

### A Transforming World: robots & Artificial Intelligence (AI)

As part of our work on A Transforming World, we introduce a new Innovation-focused theme in this Primer setting out the challenges and opportunities offered by robots and AI, as well as a Primer Picks report.

### Next industrial revolution: rise of the intelligent machines

Robots and AI are becoming an integral part of our daily lives as providers of labour, mobility, safety, convenience, and entertainment. 2014 was the third consecutive year for record sales of robots worldwide (229,000, +29% YoY). The IoT, big data, cloud computing and 3D printing have meant exponential advancements in the space, while global structural drivers, such as demographics, energy efficiency, productivity, urbanisation, and wage inflation, suggest long-term sustained growth. Robots are likely to be performing 45% of manufacturing tasks by 2025E (vs. 10% today).

### US\$153bn mkt (2020E): US\$14-33tn in disruptive impact

We estimate the robots and AI solutions market will grow to US\$153bn by 2020E, comprising US\$83bn for robot and robotics, and US\$70bn for AI-based analytics. We anticipate US\$14-33tn in annual creative disruption impact in 10Y, including US\$8-9tn of cost reductions across manufacturing and healthcare, US\$9tn cuts in employment costs via AI-enabled automation of knowledge work and US\$1.9tn in efficiency gains via autonomous cars and drones. Adoption of robots and AI could boost productivity by 30% in many industries, while cutting manufacturing labour costs by 18-33%.

### Paradigm shifts bring challenges: inequality, labour, safety

We are facing a paradigm shift which will change the way we live and work. We anticipate the greatest potential challenges arising from our ATW theme of People, notably the possible displacement of human labour (with 47% of US jobs having the potential to be automated) and growth in inequality (with a 10% supply and demand gap between skilled and non-skilled workers by 2020E). We also anticipate issues around cybersecurity (50bn connected devices by 2020E), privacy (#1 concern in human-tech interactions), and longer-term existential threats being posed by AI ("killer robots").

### Eight entry points for investors: fast growth areas

We highlight eight entry points for investors wishing to invest in the robots and AI theme: 1) AI; 2) Aerospace & Defence (incl. drones); 3) Autos & Transport; 4) Financials; 5) Healthcare; 6) Industrials; 7) Services (domestic); and 8) Ag & Mining. We anticipate fast growth for the likes of agribots, AI, automation, care-bots, cobots, drones (commercial and military), fintech, industrial robots, medical robots & computer-assisted surgery, self-driving cars, service robots, software and telehealth.

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### A Transforming World



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Refer to important disclosures on page 12 to 13.

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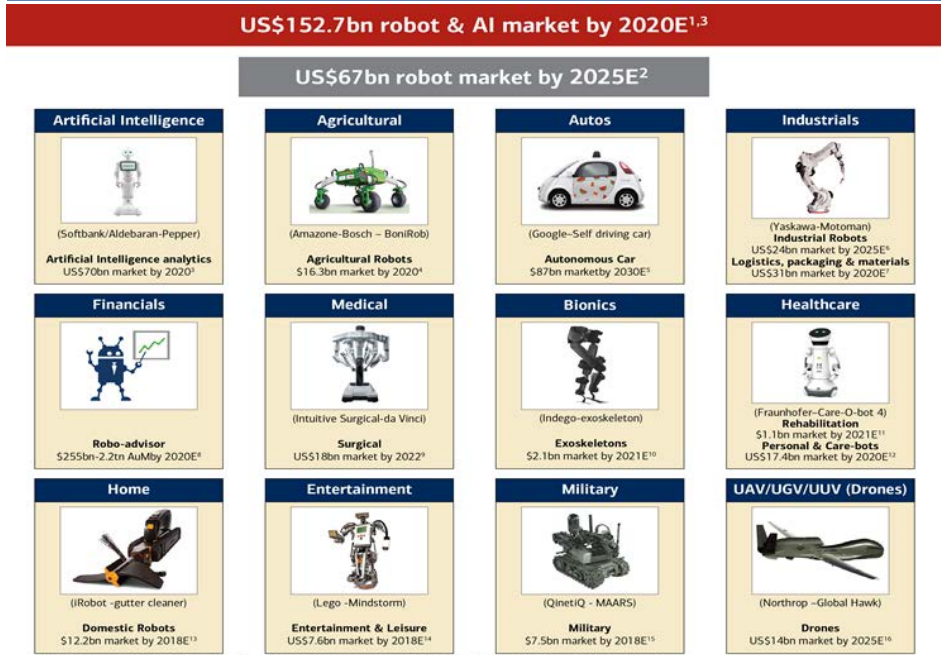
# Robot Revolution

The pace of disruptive technological innovation has gone from linear to parabolic in recent years. Penetration of robots and artificial intelligence (AI) has hit every industry sector, and has become an integral part of our daily lives. Technology has also expanded beyond routine work, and moved into complex problem-solving, and replicating human perception, tasks that only people were capable of.

2014 was the 3<sup>rd</sup> consecutive record year for sales of robots worldwide. The pace of adoption will likely accelerate and reach up to 45% penetration in many sectors within manufacturing by 2025E, up from 10% today. Costs have decline by 27% over the past decade and is expected to drop by another 22% in the next 10Y, while performance is improving at a rate of 5% per year. The confluence of global aging – where the 60+ population is expected to double from 841mn in 2013 to 2bn+ by 2050E, and EM wage inflation – where China’s average manufacturing wage has increased 9X since 2000, means demand for automation is skyrocketing.

We estimate the current robots & AI solutions market at US\$153bn by 2020E including US\$83bn for robots, and US\$70bn for AI-based analytics. Disruptive technologies will yield US\$14–33tn in annual economic impact by 2025E through cost reductions and efficiency gains. Early adoption will be a key comparative advantage, while those that lag in investment will see their competitiveness slip.

## Exhibit 1: The global robots & artificial intelligence market



Source: BofA Merrill Lynch Global Research

## Eight entry points for investors: fast growth areas

We highlight 8 entry points for investors wishing to invest in the Robots & AI theme: 1) AI; 2) Aerospace & Defence (incl. drones); 3) Autos & Transport; 4) Financials; 5) Healthcare; 6) Industrials; 7) Services (domestic); and 8) Ag & Mining.

## Artificial Intelligence (AI): Machine learning, deep learning, natural user interfaces

**Artificial intelligence (AI) is the intelligence exhibited by machines or software.** It was coined in the early 1950s by American computer and cognitive scientists who defined it as "the science and engineering of making intelligent machines". AI has become an essential part of the technology industry – including the 3.5bn+ Google searches made every day – and is increasingly providing the heavy lifting for many of the most challenging problems in computer science. The combination of AI, machine learning, deep learning, and natural user interfaces such as voice recognition) are making it possible to automate many knowledge worker tasks that were long regarded as impossible or impractical for machines to perform.

**AI will be a core technology for the Internet of Things (IoT) which we expect to double over the next five years** providing growth in (1) data compilation, (2) data analysis and future forecasting and (3) actuations based on the results of analysis. We believe the key driver for advances in data analysis is AI. In the IoT age, more than 50bn devices are expected to be connected to the internet by 2020E. Given the limitations of human beings to rapidly develop hypotheses to assess the large amounts of data produced by these devices, we believe AI, which has the ability to generate hypotheses independently, will offer a viable solution.

**AI has seen US\$17bn in AI investments since 2009 with 2014 seeing over US\$2bn invested in 322 companies** with AI-based technologies (source: Quid). US and Japanese companies have been leading the way including efforts by Apple, Facebook, Google, Hitachi, IBM, Intel, LinkedIn, NEC, Yahoo, and Twitter among others in the last year. Private investment in the AI sector has grown from US\$1.7bn in 2010 to US\$14.9bn in 2014, with YTD investment activity in 2015 on track to grow nearly 50% YoY (source: Quid).

**The market for AI based analytics could grow to US\$70bn by 2020E.** AI is already used in a wide range of applications including web search systems, marketing recommendation functions, the security business and financial trading programs. In the future, we expect the applications for AI to expand to include driverless cars and service robots. Research firm IDC forecasts the IoT market related to analytics, with AI technologies at the core, will grow by CAGR of 36% - from US\$8.2bn to US\$70bn - in 2013-20E.

**The market for AI technologies could reach US\$43.5bn by 2024E** as companies seek to derive greater value from big data via cognitive computing, machine learning, predictive application programming interfaces (APIs) and image recognition. The market for AI systems for enterprise applications is expected to increase from US\$202.5mn in 2015 to US\$11.1bn by 2024E, expanding at a CAGR of 56.1% (source: Tractica).

**There is a 50% chance of full AI (high-level machine learning) by 2040-50E and a 90% chance by 2075E** according to AI researchers. Experts expect that systems will move on to super-intelligence in less than 30 years thereafter (source: Mueller and Bostrom 2014). The greatest impacts are likely to be felt as a result of knowledge work automation which has the potential to affect over 230mn knowledge workers globally and cUS\$9tn in employment costs. This presents huge opportunities and raises challenges for leaders across business, society, and government and across multiple sectors of the economy (source: McKinsey)

## Industrials: Automation, Industrial Internet, robots

**Industrial robots are machines that can be automatically controlled or programmed to manipulate and move objects** and are a key enabler of the emerging Industrial Internet. Integrating robots, big data and software analytics can optimize the full manufacturing chain, connecting virtual design, simulation, manufacturing and supply chain management. This improves efficiencies and product quality, while increasing manufacturing flexibility and lowering turnaround time.

**2014 was the third consecutive record year for sales of robots worldwide, with sales topping 229,000, or 29% YoY growth.** This amounted to US\$10.7bn in sales, while the overall robot systems market, including software, peripherals and systems engineering is now valued at US\$32bn. The pace of automation has also been expanding. Since 2010, robotic sales have increased at a 17% CAGR (source: IFR).

**China has been the largest buyer of robots for 2Y in a row, and now makes up 25% of the global market.** China, the US, Japan, South Korea and Germany currently account for 70% of the global market. Japan has largest installed base of industrial robots, accounting for 20% of the global total. The IFR estimates that by 2018E, China will account for 38% of industrial robots sold, implying 25%+ CAGR. India should see the highest global growth, albeit from a much lower starting point (source: IFR).

**Industrial robot growth is likely to accelerate as economic and technical barriers fall.** Prices for a robotic welder dropped from US\$182,000 in 2005 to US\$133,000 in 2014, while the latest Baxter “cobot” retails as low as US\$22,000 (source: Baxter). Performance of robotic systems is expected to improve by 5% each year – and it is estimated that we are reaching the inflection point where manufacturers replace human workers with robotics in many sectors (i.e. when an automated operating system reaches a 15% discount over a worker) (source: BCG).

**There is huge scope for growth with robot penetration in industry at only 66 robots per 10,000 workers worldwide** (source: IFR). In contrast, the Japanese autos sector stands at 1,520 robots per 10k employees. In addition, only 10% of manufacturing tasks are automated worldwide, a figure which is likely to reach up to 45% in 10Y for sectors such as computers & electronics, electrical equipment, machinery, and transportation equipment (source: BCG).

**EMs will continue to drive global growth driven by modernisation of factories and wage inflation.** Productivity-adjusted wage inflation for countries like China has risen 165% since 2004, 5-30x the pace of DMs (source: EIU, BCG). Global ageing, as well as the rise of more educated workforces and rising labour unrest, will also further the shift from manual labour to automation. Cost competitiveness of countries slow to adapt will continue to decline.

**The global industrial robot market is expected to expand from US\$10.7bn in 2014 to reach US\$24bn by 2025E reflecting an 8.5% CAGR** (source: IFR, BCG). Automation within logistics, materials handling, and packaging is worth another US\$18bn in 2015, and is set to deliver 10.1% CAGR and reach US\$31.3bn by 2020E (source: WinterGreen). Beyond traditional spaces (articulated robots, SCARA robots, cartesian robots and cylindrical robots), we anticipate fast growth in areas like cobots (collaborative robots), the shift from hardware to software, autos, logistics, and warehousing.

**Adoption of industrial robots is expected to yield a positive impact of US\$600bn-1.2tn by 2025E.** DMs will see higher rates of robotic penetration as 15-25% of workers’ tasks are automated within the manufacturing, packing, construction, maintenance, and agriculture spaces. That figure will be 5-15% for EMs. 30-60mn FTEs could be replaced by automation, which could also facilitate up to a 75% improvement in productivity per unit of work automated (source: McKinsey). This would make productivity-adjusted labour up to one-third cheaper for countries with the highest adoption levels, including South Korea, China, the US, Japan and Germany (source: BCG).

## Autos & transport: Self-driving or autonomous vehicles

**The global automotive industry value chain generates US\$5tn in annual output, selling 78mn vehicles every year** (source: IHS, KPMG). However, the cost of mobility is high: the cost of vehicle ownership is now up to US\$21,000 per year and it costs US\$8-12mn per mile to construct new four-lane highways in US urban areas (source: KPMG); parking spots account for 31% of urban land (source: Kenworthy & Laube); transport accounts for about 20% of global energy use and 22% of global energy-related CO2 emissions (source: IEA); and 1.24mn die in road accidents every year (source: UN). All this makes the sector ripe for disruption.

**Self-driving cars or autonomous vehicles (AVs) can operate without human input using sensors, radars, cameras, advanced driver assistance systems, software, GDP, and data communication systems.** These advances are often safer and more efficient than relying on human drivers and passive safety systems alone. Levels of autonomy range from L1 to L5, with L4 and L5 considered fully autonomous cars. Auto OEMs have been developing AV components to gain expertise, while tech companies like Google and Apple are pioneering full AVs. All are targeting large-scale rollouts in the next 3-5Y.

**AV technology is likely to create a US\$87bn solutions market for car manufacturers, parts suppliers, and technology companies by 2030E**, of which software will take the largest share at 29% of the total (source: Lux Research). Up to 90% of new cars will be “connected” in developed markets by 2020E, reaching 20% total fleet penetration (source: McKinsey, Hitachi, Telefonica, Gartner). Cars with partial autonomous features will reach 12-13% penetration by 2025E, when the first fully autonomous cars will be commercial. By 2035E, penetration will reach 25%, with fully driverless cars comprising 9-10% of total sales (source: BCG). L4/L5 features are likely to cost an extra US\$10,000 when first introduced in 2025 (source: BCG), declining to US\$7,000 by 2030 (source: KPMG, IHS).

**Driverless cars have the potential to generate a positive economic impact of US\$200bn-1.9tn by 2025E** (source: McKinsey). This includes the potential to reduce road accidents in the US by 78% (source: Eno Centre for Transportation) and save up to 150,000 lives globally every year (source: McKinsey), reduce the weight of automobiles by 32-50% by 2050 (source: RAND), and decrease transportation-related energy demand by up to 40% (source: MacKenzie, Wadud, & Leiby 2014). Driverless cars will also free up driving time, which averages 50 minutes every day for the 80% of Americans that commute (source: KPMG) - worth US\$100bn-1tn globally. This extra time translates into 10-15% of work productivity or €5bn for every additional minute drivers spend on the internet instead of driving (source: McKinsey).

**Primary hurdles to AV adoption are regulation, insurance, cost, technology and concerns about privacy, cybersecurity and ethics.** Currently, only the US, the UK, Japan, Germany, France, Sweden and Singapore have permitted testing of AVs. An insurance framework needs to be developed addressing responsibility for collisions. Current technologies are also cost-prohibitive for widespread adoption. Cybersecurity is also a concern with one in two car buyers (54%) fearing that connected cars will be hackable, and one in three (37%) not wanting to use a connected car due to privacy concerns. Adoption would also have a potential long-term negative demand impacts for the autos and auto insurance sectors.



## Aerospace & Defense: Unmanned systems, military & commercial drones, robots & AI

The defense sector globally has been increasing its adoption of robotics and unmanned vehicle systems (UVSs) in recent decades. This is driven by the advantages they bring in terms of 1) safety – reducing the lethality of warfare, adopting riskier tactics; 2) accuracy – better range, endurance, speed; 3) flexibility – better mobility, faster response times; and 4) cost – increasing personnel cost, cheaper cost of tech. Unmanned aerial systems (UAS), or drones, comprise the largest portion of this, at 80% of total military robots (source: IFR 2015).

**US military spending on UAVs has grown 10x from US\$283mn in 2000 to US\$2.9bn for FY2016, in the face of multi-year downturns in overall US defense spending** (source: US DoD). Inventory of UAS has grown 65x from 167 to 11,000 between 2002 and 2013, with penetration of unmanned aircraft rising from 5% of the total to 41% by 2012 (source: Congressional Research Service). There are 90 countries operating drones, with 30 armed drone programmes established or in development (source: CNAS).

**Global military robot spending is growing at a 10.3% CAGR and is expected to reach US\$7.5bn by 2018E, while UAV (drone) spending is expected to reach US\$123bn over the next 10Y, or US\$14bn annually by 2025E** (source: Technavio, Teal Group). UAVs for the commercial sector will grow at an even faster rate, rising 8x to US\$4.8bn by 2021E from a much smaller base of US\$609mn in 2014 (source: Radiant Insights). Commercial adoption for agricultural crop management, consumer product delivery, media & entertainment, search & rescue, etc, will be the drivers for growth.

**Integrating drone systems has the potential to create US\$82bn in positive economic impacts by 2025E in the US alone, and generate more than 100,000 jobs,** of which 34,000 will be high-paying (US\$40,000+) manufacturing jobs. Related tax revenue is expected to total more than US\$482mn from 2015-25E. Furthermore, the US could lose US\$10bn every year that drone integration is delayed, or US\$27.6mn per day (source: AUVSI 2013).

**The success of the UAV market will depend on regulation, and addressing privacy & stakeholder concerns.** There is no unified global policy on drones, although countries like the US, Sweden, France, and the UK have passed legislation allowing private operations. In the US, the Federal Aviation Administration (FAA) is to introduce a national framework by the end of 2015, and the EU is developing a harmonized framework by 2016 or 2017. Beyond privacy concerns, the proliferation of autonomous weaponized systems must be treated with even more prudence as c.90% (39 of 44) of countries oppose US drone attacks (source: Pew). Stakeholders, including experts in AI, lawyers and activists are also expressing growing concern that growing reliance on cheap drones, the lack of human control and unpredictable/"stupid" AI could pose a "killer robots" threat, as expressed at an October 2015 UN conference.

## Financials: Robo-advisors, AI & robo-analysts, automated trading systems

**Advances in computing technology, machine learning, and user-friendly interfaces such as voice and facial recognition will bring profound changes to knowledge work employment**, which will cost US\$14tn by 2025E. By then, computerization could potentially take on the work of 110-140mn full-time equivalents, generating a US\$5.2-6.7tn direct impact, predominantly in the form of greater output (source: McKinsey Global Institute).

**Financial services have been one of the first adopters in areas including robo-advisors, robo-analysts, automated trading, fraud detection, and credit risk-checking**, all of which has arguably made the financial services sector more efficient, inclusive and user-friendly. Advances in robotics and AI will likely disrupt 25mn workers within the financial and legal services sectors, generating 45-55% in productivity gains, and resulting in US\$0.6-0.8tn in annual potential economic impact by 2025E (source: McKinsey Global Institute).

**Financial technology (FinTech) has been paving the path towards electronic banking as well as mobile banking.** FinTech companies aim to simplify payment processes, reduce fraud and ultimately make the financial services space more efficient, inclusive and user-friendly. Our European Technology team (cf The war on cash) believes that companies in the sector are seeing organic revenue growth of up to 20%. Global investment ventures in FinTech more than tripled from US\$4.05bn in 2013 to US\$12.21bn in 2014 (source: Accenture).

**Robo-advisors are a major technological disruptor for traditional wealth management, and have the potential for US\$255bn in AUM by 2018E, implying >100% CAGR**, or 2% penetration of the total addressable market (source: MyPrivateBanking, KPMG, McKinsey). This figure could be as high as US\$2.2tn by 2020E, or 5.6% of total investable assets at that point (source: AT Kearney). Key players include new entrants such as Betterment and WealthFront, but also established wealth managers, such as Blackrock, Charles Schwab, Fidelity, and Vanguard among others.

**We believe that the first adopters of robo-advisors will be Millennials (18-34 year olds), who will hold US\$7tn in liquid assets by 2018E in the US alone** and are set to inherit US\$30-40tn from Baby Boomers in the coming decades (cf Four big themes shaping industry outlook). Much of robo-advisory will be new demand for low-cost services, with the great majority of assets coming from self-directed funds of the mass affluent and mass market segment, which amounts to US\$10tn in US market potential alone (source: Ernst & Young). In the long run, we believe that robo-advisors will ally with traditional wealth managers to scale their business, and as wealth managers adopt digital technology to better serve their clients.

**Robo-analysts and automated trading are also appearing in other areas of investment banking.** The development of AI-enabled advanced natural language generation (Advanced NLG) has closed the gap between data analysis, story-telling, and the ultimate investment decision. This has facilitated the creation of robo-analysts, which are already in use today. Likewise, automated trading strategies, including algorithmic trading and high frequency trading (HFT), have also gained prominence in recent decades, with HFT volumes as high as 50-60% of the total equities and futures market (source: TABB, Rosenblatt).

**Robots and automated systems will complement rather than replace humans in financial services in our view.** Forty-three percent of executives in the financial services sector believe that technology is complicating person-to-person communication more than it is facilitating it, which is higher than in any other sector (source: EIU). As we have seen in previous crises, such as the bear market during the financial crisis or systems glitches like the Flash Crash, technology is only as good as the humans building the systems, and human guidance is often needed in the worst of times.



## Healthcare: medical robots & computer-assisted surgery, telehealth, AI, care-bots, bionics

**The global market for medical robotics and computer-assisted surgical (MRCAS) equipment is expected to reach US\$18bn by 2022E.** Key drivers include growing awareness and market penetration for healthcare IT, increasing demand for robotic surgeries, and the introduction of advanced technologies (e.g., capsule robot systems, software/applications and imaging systems). Global ageing trends and increasing per capita healthcare expenditures in EMs will also drive growth (source: Grand View Research).

**570,000 robo-surgery procedures were performed in 2014 vs. 1,000 in 2000** (source: Intuitive Surgical). Surgical robots dominate the MRCAS market with 60% market share in 2014 due to their high usage and market penetration rates and patients' acceptance of minimally invasive procedures. In terms of application, laparoscopy-enabled systems accounted for 80% of revenues in 2014. NAM is the largest market today (c.40%), while APAC is the most lucrative in terms of growth (unmet needs, growth in healthcare investment, improving reimbursement frameworks). Increases in the ageing population and the prevalence of neurological disorders are expected to drive segment growth over the forecast period (source: Grand View Research).

**An estimated 7,800 medical robots will be sold from 2015-18E vs. 1,224 medical robot units sold in 2014 or c5% of the total unit sales of professional service robots.** The most important applications are robot-assisted surgery and therapy with 978 units sold in 2014. The total value of sales of medical robots was US\$1.32bn, accounting for 35% of the total sales value of the professional service robots (source: IFR 2015). High-growth areas for MRCAS include the introduction of new robotic systems integrated with technology (data recorders, remote navigation systems, HD microscopic cameras, data analytic systems, motion sensors); 3D-Imaging and robotic controlled catheters; and non-medical hospital robotic systems (telehealth, cart robots) (source: Grand View).

**The global market for telehealth – the delivery of health-related services and information via ICT– is expected to reach more than US\$34bn by 2020** with 40% of the 2015-20 growth coming from North America (source: Mordor Intelligence). Telehealth expands and builds on telemedicine (which focuses narrowly on the curative aspect) and encompasses preventative, promotive and curative aspects that are increasingly evolving towards telesurgery.

**Algorithm- and machine-learning as well as AI-based healthcare services will play a growing role** in providing automated support and advice in healthcare. Much of the efforts and advances will be centred on efforts to bring computing power to bear in diagnosis, in order to maximize the power of data and achieve better outcomes and minimize the costs of misdiagnosis. IBM's Watson supercomputer is a sign of things to come with Watson capable of reading 1mn medical textbooks in three seconds, and oncologists at Memorial Sloan-Kettering Cancer Center using Watson to provide chronic care and cancer treatment diagnostics.

**The global personal robot market including “care-bots” could reach US\$17.4bn by 2020E driven by rapidly ageing populations,** a looming shortfall of care workers, and the need to enhance performance and assist rehabilitation of elderly and physically handicapped people (source: Frost & Sullivan). Japan is leading the way with one-third of the government budget on robots devoted to the elderly. The Japanese “care-bot” market could grow from JPY17.7bn (US\$155mn) in 2015 to JPY400bn (US\$3.72.8bn) by 2035E (source: Ministry of Economy, Trade & Industry).

**Bionics and the nextgen wearable robot wave are becoming a reality** and could be a game changer for dealing with diminished or lost functions (ageing, physical challenges or injuries). The rehabilitation robot market was estimated at US\$203mn in 2014 and is expected grow to US\$1.1bn by 2021E.

## **Service: care-bots, companions, domestic, education, entertainment, personal, transport, security**

**Service robots operate semi- or fully autonomously to perform services useful to the wellbeing of humans** and equipment, excluding manufacturing operations (source: IFR). They typically assist humans by performing jobs that are dirty, dull, distant, dangerous or repetitive, including household chores. They are typically autonomous and/or operated by a built-in control system, with manual override options.

**The use of advanced robots for household tasks could result in cost savings of US\$200-500bn** given that an estimated 90-115bn hours per year are spent performing household tasks in DMs. If 25-50% of people in DMs were to adopt the use of service robots by 2025E, US\$200-500bn worth of time savings could be realised. Such adoption will be driven by rapid advances in low-cost robotics technology, the relatively limited sophistication of the robots required for these applications, and the demonstrated willingness of many consumers to pay for household time-saving devices (source: McKinsey).

**In 2014, the market for service robots for personal and domestic use increased to US\$2.2bn off the back of 4.7mn robots sold**, 28% more than in 2013. Domestic (household) robots currently dominate the market (3.3mn robots sold in 2014) followed by entertainment or “toy robots” (1.3mn sold). Fast growth areas include assistance for the physically challenged / handicapped and robots for personal transportation and security & surveillance (source: IFR).

**Sales of robots for domestic tasks are expected to reach US\$12.2bn by 2018E** – with 25.9mn units sold in 2015-18E (vacuum cleaning, lawn-mowing, window cleaning and other duties). Sales of all types of entertainment and leisure robots are projected to total about 9mn units, with a value of c.US\$7.6bn. Sales of robots to assist the elderly and disabled will be about 12,400 units in 2015-18E. This market is expected to increase substantially over the next 20 years (source: IFR).

**2015-18 will see growth in sales of robot companions/assistants/humanoids to perform typical everyday tasks** in production, office or home environments – with 8,100 units of these robots projected to be sold (source: IFR). These projections could be conservative given the rapid developments in this field, including sales of over 4,000 of Softbank’s “Pepper” human companion robot, costing US\$1,650, in 2015.

**The global personal robot market including “care-bots” could reach US\$17.4bn by 2020E driven by rapidly ageing populations**, a looming shortfall of care workers, and the need to enhance performance and assist rehabilitation of the elderly and disabled (source: Frost & Sullivan). Japan is leading the way with one-third of the government budget on robots devoted to the elderly. The Japanese “care-bot” market could grow from JPY17.7bn (US\$155mn) in 2015 to JPY400bn (US\$3.72.8bn) by 2035E (source: Ministry of Economy, Trade & Industry). We discuss care-bots further in the “Healthcare” section of the report.

## **Agriculture: Automation, agribots, drones & UAVs, precision ag**

**Agricultural mechanisation was one of the most important accomplishments of the 20<sup>th</sup> century** - increasing productivity and reducing losses (e.g. 1 farmer in mechanised countries can feed 155 people today and this is expected to rise to 200 by 2020E vs. 1:25 in 1960 and 1:2.5 in the early 20<sup>th</sup> century). Industry fundamentals support long-term growth with drivers including the growing global population, growing per capita protein consumption, and farmers' relatively strong financial condition.

### **Demographics and the agricultural labour crisis are key drivers for take-up.**

Agricultural automation is gaining increasing traction off the back of the agricultural labour crisis (ageing farmers, lack of young skilled farmers/workers) and the tendency towards larger scale farms. Autonomous technology (e.g. driverless tractors, milkbots etc) and the use of drones for Ag are examples seeing large scale take-up.

**The global agribot – agricultural robot - market is expected to grow to US\$16.3bn by 2020** vs. US\$817mn in 2013 (source: WinterGreen). Take-up is expected to encompass areas such as: adaptive robots, autonomous navigation in fields, automated or autonomous operations (eg inputs, mowing, ploughing, post-harvest, pruning, seeding), cobots, computer vision, precision ag, and UAVs, among other areas.

**The agricultural drone market is projected at US\$2bn in 2015E or 47% of the total market.** Up to 80% of the commercial market for drones could eventually be dedicated to agriculture. This has the potential to generate an additional 100,000 jobs in the US alone, and US\$82bn in economic activity between 2015-2025E (source: AUVSI).

**Precision agriculture (PA) is expected to become a US\$4.55bn market by 2020E and a US\$6.34bn market by 2022E** vs. US\$1.5-2.0bn today (source: MarketsandMarkets, Research and Markets). PA uses technology and big data analytics to optimise the use of Ag inputs to increase production and profits. The US is the most mature market with 70% penetration of precision technologies (source: Alix Partners), but EMs are seeing the fastest growth.

## **Mining: Automation, big data**

**Relative to other sectors, many view the mining space to be somewhat “immature” on the scale of automation,** which also provides an opportunity to growth robotics penetration.

**Our global metal & mining research team believes that that the application of Big Data & Automation will grow in importance as the sector deals with the fall-out from the end-of the China driven supercycle.** A focus in the near term has been using big data to standardise operations and lower the number of machines in mining fleets, while concurrently each company is rapidly rolling out autonomous (driverless technology).

**Technology advances lead to two major benefits for a miner (1) lower unit costs and (2) improved capital productivity.** Thus despite the current austerity paradigm within the mining space, the efficiency gains are supportive enough to justify larger automation efforts (particularly driverless trucks). Hence the large global diversified miners as leading the way near term.

**We see this increasing use of technology as a boon for some suppliers,** such as CAT and Komatsu but a headwind for others, particularly such as suppliers of labour in the form of contract miners mining such as Downer and CIMCO and part supplier Bradken.

# Disclosures

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