data-per-flight-says-virgin-atlantic/

Airline passengers almost certainly want this massively increased safety and efficiency when they fly, yet criticisms of the smart city, ICT and automation gloss over this perhaps inconvenient truth. Nor, it seems, has any critic yet dealt with the stubborn fact that the core of the smart city includes the smart power grid whose technology appears essential for the diffusion of such intermittent renewables power sources as solar and wind.

Komatsu's Light Armoured Vehicle and history of howitzers and tanks might stimulate objections when it comes to the firm's smart construction business. But the case of Being seems instructive here. Boeing does not only make passenger aircraft that scholars and activists readily ride on. Boeing's "Defense, Space and Security" arm is a USD 33 billion business whose 56,000 employees worldwide outnumber Komatsu's total workforce[41]. Working together with Bell, for example, Boeing builds the V-22 Osprey whose deployment by US forces in Japan, and impending purchase by the Japanese military[42], is of enormous controversy because of its record of crashes. Boeing also built the iconic B-52, which carpet-bombed Vietnam. The advances that have kept that airframe flying for 60 years are incorporated in and upgraded for the 787 as well.

Boeing also builds such potentially lethal drone technology as the Phantom Eye, whose liquid-hydrogen propulsion system (which leaves only water in its wake) has such exceptional fuel economy that it can stay aloft for four days at 20 kilometers in the sky. And its 200 kilogram payload of sensor packages can spy on motion and communications across a 750 kilometre line of sight horizon[43]. That same mix of technologies is almost surely to be invaluable in coping with the extreme weather and

41) See Boeing's website here : http ://www.boeing.com/boeing/companyoffices/aboutus/brief/bds.page?

42) See "Japan picks MV-22 Osprey for tilt-rotor aircraft purchase," *Stars and Stripes,* November 21, 2014 : http ://www.stripes.com/news/japan-picks-mv-22-osprey-for-tilt-rotor-aircraft-purchase-1.315374

On Okinawan opposition to the Osprey, see Matthew M. Burke and Chiyomi Sumida, "Japan opens door for possible shift of Ospreys off Okinawa," *Stars and Stripes,* November 20, 2014 : http ://www.stripes.com/news/pacific/japan-opens-door-for-possible-shift-of-ospreys-off-okinawa-1.315156

43) On the Phantom Eye, see Boeing's outline here : http ://www.boeing.com/boeing/bds/phantom_works/phantom_eye.page?

other disasters amplified by the climate change accelerated by flights on the 787 Dreamliner.

Komatsu is not the social movement idealized in, for example, Naomi Klein's *This Changes Everything : Capitalism vs. The Climate*[44] and other people-centred narratives of how to fight climate change, resource scarcity and compounding collective crises. Yet as the very climate— and energy—literate Elizabeth Kolbert has suggested, and with compelling detail, there are perhaps too many hard facts and unpleasant choices being left out of such accounts[45].

Weighing all these factors, on balance, Komatsu's ambitions seem credible and creative. Surely Komatsu exemplifies a firm to learn from rather than point disapproving fingers at [ms1]. As we have seen, Komatsu's deep efficiency and renewable-power rebuild of its Japan-side factories have set a high bar that at least some communities see as a benchmark. Its increasingly automated shovels and trucks also help reduce the precious oil required for getting at the depleting ore grades of copper we increasingly use in smart phones and electric cars[46]. And it has shown itself to be committed to working with the multiple stake-holders in Japanese communities, a model of organizational management practices that break down silos to solve collective problems. Komatsu's resilience-oriented ambitions also link to a global movement, the Resilient Cities Acceleration Initiative, which includes big capital such as IBM alongside NGOs, to "transform cities" and foster community-based resilience[47]. Komatsu's creative role helped lead to the December 2014 selection of Japan's smart, resilient and

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44) Naomi Klein, *This Changes Everything : Capitalism vs. The Climate,* Simon & Schuster, 2014 : http ://thischangeseverything.org

45) See Elizabeth Kolbert, "Can Climate Change Cure Capitalism?" *New York Review of Books,* December 4, 2014 : http ://www.nybooks.com/articles/archives/2014/dec/04/can-climate-change-cure-capitalism/

See also Naomi Klein and Elizabeth Kolbert, "'Can Climate Change Cure Capitalism?' : An Exchange," *New York Review of Books*, January 8, 2015 : http ://www.nybooks.com/articles/archives/2015/jan/08/can-climate-change-cure-capitalism-exchange/

46) Tim Maverick, "New Robo-Trucks Poised to Revolutionize the Mining Industry," *Wall Street Daily,* May 21, 2014 : http ://www.wallstreetdaily.com/2014/05/21/mining-robo-trucks/

47) The list of Resilient Cities Acceleration Initiative partners is here : http ://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/RESILIENCE-Resilient-Cities-Acceleration-Initiative.pdf

compact city, Toyama, as one of the Rockefeller 100 Resilient Cities[48]. Komatsu not only has one of its head offices in the city's environs, but its executive ranks have long been part of the discussion on building resilience through city, university, NGO and business collaboration[49].

In the Japanese context, Komatsu and its initiatives could become key to a coalition that creates a majoritarian political movement for resilience and sustainability. The acceleration of energy and climate crises indicate that it is imperative to diffuse smart communities centred on renewables, efficiency, new materials, and other technologies. There does not appear to time to wait for them to grow organically, confronted as we collectively are with accelerating climate change, increasingly volatile geopolitical and market effects from resource depletion, and the ongoing failure of central banks to blow life—as opposed to asset bubbles—into the energy—and materials—intensive conventional economy. So this article takes Komatsu seriously, and looks forward to its smart construction model quickly becoming an element in collaborative and resilient smart communities.

48) See the Rockefeller Foundation 100 Resilient Cities : http ://www.100resilientcities.org

49) See (in Japanese) the outline of a September 22, 2011 event titled "What is the Business Strategy in an Era When the Industrial Structure is at a Turning Point?" JRM CEO Kimura Blog : http ://www.jrm.co.jp/president/ceo/71.html