GLOBAL OUTLOOK 2014: SPATIAL INFORMATION INDUSTRY

Peter Woodgate, Isabel Coppa and Nicola Hart

August 2014

14

ACCESS AND AVAILABILITY

The report is available in PDF format at http://www.crcsi.com.au

We welcome your comments regarding the readability and usefulness of this report. To provide feedback, please contact us at info@crcsi.com.au

CITING THIS REPORT

Woodgate, P. W., Coppa, I. and Hart, N. (2014), 'Global Outlook 2014: Spatial Information Industry'. Published by the Australia and New Zealand Cooperative Research Centre for Spatial Information.

ISBN (online) 978-0-646-93034-3

COPYRIGHT

All material in this publication is licensed under a Creative Commons Attribution 3.0 Australia Licence, save for content supplied by third parties, and logos. Creative Commons Attribution 3.0 Australia Licence is a standard form licence agreement that allows you to copy, distribute, transmit and adapt this publication provided you attribute the work.

The full licence terms are available from creativecommons.org/licenses/by/3.0/au/legalcode. A summary of the licence terms is available from creativecommons.org/licenses/by/3.0/au/deed.en.

DISCLAIMER

While every effort has been made to ensure its accuracy, the CRCSI does not offer any express or implied warranties or representations as to the accuracy or completeness of the information contained herein. The CRCSI and its employees and agents accept no liability in negligence for the information (or the use of such information) provided in this report.

ACKNOWLEDGEMENTS

Wendy Jackson.

INDEX OF TABLES

INDEX OF FIGURES

TABLE OF CONTENTS

1 PURPOSE OF THIS PAPER

This paper presents a summary for 2014 of the global trends in the spatial industry in the context of global economic drivers.

2 EXECUTIVE SUMMARY

This paper contains a scan of published material on three interconnected trends: global technology developments; global spatial markets and their technologies; and the global economic picture.

Evidence is emerging to support broadly Oxera's (2012) estimate that the geoservices industries are growing at 30% per annum. Starting at the early phase of the global supply chain, estimates suggest that over 3000 satellite payloads (including communications, imaging and positioning) are scheduled for launch or under consideration for the period 2013 to 2032, almost tripling the number of satellites that are currently in orbit. Companies like Skybox Imaging and Planet Lab are planning to launch over 100 satellites between them, some as small as shoeboxes. The global remote sensing market is forecast to grow at an 8% compound annual growth rate between now and 2019.

In 2015 the US Federal Aviation Administration will open the market for commercial Unmanned Aerial Vehicles (UAVs). Costs are expected to fall rapidly as use increases. Similar developments in a number of US states are expected to power growth in autonomous vehicles.

Globally, Global Navigation Satellite System (GNSS)-enabled smartphones account for over half of all smartphone-enabled devices in 2014, and are experiencing a usage growth rate of 22%. Significant growth in indoor positioning devices and applications is being fueled by Apple iBeacon, Google Maps Indoors, SkyHook, IndoorAtlas, Nokia-HERE, Ubisence and Broadcom, among others.

Estimates suggest that investment in mobility will grow from 17% three years ago to 31% two years from now (82% growth); the cloud will more than double from 12% to 30% (150% growth); and collaboration tools will increase from 18% to 26% (44% growth).

By the end of this decade, 50 billion 'things', such as clothes, cars, trains, tractors and body sensors, will connect to the mobile network. They will consume 1000 times as much data as today's mobile devices and at rates 10 to 100 times faster than existing networks can support. Metcalfe's law, that the value of a telecommunications network is proportional to the square of the number of connected users of the system (n2), will be tested.

There are now 178 wearable devices on the market or soon to be launched for a range of uses including industrial, medical, gaming, fitness, lifestyle and entertainment. Augmented reality devices like Google Glass are among them. In particular, rapid growth is expected in wearable medical devices for disease diagnosis through the advent of continuous monitoring of a person's vital signs and lifestyle choices. More than half these devices have an inertial measurement unit (accelerometers, gyroscopes and/or magnetometers).

The market for wireless sensor networks (WSNs) was $552.4 million in 2012, and is growing rapidly towards an expected $14.6 billion in 2019. WSNs aid many applications, including geo-targeted mobile advertisements. Spending on these ads reached $725 million in 2013 and is forecast to more than triple to $2.74 billion by 2017.

New algorithms are being developed that analyse the history of movement of any individual and predict behaviours. These are being powerfully aided by the 'always online whether we know it or not' phenomenon.

Thus, enabling of technologies, data-rich content and accessibility of information products, as well as the willingness of consumers to cooperate, seems set to contribute to accelerated growth of the spatially-related markets over the next year. However, cybersecurity, privacy and the ethics of data and information management will be important issues in moderating this growth.

Developments in global technology are set against the backdrop of the global economy. Global GDP growth is expected to be 2.9% in 2014, up from the 2% experienced in 2013. Good growth of 7% is expected in China, which contributed 50% of the world's growth in 2013. Growth rates for other countries include India at 6%, New Zealand at 3.3%, Sub-Saharan Africa at 3.2%, Latin America at 3.2% and Australia at 3%. The US grew by 2.4% in 2013 and is forecast to increase to 3.0% in 2014. Europe languishes at 1%.

Government debt levels are expected to grow in 2014, but less rapidly than in 2013. Japan has the highest forecast debt-to-GDP ratio at 230%; the US is at around 100% and growing. China sits at around 50%, New Zealand at about 36% and Australia at 17.5%.

Global productivity growth is considered to be slow at a forecast 2.3% for 2014 as a result of predominantly weaker demand, a mismatch in resource allocation between labour and capital, and suboptimal innovation outcomes despite technology advancements in mature economies.

3 GLOBAL MEGATRENDS

The mass adoption of connected digital services by consumers, enterprises and governments is known as digitisation. Digitisation is a fundamental driver of world growth. The World Economic Forum (WEF) [1] and Booz & Company [2] estimate that digitisation has added US$200 billion to the world economy since 2011. The WEF has created a Digitisation Index to score a country's digitisation level, permitting measurement of its impact on economic and social factors. The WEF has found that a 10% increase in the index for any given country yields a 0.75% growth in GDP per capita and a 1.02% drop in unemployment.

Ernst & Young [3] and PriceWaterhouseCoopers [4] have independently published their views on global megatrends. These are compared in Table 1.

TABLE 1: GLOBAL MEGATRENDS ACCORDING TO ERNST & YOUNG AND PRICE-WATERHOUSECOOPERS

ERNST & YOUNG [3]	PRICEWATERHOUSECOOPERS [4]
Global rebalancing	Demographic shifts
Resourceful planet	Resource scarcity and climate change
Reconfiguring the financial system	Shift in global economic power
Digital transformation	Technological breakthroughs
Rethinking government	Accelerating urbanisation
Future of work	

In the geospatial sector, the 'ripe issues' according to the Open Geospatial Consortium (OGC) [5] are:

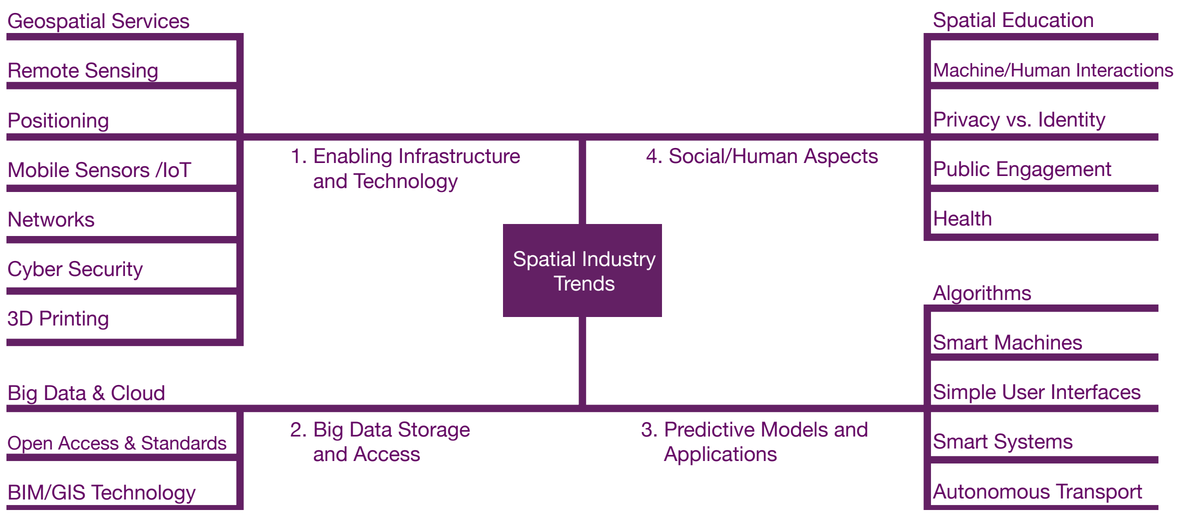
- The Power of Location
- Internet of Things
- Mobile Development
- Indoor Frontier
- Cartographers of the Future
- Big Processing of Geospatial Data
- Smart Cities Depend on Smart Location

4 SPATIAL INDUSTRY TRENDS

4.1 INTRODUCTION

This chapter is structured to cover interconnected aspects of technology and society as shown in Figure 1:

FIGURE 1: INTERCONNECTED ASPECTS OF TECHNOLOGY AND SOCIETY



4.2 ENABLING INFRASTRUCTURE AND TECHNOLOGY

4.2.1 GEOSPATIAL SERVICES

Geospatial services are now a substantial part of the global economy. Worldwide, the geospatial services sector generates $150 to $270 billion annually according to a 2012 study by Oxera (commissioned by Google) [6]. They estimate that the geoservices industries are growing globally at 30% annually with a Gross Value Add (GVA) of US$113 billion or 0.2% of the estimated US$70 trillion global GVA [6].

On the basis of the Oxera estimates, the revenue of the geospatial services industry is greater than the $25 billion generated by the video games industry, roughly equivalent to the $140 billion from the global security services industry, and about one third of the global airline industry's annual revenue of $594 billion [7].

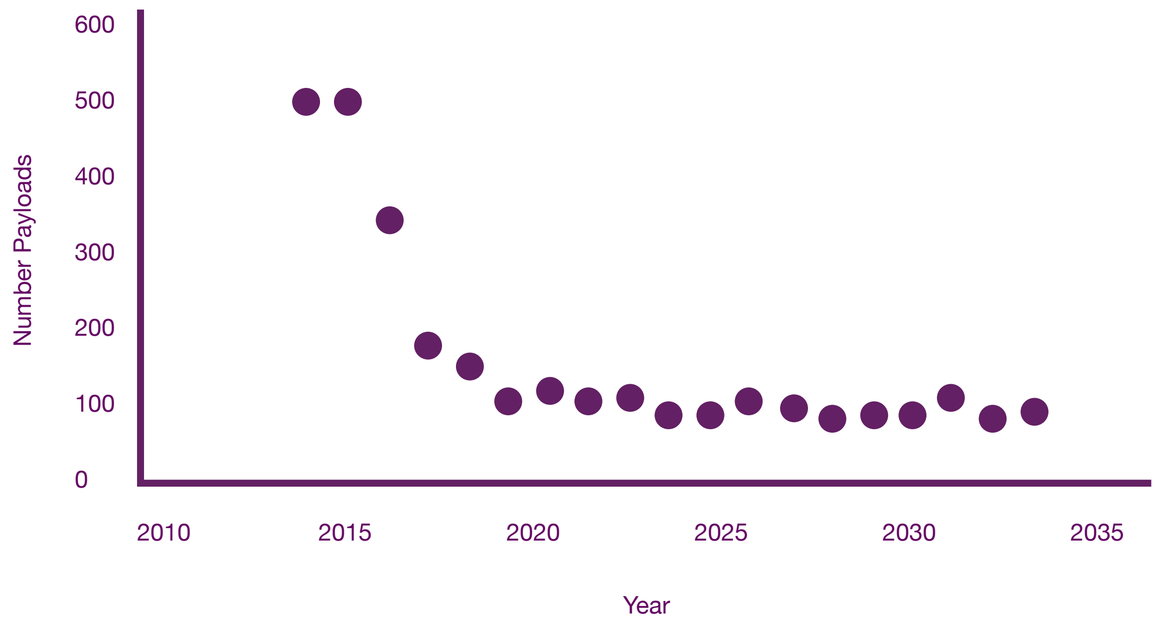
Boston Consulting (2012) estimates that the US geospatial industry generated US$73 billion in revenue in 2011 and helped generate $1.6 trillion in revenue for the rest of the US economy. It also produced US$1.4 trillion in cost savings, and made a significant contribution to improved efficiency gains. Further, Boston Consulting estimates that the geospatial services industry is currently in a high-growth phase [8].

4.2.2 REMOTE SENSING

4.2.2.1 SATELLITES

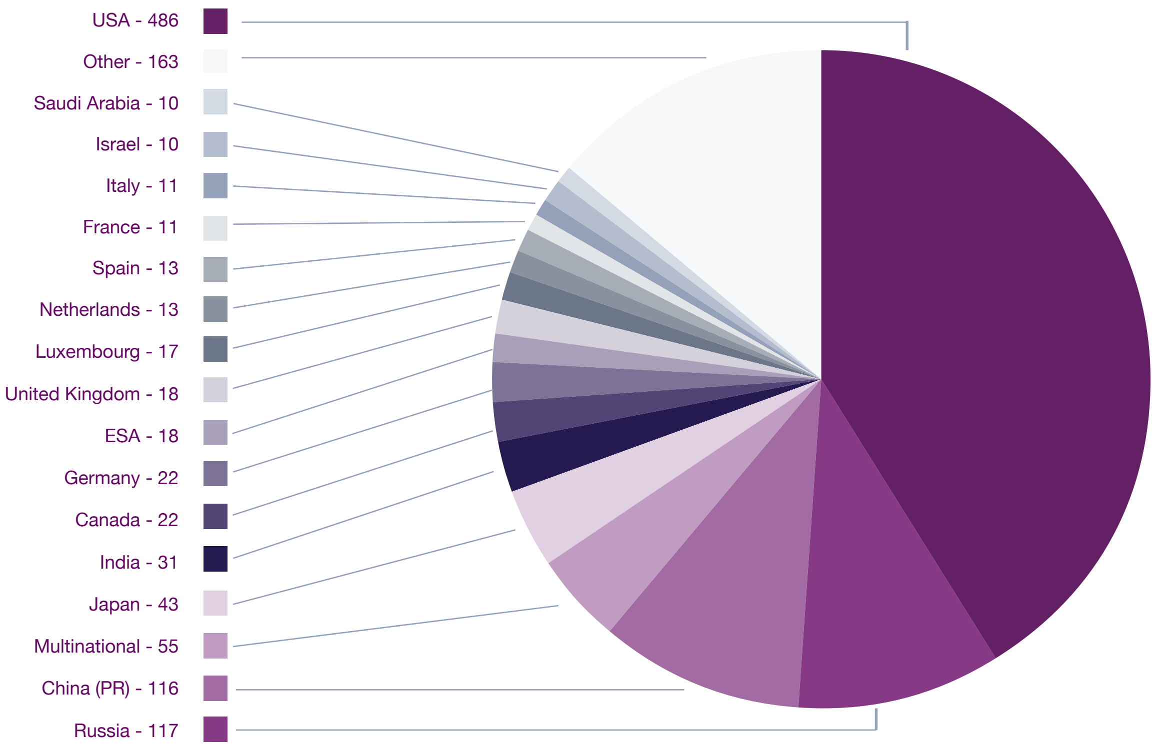
The Teal Group [9] estimates that 3,164 payloads are under consideration for launch between 2013 and 2032, with an estimated value of $235 billion. The decline in launches in the future is consistent with a forecast model as shown in Figure 2, as some planned launches are not yet publicly known:

FIGURE 2: FUTURE EXPECTED SPACE PAYLOAD LAUNCHES



According to data from the USA's Union of Concerned Scientists (UCS), there are currently 1176 active satellites in orbit as of 31 January 2014 [10]. Figure 3 shows satellite operators by country:

FIGURE 3: NUMBER OF SATELLITES BY COUNTRIES



Australia (listed under 'Other' in Figure 3) operates five communication satellites and one shared communication satellite with the US, listed in Table 2:

TABLE 2: AUSTRALIAN SATELLITES, ACCURATE AT 31 JANUARY, 2014

NORAD NUMBER	SATELLITE NAME	USERS	DATE OF LAUNCH	CONTRACTOR
27831	Optus and Defence C1	Military/Commercial	12/06/2003	Space Systems/Loral
23227	Optus B3	Commercial	28/08/1994	Hughes Space and Communications
29495	Optus D1	Commercial	13/10/2006	Orbital Sciences Corp.
32252	Optus D2	Commercial	5/10/2007	Orbital Sciences Corp.
35756	Optus D3	Commercial	21/08/2009	Orbital Sciences Corp.
20410	Leasat 5 (Syncom IV-5, Leased Satellite F5)	Military	9/01/1990	Hughes

Source: [10]

There are currently no Australian imaging or positioning satellites planned or in orbit.

According to UCS [10], there are 94 active satellites for Navigation/Global Positioning (see Appendix A) and 227 imaging satellites[1] (see Appendix B) as at 31 January 2014.

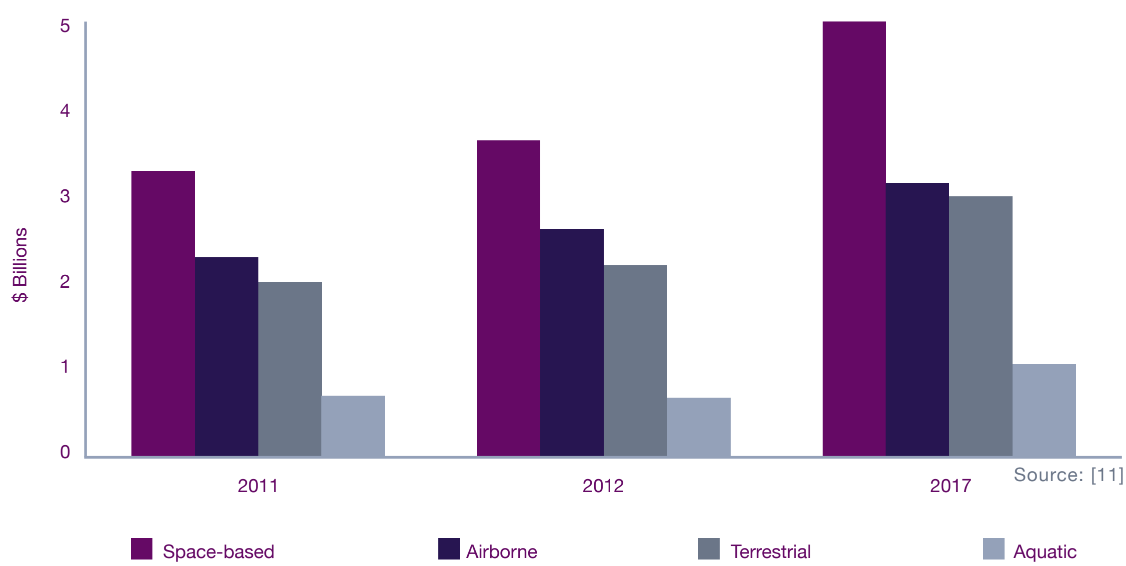
4.2.2.2 REMOTE SENSING MARKETS

The global remote sensing[2] market was estimated at $7.6 billion in 2013, with expected growth to $8.1 billion in 2014. BCC Research forecasts that the market will reach $12.1 billion in 2019 with a five-year CAGR of 8.2% [11].

World sales of satellite imagery are expected to grow at 12% compound over the next decade from $1.3 billion in 2010 to $4.0 billion by 2020. Synthetic Aperture Radar (SAR) imagery already accounts for 17% of sales [12]. The number of high-resolution satellites is set to double over the next three years. Over 40 countries will be launching Earth Observing (EO) satellites over the next seven years [12, 13].

The US Congress-mandated ‘Open skies’ policy for UAVs, together with increased capabilities of Geographic Information Systems, will stimulate production and reduce costs of remote sensing products. The ease of access to free and low-cost historic, recent and real-time imagery is increasing and complete unmanned aerial systems can now be purchased for what was previously the cost of one manned aircraft mission [11, 14]. The value of remote sensing products, categorised by platform, is summarised in Figure 4.

FIGURE 4: VALUE OF REMOTE SENSING PRODUCTS BY PLATFORM, 2011 TO 2017 ($BILLION)



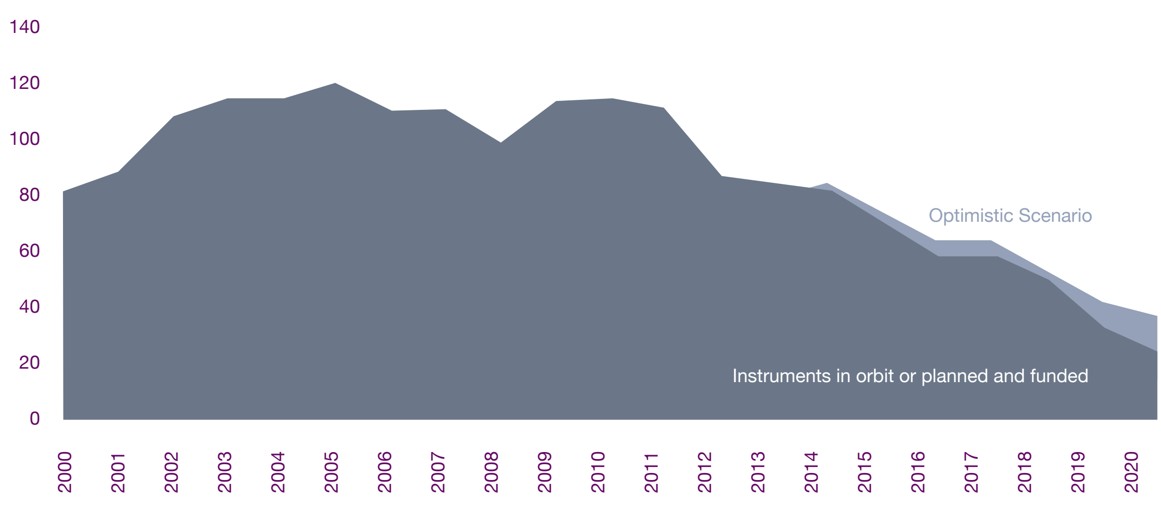
[1] Includes the following classes of satellites: Earth Observation, Earth Science, Meteorology, Reconnaissance, Remote Sensing, Surveillance
[2] Remote sensing comprises satellite earth observation and airborne (manned and unmanned) aerial imaging.

Commercial remote sensing is at a tipping point. Satellite imagery will become plentiful with planned constellations of lightweight and comparatively inexpensive satellites such as those from Skybox Imaging and Planet Lab. Skybox Imaging successfully launched its first small (60 x 60 x 90 centimetres) high-resolution satellite (Skysat 1) in November 2013 [15]. The constellation is planned to be extended with a further 23 satellites with a 1-metre pixel resolution (achieved by merging video stream data) to be launched by 2016; data are accessible in the cloud.

Planet Lab has secured funding for its constellation of 100 shoebox-sized 'Dove' satellites (3–5 metre resolution). Twenty-eight satellites were deployed in February 2014 ('Flock 1'), joining the four experimental Doves launched in 2013. The remainder will be launched in 2014 [16]. Russia's GazProm plans to launch its SMOTR constellation. UrtheCast flies two video cameras (1- and 6-metre resolution) on the International Space Station (ISS) [17]. A further upcoming endeavour on the ISS is Teledyne's MUSES system [17].

Planet IQ is launching the first commercial weather satellite constellation by 2017 to compensate for a decline in public weather data [18]. Dauria Aerospace (a German/Russian startup) plans four satellites between 2014 and 2017. Tyvak offers a complete nanosatellite solution; the founders invented the CubeSat standard [17]. NovaWurks builds modular multi-use space platforms [17]. GeoOptics will launch its CICERO constellation (12 satellites) between 2014 and 2017 [19]. Figure 5 shows the decline in the number of NASA/NOAA Earth-observing instruments.

FIGURE 5: NUMBER OF NASA/NOAA EARTH-OBSERVING INSTRUMENTS [20]



Source: [20]

4.2.3 POSITIONING AND LOCATION-BASED SERVICES (LBS)

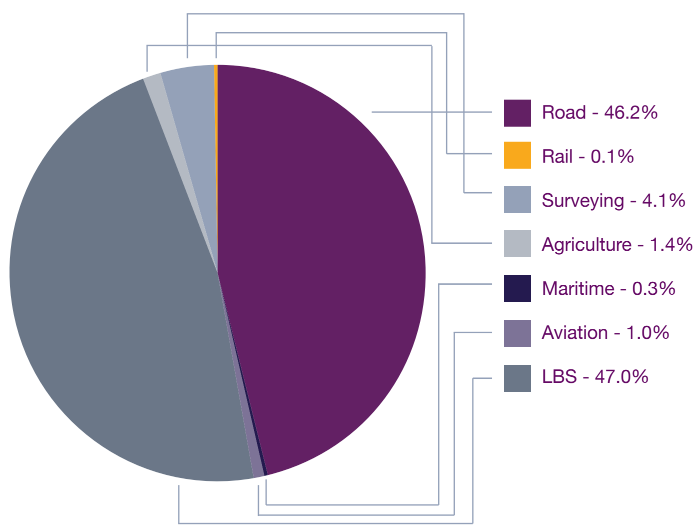
Improved technologies are starting to challenge the way vertical reference systems are defined [21]. There is significant growth in indoor positioning: for example, Apple launched the iBeacon service in December 2013. It works on Bluetooth Low Energy (BLE) and aims to simplify payment and enable on-site offers. It has a spatial accuracy of approximately 30 centimetres and a range of 10 to 15 metres, depending on where the receiver (iPhone) is stored. In December 2013, iBeacon was introduced to 254 retail stores in the US [22]. The device works at three distances: immediate (a few centimetres, like Near Field Communication (NFC)), near (a couple of metres) and far (more than 10 metres). It will transmit to and receive from mobile devices, using specialist Apps to provide micro-location awareness. The developer kit for iBeacon allows companies to develop their own applications. For example, the Australian company Tzukuri is developing sunglasses that notify the owner when they are left behind [23], sending alerts at 4 metres, 8 metres and 16 metres and including guidance as to where to find them. It is predicted that iBeacon will revolutionise the shopping experience in brick-and-mortar shops as well as how groups interact with each other in educational and corporate contexts [22].

Google has developed Google Maps Indoors for Android, which includes interior maps and measuring and mapping of the Wi-Fi signal strength throughout the building to within 2 to 3 metres' accuracy.

SkyHook has cell tower triangulation as well as a Wi-Fi network database to determine position indoors accurate to 3 to 4 metres. IndoorAtlas senses location within several metres using magnetic sensors in smartphones to detect signature magnetic anomalies within buildings and map the unique patterns of their interiors. Nokia uses Bluetooth technology to provide 0.3-metre position accuracy by measuring the Direction of Departure (DoD) of signals from installed positioning beacons. Broadcom offers a special chip that takes in data from the inertial sensors on the device, Wi-Fi access points, Bluetooth low energy beacons and multiple Global Navigation Satellite System (GNSS) signals to determine indoor position. Finally, Ubisense provides precise real-time location systems for tracking moving assets using ultra-wideband transmitters that signal a network of base stations, which then triangulate the position to within 15 to 30 centimetres [21, 24].

The European GNSS Agency [25] has summarised the markets for Location-Based Services (LBS), road, aviation, rail, maritime, agriculture and surveying in Figure 6:

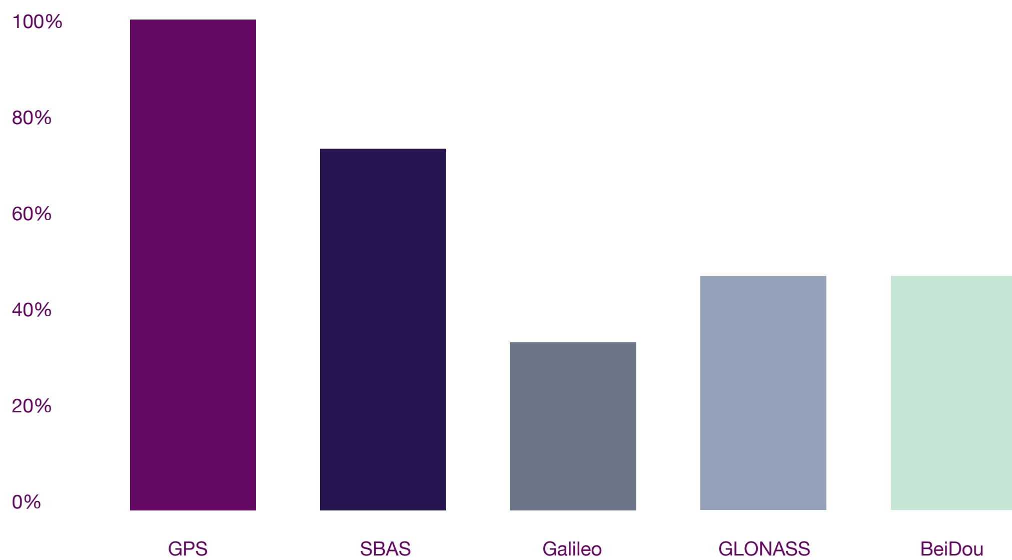
FIGURE 6: CUMULATIVE CORE REVENUE FOR VARIOUS SECTORS BETWEEN 2012 AND 2022



Location-based services delivered via smartphones will comprise almost half of the total global GNSS market in 2022, estimated at € 250 billion per annum [25]. GNSS-enabled smartphone ownership will greatly increase, especially in low-income countries, due to lower smartphone costs of around $25 per unit [26].

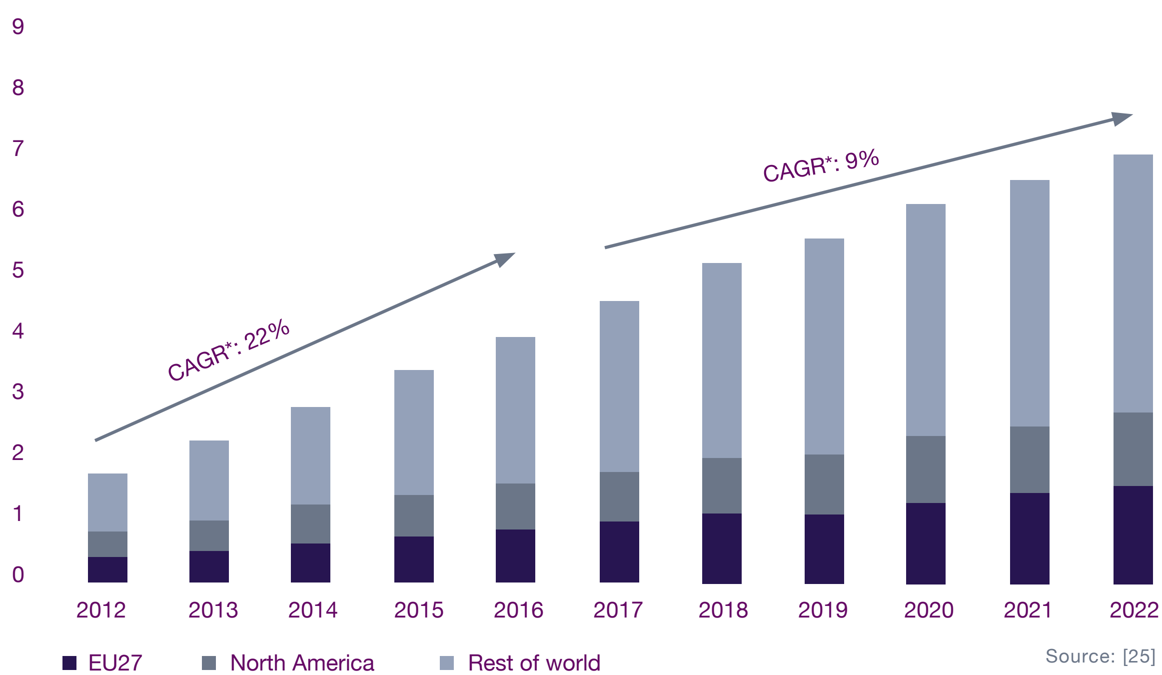
Multi-constellation devices are becoming more common in the market with more than 70% of models being Global Positioning System (GPS) and Satellite Based Augmentation System (SBAS) capable[3]. These trends are highlighted in Figure 7 and Figure 8.

FIGURE 7: GNSS CAPABILITY IN RECEIVERS [25]



Source: [25]

FIGURE 8: INSTALLED BASE OF GNSS DEVICES BY REGION



Source: [25]

[3] Satellite Based Augmentation System (SBAS) are systems that transmit additional information on clocks, ephemeris and ionospheric delays to improve the accuracy of Global and Regional Satellite Navigation Systems.

It is forecast that in 2022 there will be 7 billion GNSS devices (almost one for each person on the planet) and these are likely to contribute to global efficiency gains. Most of the devices serve the LBS and transport markets. Initial growth rates to 2016 are projected at 22% CAGR, tapering off to 9% CAGR after 2018 [25]. Table 3 gives an overview of GNSS systems:

TABLE 3: OVERVIEW OF GNSS SYSTEMS

SYSTEM	GPS	GLONASS	COMPASS	GALILEO	IRNSS
POLITICAL ENTITY	United States	Russian Federation	China	European Union	India
CODING	CDMA	FDMA/CDMA	CDMA	CDMA	CDMA
ORBITAL HEIGHT	20,180 km (12,540 mi)	19,130 km (11,890 mi)	21,250 km (13,140 mi)	23,220 km (14,430 mi)	36,000 km (22,000 mi)
PERIOD	11.97 hours (11h 58m)	11.26 hours (11 h 16 m)	12.63 hours (12h 38 m)	14.08 hours (14 h 5 m)	N/A
EVOLUTION PER SIDEREAL DAY	2	17/8	17/10	17/10	N/A (geostationary)
NUMBER OF SATELLITES	At least 24 1.57542 GHz	31, including 24 operational, 1 in preparation, 2 on maintenance, 3 reserve, 1 on tests	5 geostationary orbit (GEO) satellites, 30 medium Earth orbit (MEO) satellites	4 test bed satellites in orbit, 22 operational satellites budgeted	7 geostationary orbit (GEO) satellites
FREQUENCY	(L1 Signal) 1.2276 GHz (L2 Signal)	Around 1.602 GHz (SP) Around 1.246 GHz (SP)	1.561098 GHz (B1) 1.589742 GHz (B1-2) 1.20714 GHz (B2) 1.26852 GHz (B3)	1.164-1.215 GHz (E5a and E5b) 1.260-1.300 GHz (E6) 1.559-1.592 GHz (E2-L1-E11)	N/A
STATUS	Operational	Operational, CDMA in preparation	15 satellites operational, 20 additional satellites planned	In preparation	2 satellites launched, 5 additional satellites planned

Source: [27]

A 61% increase in satellite numbers within Global Navigation Satellite System (GNSS) and Regional Satellite System (RNSS) constellations is expected by 2020, as shown in Table 4:

TABLE 4: CURRENT AND PLANNED NUMBERS OF GNSS AND RNSS SATELLITE NUMBERS

NAME	CURRENT ACTIVE SATELLITES	TOTAL PLANNED TO CIRCA 2020	
GNSS			
• GPS (US)	30	24	
• Glonass (Russia)	28	24	
• Galileo (EU)	4	31	
• BeiDou (China)	14	35	
RNSS			
•QZSS (Japan)	1	3	
•IRNSS (India)	0	7	
TOTAL	77	124	Source: [28]

The Japanese are developing an RNSS known as the Quasi-Zenith Satellite System (QZSS) and South Korea have announced that they will develop a regional SBAS[4].

4.2.4 MOBILE SENSORS AND USAGE – INTERNET OF 'THINGS'

There are predictions of massive growth of interconnected sensors including estimates of over 50 billion 'things' in a hyper-connected environment by 2020 [21].

An estimated 485 million wearable computing devices will be shipped by 2018, of which 61% will be for wearable fitness or activity tracking [29].

The global market for health Information and Communications Technology (ICT) products is estimated to be $96 billion and growing. E-health is considered to be one of the six most promising lead markets of the European Union [1].

International and Australian Telephone, Mobile and Internet Usage, and ICT
In 2013 the Consumer Electronics Association estimated that shipment revenues for smartphones would be about $37 billion in 2013, with almost 126 million units shipped to dealers, a 16% increase on 2012. They also estimated that tablet computer unit sales would exceed 105 million and be worth $36 billion in shipment revenue, up 54% from 2012 [30].

Some other interesting statistics include [31]:

- In Australia, 81% of people use the Internet
- Smartphone usage increased by 272% in Australia in 2011
- Of online Australians, 61% have an active Facebook account
- Of online Australians, 86% purchased products and services online in 2011

[4] The following countries have SBAS: US – WAAS; Europe – EGNOS; Japan – MSAS; India – GAGAN; Russia – SDCM; China – COMPASS; South Korea – name yet to be published.

Mobile phone usage differs by demographics and market. For example, the majority of mobile consumers in developed markets such as South Korea (67%), Australia (65%) and the UK (61%) prefer smartphones. Pew data shows smartphone ownership has risen 20% just in one year [29]. Basic phones are more commonly used in India (80%), Turkey (61%) and Russia (51%). Mid-range multimedia phones, which have more capabilities than feature phones but less than smartphones, are least popular, with less than 10% usage in most countries [29]. The mobile phone usage (smartphones and other phones) for the following countries is; Brazil (84%), Australia (86%), China (89%), USA (94%), Italy (97%), UK (97%), Russia (98%), and South Korea (99%) [32].

In Europe, investment in ICT will accelerate over the next two years, though not as significantly as in Asia. Comparing data from three years ago to projections for two years from now, survey data shows that as a percentage of the total European ICT budget [33]:

- Investment in mobility will increase from 12% to 20% (66% growth);
- Investment in cloud-based services will almost double from 12% to 23% (96% growth); and
- Investment in collaboration tools will rise slightly from 16% to 17%.

In Asia-Pacific, firms are investing a much greater percentage of their information and communications technology budgets in new technology, and expecting to grow those investments more quickly, compared to all other regions. For example [33]:

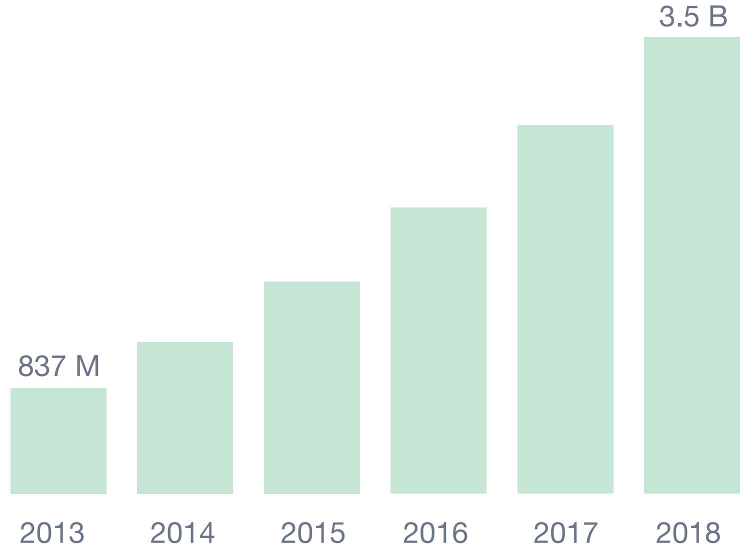
- Investment in mobility will grow from 17% three years ago to 31% two years from now (82% growth)
- Investment in the cloud will more than double from 12% to 30% (150% growth); and
- Investment in collaboration tools will increase from 18% to 26% (44% growth).

By the end of this decade, it is estimated that the 50 billion ‘things’ that will connect to the mobile network, such as clothes, cars, trains, tractors, and body sensors, will consume 1000 times as much data as today’s mobile devices at rates 10 to 100 times faster than existing networks can support [34].

In early 2014 Google made the announcement that it had bought the smart thermostat maker Nest Labs for $3.2 billion. At present a connected nest smoke alarm costs about $130, while a stand-alone version costs just over $5. Mass production is likely to see these costs fall.

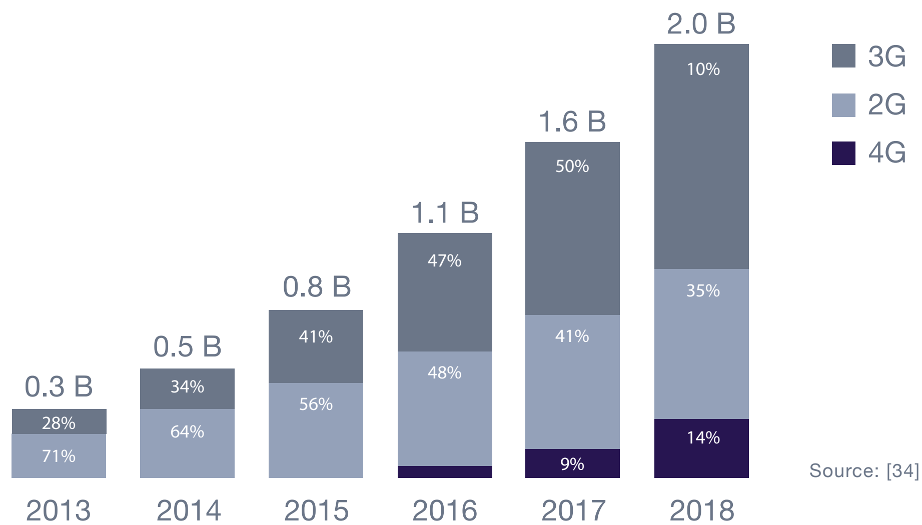
Cisco has estimated significant growth in both smartphones and tablets as well as machine-to-machine (M2M) connections, as shown in Figure 9 and Figure 10 respectively. In 2013, 4G accounted for 0.43% of global M2M connections, and this is expected to rise steadily to 1.5% in 2014, 3% in 2015 and 5.6% in 2016 [34].

FIGURE 9: GLOBAL NUMBERS OF IPV6-CAPABLE SMARTPHONES AND TABLETS, 2013 TO 2018



Source: [34]

FIGURE 10: GLOBAL MACHINE-TO-MACHINE GROWTH AND MIGRATION, 2013 TO 2018



Source: [34]

According to Mat Hatton, director of Machina Research, a connected home is a complex thing, plagued by a lack of standards and general difficulties for end users [35]. There is no guarantee that the different devices and hubs will interoperate, as all use different protocols. But smartphones can help. While individual smart appliances may not be able to communicate with each other, they can communicate with a smart mobile device. Smart phones act as remote controls for many devices. Google/Nest Duo are creating open platforms like Android, says Jeremy Warren, Vice President of Innovation at Vivint.

An open platform could effectively be like Wi-Fi, a technology all can use to allow us to connect more devices, more readily [35]. Vandrico has compiled a comprehensive database and analysis of 178 wearable devices for a range of uses including industrial, medical, gaming, fitness, lifestyle and entertainment. Vandrico expects to see particularly rapid growth in wearable medical devices for disease diagnosis through the continuous monitoring of a persons vital signs as influenced by their lifestyle choices. More than half the devices reviewed by Vandrico had an inertial measurement unit (accelerometers, gyroscopes, and or magnetometers) [36]. Mobile sensors are integrated in wearable devices, and can be controlled by the user (actively or passively) to augment knowledge, facilitate learning or enhance the user experience.

Sarah Rotman Epps, a former Forrester analyst who specialises in wearable computing, expects the Apple smartwatch (which may be announced in 2014) to change the way we engage with our wrist in the same way Apple changed the mobile phone industry in 2007. Expected sales are as high as $17.7 billion [37]. Already available is the Pebble smartwatch [38], which displays phone and email messages and calendar entries, and even connects to the Mercedes-Benz Smart Car App, which acts as a real-time data centre informing drivers about hazards such as accidents and road construction using vibrations [39].

Other examples of wearable technology are the Samsung Gear Smartwatch [40], FitBit [41], Jawbone Up [42], Nike FuelBand [43] and Sony Smartband Core [44]. A form of wearable technology that came to prominence in 2013 was Google Glass, a heads-up display with integrated camera and sound projection technology. Google Glass connects to the Android phone and encourages people to look up in the world again, rather than being buried in their smartphone screen (a commonly observed phenomenon, particularly among younger smartphone users) [45].

Oculus Rift, partially crowdfunded on Kickstarter, created immersive Virtual Reality[5] goggles, which can be used in applications such as gaming. In March 2014 the company announced their sale to Facebook for $2 billion [46].

It is expected that eight million wearable technology units will be shipped in 2014, rising to 23 million units in 2015 and 45 million units in 2017 [47].

4.2.5 NETWORKS

As shown in Table 5, Australia ranks 43rd globally in Internet connectivity with an average connection speed of 4.8 megabits per second (Mb/s). South Korea is the global leader with 13.3 Mb/s, followed by Japan with 12 Mb/s [48]. Currently, more than two thirds of Australian households have a broadband Internet subscription. With current technology, the fastest connection Australian telecommunication companies can guarantee is 50 Mb/s [48].

[5] Virtual reality is a computer-generated simulation of the real world. This should not be confused with augmented reality, which is a computer generated overlay superimposed on the view of the real world with both visible simultaneously.

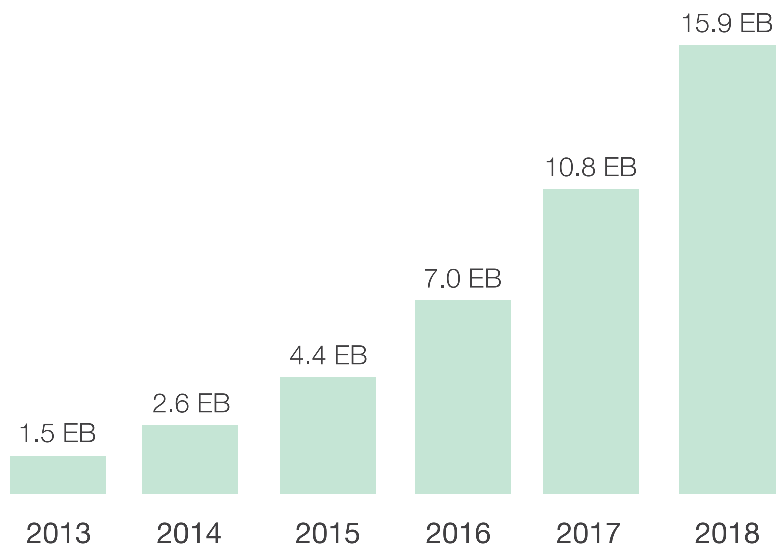
TABLE 5: AVERAGE INTERNET CONNECTION SPEEDS BY COUNTRY

GLOBAL RANKING	AVERAGE CONNECTION SPEED (Mb/s)
1 - South Korea	13.3
2 - Japan	12.0
3 - Switzerland	11.0
4 - Hong Kong	10.8
5 - Latvia	10.6
6 - Netherlands	10.1
7 - Czech Republic	9.8
8 - United States	8.7
9 - Sweden	8.4
10 - United Kingdom	8.4
43 - Australia	4.8
Global Average:	3.3 Mb/s

Source: [48]

The CISCO visual networking index predicts that global mobile data traffic will increase 18-fold between 2011 and 2016, as shown in Figure 11 [34].

FIGURE 11: GLOBAL MOBILE DATA TRAFFIC, 2013 TO 2018



Source: [34]

According to Kelly Ahuja, Senior Vice President and General Manager of Cisco's Mobility Business Group, the many new sensors associated with Internet of Things (IoT) will put pressure on the wireless spectrum. Strategic small cell development will help cities and service providers to combat congested cell towers and customer frustration. Small cells also offer new market opportunities for location-based services [50].

The WinterGreen Research team published a report on wireless sensor network markets [51]. The market for wireless sensor networks was $552.4 million in 2012 and is growing rapidly to an expected $14.6 billion in 2019.

According to Metcalfe's law, the value of a telecommunications network is proportional to the square of the number of connected users of the system (n2). At the edge of the Internet of Things are appliances and equipment in use every day. These 'things' are connected by an infrastructure backbone such as ZigBee, sub-GHz, Wi-Fi or Power Line communications (PLC), thus providing a robust bidirectional communication link with relatively long range, low latency for fast responsiveness, low power and a sufficient data rate to aggregate information from many connected devices. This infrastructure serves as a gateway to the Internet and enables remote monitoring and control of devices by end users, utility companies and other networks [52].

Most connected devices in the IoT are nodes located in the last centimetres of the network. It is essential that machines communicate among themselves. For example, users do not want to have to monitor fifty or more sensors throughout their house to see if the air conditioning has been left on with a window open. Smart sensor systems are able to recognise this independently [52].

The connected and smart home product market grew by almost 19% between 2010 and 2012. It is estimated to continue growing at an 8% CAGR to reach $930 million by 2015 [35].

The Sense-T network is a living laboratory in Tasmania where shared data drives new approaches to social, environmental and economic sustainability. The system uses sensor technology to aggregate data in the cloud and provides sophisticated modelling and data analysis in real time. New ideas are tested using Sense-T and scaled cost effectively elsewhere. Specific applications are in development, such as for the beef, dairy, viticulture, aquaculture and water industries. The 'Pathways to Market' project partners Sense-T with the Tasmanian government, the University of Tasmania, CSIRO, IBM and Grey Innovation among others. The World Bank's chief innovation officer, Chris Vein has identified this development as disruptive in nature and highly interesting, with potential for deployment in developing nations [53].

Another example of device connection via IoT is a wireless sensor system designed and tested by Taggle in cooperation with CSIRO in Queensland, whose applications include cattle tracking, water meters and irrigation systems [54].

4.2.6 CYBERSECURITY

In the early stages of development of the IoT, the design of physical security has had limitations. The security function usually resides within the web servers that sit in front of the object. Objects will initially focus on message integrity and secure communication, but as the technology develops, the security levels will move closer to the objects before eventually becoming embedded [55].

The first stages of IoT will exist on current infrastructure and protocols, using object gateways and consolidators. The true IoT, however, will need to be built on the foundation of Internet Protocol version 6 (IPv6), a protocol that offers almost limitless IP addresses but whose adoption will take time [55].

According to Caitlin Cosoi, Chief Security Strategist and Global Communication Director at Bitdefender, cybersecurity threats and vulnerabilities represent a serious concern when it comes to devices such as wearable technology, smart TVs, smart houses, smart cars, smart infrastructure appliances and smart medical devices. She predicts that in 2014 such security flaws may lead to human casualties [50].

A big Internet issue is authentication. Having to keep track of a multitude of passwords that need to be changed frequently is annoying for the user. Security flaws, such as Heartbleed [56], are a huge threat to user privacy and carry the risk of identify theft. Apple kicked off mobile biometrics in 2013 with the iPhone's 5S Touch ID. Motorola was first to develop a fingerprint-reading phone, but Apple's Touch ID is more user-friendly, allowing users to easily unlock the phone and authenticate iTunes purchases [50]. The Samsung Gallaxy S5 has a more complex fingerprint 'swipe', and can be used to authorise Paypal payments.

Recently, Google acquired the startup SlickLogin, which uses sound as an authentication tool. SlickLogin creates a sound that is inaudible to the human ear. Apps, websites and services that use SlickLogin technology can do away with passwords by simply allowing authentication of users by playing an inaudible sound from a nearby smartphone [57].

Biometrics are likely to play a bigger role in 2014 and beyond, particularly for secure logins and banking applications. Companies such as Bionym and EyeVerify have unique biometric technology that would be perfect for phones. [50].

The spatial enablement of the IoT, especially through the rapidly expanding use of location-based services, substantially increases the risk of breaches of security, privacy and confidentiality.

4.2.7 3D PRINTING

Sales of 3D printers are expected to grow by 75% in 2014, followed by a near doubling of units in 2015. While very expensive additive manufacturing devices have been around for 20 years, the market segment between $500 and $50,000 is rapidly growing. The advantges of 3D printing include its ability to reduce costs, improve design, streamline product prototyping and help with short run manufacturing [58].

New 3D printing tools and techniques are empowering anyone from do-it-yourself enthusiasts to global corporations to create new devices, such as car parts, batteries, prosthetics, computer chips, jewellery, clothing, firearms and even pizza, more quickly, cheaply and easily than ever before. In 2014 there will be more 3D tools and processes including crowdfunding sites [49].

Among 3D innovations is printing of biological materials, such as human tissue and bone. Organovo, a biotech company from San Diego, recently claimed that it would have a 3D printed liver available by the end of 2014 [59]. The University of Sheffield recently demonstrated their laser-sintered, entirely 3D printed UAV [60].

Spatial applications for 3D printing are not yet evident in practice but in theory the geo-referencing of points, lines and polygons inside tangible 3D printed objects such as human organs could quite feasibly lead to a form of modelling equivalent to a Building Information Model.

4.3 BIG DATA STORAGE AND ACCESS

4.3.1 BIG DATA AND THE CLOUD

Digitisation: The World Economic Forum (WEF) reports that in 2013 Australia was ranked 18th of 144 countries in terms of its digitisation index. This is one place lower than in the previous year. Very high costs of telephony by world standards work against Australia. New Zealand has dropped six places to 20th for the same reason. Finland, Singapore and Sweden make up the top three positions respectively [1].

The Cloud: The quantity of information that was generated from the dawn of time until 2005 (5 exabytes) is now being created every two days according to Eric Schmidt, executive chairman of Google [61]. According to Brock et al. [62], five major applications can be envisaged: generating new business insights; improving core operating processes; enabling faster, better decision-making; taking advantage of changing value chains; and creating new data-centric businesses. New technologies like Hadoop and MapReduce allow data to be processed in its native form.

TABLE 6: CLOUD COMPUTING SCORECARD MEASURING 'CLOUD-READINESS'

MEASURES	JAPAN	AUSTRALIA	GERMANY
Rank Worldwide	1	2	3
Data Privacy	8.8	7.9	6.6
Security	8.4	8	6.4
Cybercrime	10	9.4	10
Intellectual Property	17.2	17.8	16.8
Support for Industry-Led Standards	8.8	10	9.8
Promoting Free Trade	9.2	7	9.2
ICT Readiness, Broadband Deployment	20.9	21.3	20.2
TOTAL	83.3	79.2	79

Source: [63]

Use of the cloud will become the norm, enabling the desired information to be accessible to anyone, anywhere, anytime, on the device of their choice [21].

The Cloud Computing Scorecard (see Table 6) placed Australia 2nd in the evaluation of 24 countries for ‘cloud-readiness’.

According to Gartner, big data are estimated to have influenced $34 billion in IT spending in 2013 [64]. Big data are perceived to be more difficult to manage due to their volume, velocity and variety. Skilled data analysts and new tools are needed to support the growing big data needs of industry, including insurance, financial, marketing, scientific research and healthcare sectors. The IEEE predicts that in 2014 simpler analytics tools will be created, resulting in new market leaders in the data management and analytics space [49].

Cloud computing is now used by 54% of businesses [65]. One of the drivers behind the move toward cloud computing is the increase in mobile computing. Mobile devices have limitations in memory, processing power and battery life but when combined with cloud services are the processing and storage can happen outside the mobile device improving their utility [66].

4.3.2 OPEN ACCESS AND STANDARDS

In 2011 McKinsey & Company published a report on big data that highlighted the rapid rate of growth of digital information: 40% growth in global data per annum, 30 billion pieces of information shared on Facebook per month, and the need for 1.5 million more analysts in the US alone to take advantage of big data. McKinsey & Co. estimate that the use of personal location data contributes $300 billion in annual value to the US health care system and $600 billion in annual consumer surplus globally [67].

Australian governments are working toward making geospatial data available within the data.gov.au initiative, which comprises 3,500 public datasets currently available on the website. Australian governments are moving to make more of their data open and accessible. For example Queensland has seen a 500% increase in usage since it started its Queensland Globe less than a year ago. It is now receiving 8 million hits per day and serviced its one billionth map request in June [68]. Table 7 gives a summary of some of the prominent government-run and public web-based spatial data services in Australia.

High user-friendliness

Low user-friendliness

TABLE 7: SUMMARY OF PROMINENT GOVERNMENT-RUN PUBLIC WEB-BASED SPATIAL DATA SERVICES IN AUSTRALIA

	QUEENSLAND GLOBE	SLIP FUTURE [LOCATE] (WESTERN AUSTRALIA)	DATA VIC (VICTORIA)	NEW SOUTH WALES GLOBE	DATA-GOV.AU AUSTRALIAN GOVERNMENT
ABOUT	A free plug-in developed by the Queensland Goverment. Includes addresses, localities and boundaries, roads and rail networks, land parcls and tenure and areas affected by flood topographical maps http://www.dnrm.qld.gov.au/mapping-date/queensland-globe	Viewable via a browser in either 2D or 3D using Google Earth. Contains many layers, including aerial photography, property, road, public transport routes, historical maps, census data, schools, health facilities and more to come. http://slipfuture.landgate.wa.gov.au/pages/locatehome.aspx	Provides public access to data generated or owned by the Victorian Government. The Victorian Government's DataVic Access Policy promotes open access to government data to drive innovation, create new business opportunities and enable new services. http://www.data.vic.gov.au	Encompasses Land and Property Information, for NSW land and property information. globe.six.nsw.gov.au	Provides an easy way to find, access and reuse public datasets from the Australian Government. See draft data.gov.au roadmap, the new data.gov.au launch page and Government Data Landscape mind map for more information about related policies and initiatives. http://data.gov.au
KML ENABLED	Yes	Yes	Not fully*. Selected KMLs here: http://www.vic.gov.au/search-results.html?q=kml	Yes	Selected datasets can be downloaded in KMZ/KML format
2D GOOGLE MAPS	No	Yes	Other system	Yes	Not found
MOBILE DEVICE VERSION	Yes	Yes	No	Yes	No**
MORE INFO	http://www.spatialsource.com.au/2013/04/09/queensland-releases-google-earth-plugin	http://www.spatialsource.com.au/2013/11/05/landgate-launches-locate	http://www.governmentnews.com.au/2013/09/victoria-broadens-geospatial-mapping-data-release	http://www.spatialsource.com.au/2013/11/12/lpi-launches-nsw-globe	http://www.finance.gov.au/blog/2013/10/26/government-data-landscape-australia

ADDITIONAL NOTES/LINKS TO TABLE 7

* http://www.depi.vic.gov.au/_data/assets/pdf_file/0013/126310/3.0-IWS-Connecting-Google-Earth.pdf
** http://australia.gov.au/services/apps-services [APPS using specific government data, not a general Mapserver]

See also data from Geoscience Australia: http://www.ga.gov.au/meta
https://data.qld.gov.au/maps-geospatial/qld-globe
http://www.dnrm.qld.gov.au/mapping-data/queensland-globe/install-mac-pc
http://slipfuture.landgate.wa.gov.au/Pages/LocateGettingStarted.aspx#3dtips
http://globe.six.nsw.gov.au
https://mapsengine.google.com/09372590152434720789-0091331548129055690-4/mapview
http://er-info.dpi.vic.gov.au/sd_weave/anonymous.html [Not Google Maps]
http://maps.six.nsw.gov.au
http:// www.dnrm.qld.gov.au/mapping-data/queensland-globe

Geospatial information, resources and applications are increasingly being built collaboratively with open and rapid deployment strategies and open standards [7]. Government custodians of the data and information are increasingly inclined to provide open access to the data and resources and to make it freely available in a comprehensive and efficient way. Calls are being made for it to be organised in a way that can be easily shared, integrated and analysed, ready for value-adding services, resulting in a more spatially enabled society [70].

Other observations from the United Nations Initiative on Global Geospatial Information Management on the question of open data include [21]:

- Open source will be the preferred approach where resources are scarce or where it provides the best expertise
- Open source improves the ability to modify and share easily, and build common user communities
- Future geospatial leaders are increasingly exposed at an early stage to the use of open source and so are already culturally attuned
- Collection and maintenance of data is costly and no-cost open source, open access may not provide the best business model
- With likely reductions in central government funding for geospatial data, the private sector will be under pressure to make greater investments
- Transnational frameworks will be needed to overcome the increasing trend in data piracy and hacking
- Increasing demand will exist for global frameworks relating to ethics, privacy, security and IP protection, to enable consistent, transborder legal protections for individuals
- Getting the best from volunteer geospatial community and government will be a major challenge for society over the next five years
- Interoperability and unification of geospatial information datasets across the globe will become increasingly important

A 2011 report for the Australian National Data Service by Professor John Houghton of Victoria University's Centre for Strategic Economic Studies concluded that the benefits of open data typically outweigh the costs of making it available, without including additional long-term benefits [71]. He found that the overall benefit associated with free online access to Australian Bureau of Statistics data under an unrestricted standard licensing was worth between $6 million and $25 million per annum, up to five times the revenue it received for its publications when it was charging [71].

The US open licence weather data have provided an estimated 39-fold return on the initial investment [72]. Open data access contributes €40 billion to the economy of the EU each year [72]. In the UK, Deloitte estimated that data.gov.uk, to which 8400 datasets have been uploaded since 2009, could be worth about £16 billion ($24.1 billion) to the economy [72].

Lateral Economics published a study in June 2014 that suggested that a global open data policy could add an extra 1 percent of growth to global economy over the next five years, worth $13 trillion, including $16 billion in cumulative GDP to the Australian economy over the same period [69].

4.3.3 BIM AND GIS TECHNOLOGY

Building Information Models (BIM) and Geographic Information Systems (GIS) technology are merging, allowing seamless transition from the outdoor virtual world to indoor virtual models. Seamless models[6] are particularly important for virtual and augmented reality visualisation [77], as demonstrated in the San Francisco Golden Gate development [78]. The UK will introduce a BIM Level 2 standard for all government buildings with a view to introducing BIM Level 3 in 2018 [79], positioning itself to becoming a world leader in BIM.

In 2012, BuildingSMART called on the Australian Government to mandate the adoption of BIM, GIS and related digital technologies and processes for planning in the Australian built environment sector. It estimated that this would result in a $7.6 billion benefit to the Australian economy over the next ten years [80].

While the local government sector is already Australia's largest user of GIS technology, 38% of councils surveyed planned to increase their GIS technology budget in the near future [81].

4.4 PREDICTIVE MODELS AND APPLICATIONS

4.4.1 ALGORITHMS

In a peer-reviewed paper published in Science magazine, Song et al. studied 50,000 mobile phone users over three months and measured the entropy of each individual's trajectory. Based on the results, they reported a 93% potential predictability in user mobility [82].

Contextual computing (also referred to as predictive computing by Tom Malik) collects large amounts of personal data about the user including their history, preferences and location, and suggests information that the user might need right now – even before the user realises that it might be wanted [83, 84].

Google NOW [85] uses data that Google collects about users to predict what information the user would like to have at any given time, and presents the information as a report. If a user always checks the weather or traffic report at the start of the day, Google NOW will automatically bring up these reports without the user searching for it. If Google NOW sees a flight in the calendar, it will automatically check for flight updates for that particular flight. Preferences can be selected to optimise

[6] For in-depth information related to 3D models and theories refer to the following books: 'Advances in 3D geoinformation systems', edited by Peter van Oosterom [73]; 'Spatial data modeling for 3D GIS' by Alias Abdul-Rahman and Morakot Pilouk [74]; 'Geomodelling' by Jean-Laurent Mallet [75]; and 'An introduction to solid modeling' by Martti Mäntylä [76].

customisation and user experience. Google NOW is available in Google Glass.

Consumers are signing up for constant location monitoring when they opt into Google's location services. Google is testing a program to use smartphone users' location information (regardless of whether they are using a Google application or not) to test the usefulness of their location-based search advertising. In this program, phone location data are used to determine whether a user visited a store after being shown an ad for that retailer during a search [65].

Gartner predicts that revenue from consumer location-based services will reach $13.5 billion in 2015. Advertising will be a dominant contributor, as location targeting more than doubles the performance of mobile ads [86].

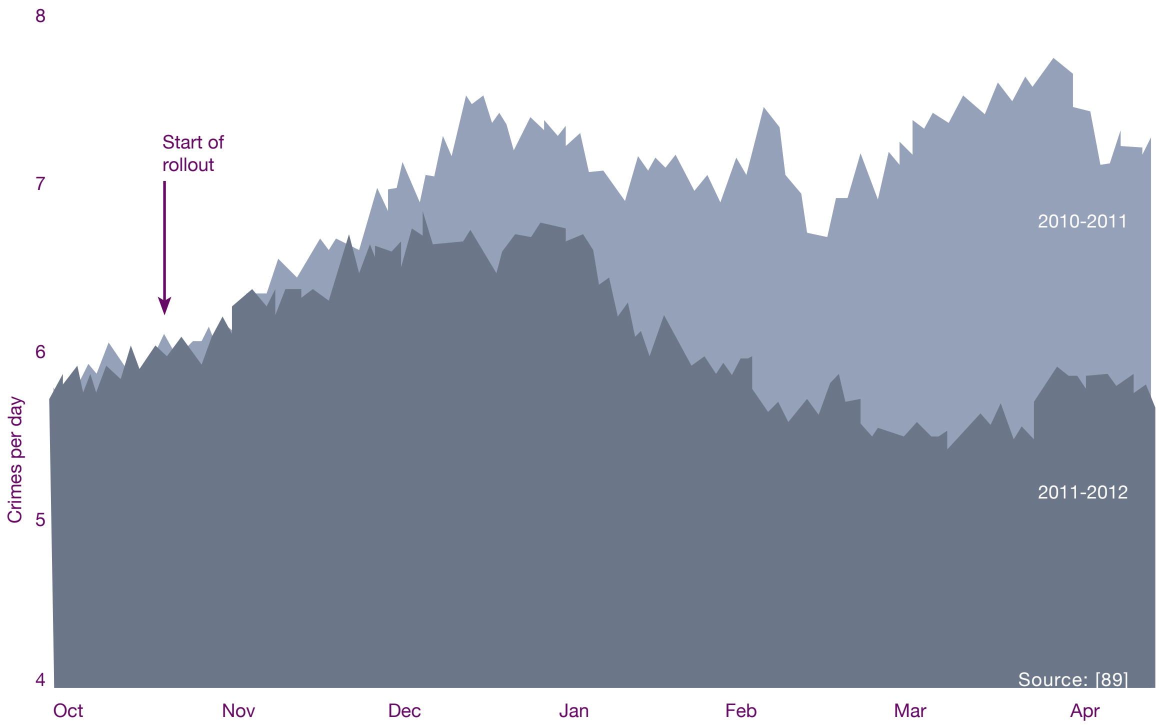
BIA/Kelsy estimate that spending on geo-targeted mobile ads reached $725 million in 2013 and will more than triple to $2.74 billion by 2017.
Alistair Goodman, CEO of Placecast, a location-based advertising provider, says that brands are realising that consumers are increasingly using mobile devices to navigate the physical world and that a unique opportunity exists to put a message into that experience [65].

Apple's iBeacon has substantial potential for location-based advertising [22]. Urban Airship's Push notification service is compatible with Apple's Bluetooth based iBeacon for more accurate location-based targeting of consumers. According to Ryan Caldbeck, 'Indoor GPS technology allows advertisers to target customers down to a particular aisle. This finally makes return on mobile advertising measurable and presents new opportunities for business services to market themselves with new efficiencies' [65].

Currently e-commerce accounts for less than 6% of total retail sales. IBM's Smarter Commerce initiative predicts that in five years advances in wearable technology, augmented reality and location-based technology such as Apple's iBeacon will transform traditional retailing. When a potential customer walks into a store, the smartphone will search the store's inventory and recommend options based on the user's purchasing history. This information can then be sent to the salesperson, who will use this information to assist further [87]. According to Damian Rollison, companies such as Goodzer and Retailigence may use inventory-tracking technologies to create local comparison-shopping or delivery services. [88].

Predpol has successfully reduced crime by merging big data with analytical algorithms. Operational Police staff are guided to target locations (a 500' x 500' prediction box). A 13% crime reduction was observed when Predpol was rolled out in the Los Angeles Foothill Division, compared to a 0.4% increase in other areas of Los Angeles at the same time (see Figure 12) [89]:

FIGURE 12: INCIDENCE OF CRIME PRE/POST APPLICATION OF PREDPOL



All these markets are powerfully aided by the fact that we are now almost always online, whether we know it or not.

4.4.2 SMART MACHINES

Smart machines will rapidly develop over the next decade, with the proliferation of contextually aware, intelligent personal assistance and smart advisers such as the IBM Watson. Further applications include global industrial systems and autonomous vehicles. Smart machines are predicted to be highly disruptive. New systems will do what was previously only thought possible by humans, and may well do it better. Gartner expects individuals to invest in, control and use their own smart machines to become more successful. Enterprises will also invest in smart machines to optimise their operation [58].

Jack Gold, information technology analyst at J.Gold Associates, speculates that in the next two or three years the personal computer model will morph into an 'Everything Computing' (EC) model. Smartphones and tablets are preliminary steps. Smart peripherals (such as wearables), embedded systems (cars, appliances) and personal assistants will change how individuals communicate, socialise and operate in a business setting. New methods of content delivery and accumulation and analysis of the immense streams of data created will be required to provide true universal connectivity. Most users will have three to six devices operating on a continuous basis. Evidence for this observation is mounting with M2M connections growing by 21.6% in 2013 [90].

FIGURE 13: M2M CONNECTIONS IN VARIOUS FIELDS

Banking	Mobile Payments
Healthcare	Remote Real-Time Patient Monitoring
Security	Remote Real-Time Surveillance
Oil and Gas	Oil and Gas Field Asset monitoring
Transport	Intelligent Transportation Networks
Retail	Location based promotions, Remote Vending Management
Automotive	Real- Time engine monitoring
Industrial	Remote Diagnostics and Updates

Source: Jeffries & Co. estimates

4.4.3 SIMPLE USER INTERFACES FOR BETTER USER EXPERIENCE

Foursquare, a location-based social network, is at the forefront of innovation when it comes to Apps using location. It works in the background to collect different pieces of information about the user such as location, time of day, where their friends have been and so on to suggest what that user might want to do. For example, if you are walking close by a coffee shop in the morning Foursquare might suggest, ‘It looks like you’re near “I Moccachino”. Your friend Dennis has been there and recommends the cappuccino’ [91].

Waze is another good example of a new company that is harnessing location-based information from mobile devices. Waze is a startup that provides community-based traffic reports, and was acquired by Google in 2013 for about $1 billion. CEO Noam Bardin suggests that ’maps are to mobile what search was to the web’. Location information of all types will drive an economy of activity based on location-enabled mobile and embedded devices [92].

Google Goggles allows image-based searches on the web and works well with books and DVDs, landmarks, barcodes, logos, artwork, businesses, products and text. It may be just a matter of time until Google Goggles is combined with Google NOW and becomes available on Google Glass, which in effect will make it an augmented reality solution [93].

Widespread augmented reality applications are closely linked to availability of wearable technology such as glasses with heads-up display. K-Glass, developed at the Korean Advanced Institute of Science and Technology (KAIST), uses the world’s first augmented reality chip that works just like human vision. The processor works with a visual attention model (VAM) to simulate the way the human brain processes visual data, allowing it to recognise a target object.

For example, when a K-Glass wearer walks up to a restaurant and looks at its name, the menu and 3D images of food pop up. The display can even show the number of tables available in the restaurant. The processor uses 65-nanometre manufacturing processes and is able to deliver a 1.22 tera operations per second peak performance when running at 250 megahertz. The real-time operation camera runs at 30 frames per second.

Professor Yoo of the Department of Electrical Engineering at KAIST has said that the market is growing fast, and it is really only a matter of time before mobile users adopt the optical see-through heads-up display into their daily routine [94].

To enable rapid development of augmented reality applications, some software development kits (SDKs) have emerged. Some well-known augmented reality SDKs are offered by Metaio, Vuforia, Wikitude and Layar [95]. Augmented Reality Markup Language (ARML) is a data standard developed within the Open Geospatial Consortium [96].

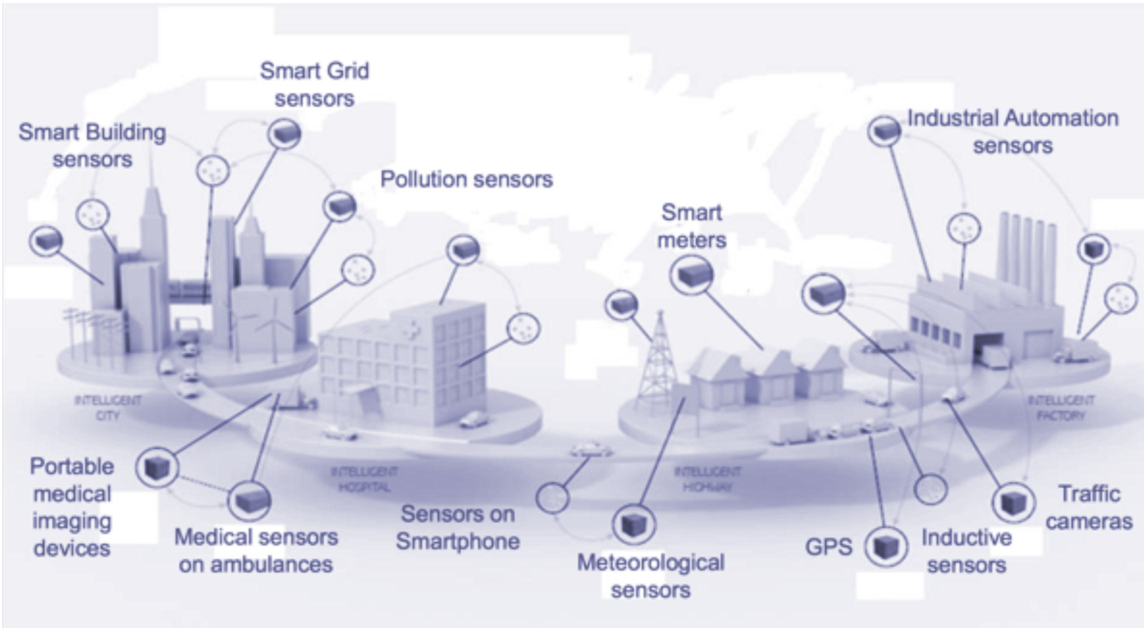
4.4.4 SMART SYSTEMS

The European Commission estimates economic losses due to traffic delays to be approximately $150 billion per year in Europe. The need to search for parking spaces is a significant contributor to congestion and a major cause of stress and delay for motorists. Over the years studies have shown that motorists searching for parking spaces accounted for 74% of traffic in Freiburg, Germany (1977); 30% in Cambridge, Massachusetts, USA (1985); 8% in New York, USA (1993); 28% in Soho, UK (2006); 45% in Brooklyn, USA (2007); and 60% in Berkeley, US (2013) [97, 98].

FIGURE 14: THE SPANISH CITY OF SANTANDER, WITH WIRELESS INTELLIGENT MOTES REPRESENTED BY YELLOW PINS

Source: [89]

FIGURE 15: TYPES OF SENSORS IN A WIRELESS SENSOR NETWORK



Source: [98]

The Spanish city of Santander [99] (see above) is a large-scale living lab for smart cities (see Figure 14). It aims to create a unique European experimental test facility for research and experimentation with different IT architectures, key enabling technologies and services and applications for the Internet of Things. A wireless sensor network using a distributed network of intelligent motes assists in efficient city management (see Figure 15). Parameters such as noise, temperature, carbon monoxide concentrations, ambient light levels and the locations of available parking spaces are monitored to benefit citizens. To realise the project, Libelium has deployed a large number of Waspmote wireless sensor nodes. The project aims to deploy 20,000 sensors in the European cities of Belgrade, Guildford, Luebeck and Santander [100].

IBM is working with local government agencies, farmers and ranchers in the Paraguay–Parana River basin to monitor and ensure the quality and availability of Sao Paulo's water system. A smart grid is being built in Malta to link power and water systems, detect leakages and allow more consumer control via variable pricing. New York, Syracuse, St Louis and Santa Barbara are using data analytics, wireless and video surveillance capabilities to strengthen crime fighting and coordinate emergency response services [101].

4.4.5 AUTONOMOUS TRANSPORT INCLUDING UAVS

Remote sensing and positioning are coming together in the form of intelligent transport, robotics and semi-autonomous UAVs. Washington DC is the first state to have published new guidelines for self-driving operators (not just testers) [102].

As of September 2014, California will issue Driver Licences to self-driving cars. However, the car still needs to bring along a licensed, sane, sober, attentive, insured human [103]. Legislation and guidelines for the operation of autonomous vehicles has been proposed or signed into law in California, Nevada, Arizona, Hawaii, Florida and Oklahoma [104]. Driverless vehicles use radar, lasers, light detecting and ranging (LiDAR), cameras, ultrasonic sensors and built-in navigation systems to pilot themselves and detect obstructions. Audi, Toyota, Nissan, Tesla, BMW, GM, Volvo, Volkswagen, Mercedes-Benz and Cadillac are all developing driverless cars [105, 106].

Google's Sergey Brin claims that in 2017 'Google's self-driving cars will be available for everyone' [107, 108]. Google is reported to have logged 500,000 kilometres in driverless vehicles without an accident [109]. A comprehensive study estimates that autonomous cars offer significant annual benefits to the US (see Table 8) [110]:

TABLE 8: ESTIMATES OF ANNUAL ECONOMIC BENEFITS FROM AVS IN THE UNITED STATES

CRASH COST SAVINGS FROM AVS	**10%**	**50%**	**90%**
Lives Saved (per year)	1,100	9,600	21,700
Fewer Crashes	211,000	1,880,000	4,220,000
Economic Cost Savings	$5.5 B	$48.8 B	$109.7 B
Comprehensive Cost Savings	$17.7 B	$158.1 B	$355.4 B
Economic Cost Savings per AV	$430	$770	$960
Comprehensive Cost Savings per AV	$1,390	$2,480	$3,100
CONGESTION BENEFITS			
Travel Time Savings (M Hours)	756	1680	2772
Fuel Savings (M Gallons)	102	224	724
Total Savings	$16.8 B	$37.4 B	$63.0 B
Savings per AV	$1,320	$590	$550
OTHER AV IMPACTS			
Parking Savings	$3.2	$15.9	$28.7
Savings per AV	$250	$250	$250
VMT Increase	2.0%	7.5%	9.0%
Change in Total # Vehicles	-4.7%	-23.7%	-42.6%
ANNUAL SAVINGS: ECONOMIC COSTS ONLY	$25.5 B	$102.2 B	$201.4 B
ANNUAL SAVINGS: COMPREHENSIVE COSTS	$37.7 B	$211.5 B	$447.1 B

Source: [110]

No legislation has yet been passed in Australia to endorse self-driving cars. Concerns include cost, technological challenges, privacy concerns and the possibility of hacker attacks of autonomous cars [111]. However, several organisations in Australia are working in the space, including the University of New South Wales with GoGet, CSIRO, BAE, Cohda Wireless and the Autonomous Ground Vehicle Challenge (AGVC). Sinclair Knight Merz (SKM) [112] outlines potential future developments in Table 9.

TABLE 9: POTENTIAL FUTURE DEVELOPMENTS IN AUTONOMOUS VEHICLES

	POTENTIAL IMPLEMENTATION
NOW-2025	▸ Increasing automation of driving functions, even on affordable cars ▸ Vehicles park themselves ▸ Vehicle to Vehicle communication ▸ Vehicles drive themselves in traffic jams or highways (adaptive cruise control) ▸ Early-adopter entrepreneurs start to hire out AVs ▸ Taxi industry disruption ▸ Standardisation of communication and technology protocols
2025-2035	▸ Car ownership declines — car sharing increases. Demand for parking starts to decline ▸ Bus service disruption — segregated or guided busways become fully driverless, bringing costs down ▸ Logistics industry disruption ▸ Vehicle to vehicle, and vehicle to infrastructure communication technology matures ▸ Accidents/collisions significantly reduce
2040-2045	▸ Vehicle size/weight/emissions reduce. New vehicle platforms ▸ Catalyst for alternative mass produced propulsion systems — electric ▸ Catalyst for fiscal incentives (road charging, pay as you go) ▸ Urban road-space optimisation — narrower lanes, tighter intersections, etc. ▸ Reduced need for urban parking — re-inventing/relocating car parks, on-street parking space reclaimed for other road uses (walking, cycling, market stalls) ▸ Vehicles on demand — no reduction in availability or quality of services
2045 ONWARDS	▸ Maturing technology, convergence and standardisation. Artificial intelligence on vehicles 'learns to read' the road ▸ Eradication of congestion on highways ▸ Elimination of accidents/collisions ▸ Significant reduction in urban congestion ▸ Ubiquitous autonomous door to door travel ▸ Increased urban sprawl

Source: [112]

Vehicles with drivers will also see major innovative improvements with automated vehicle-to-vehicle communication warning of accidents, excessive speeding and other problems in the general vicinity of vehicles [113, 114]. One commentator even suggests that it is possible to expect flying cars to be autonomous and common by 2045; see for example flying car developments of Terrafugia [115].

Rapid growth in UAV use is expected as costs fall and jurisdictions around the world open up the skies to more use. The Teal Group (2013) predicted that the worldwide UAV market would be worth $US89 billion over the next ten years [116]. The US Federal Aviation Administration will open the market for commercial UAVs in 2015. The Association for Unmanned Vehicle Systems International (AUVSI) report on the economic impact of UAVs in the US estimates the commercial benefits from UAV integration to include 70,000 new jobs and an economic gain of $13.6 billion within the first three years. By 2025, it estimates that this will increase to include 100,000 new jobs and $82 billion in economic gain [117]. Currently six states, including New York and Virginia (home to huge tech communities), are cleared to host drone test facilities.

Australia promulgated the first operational regulations for UAVs in the world in 2002 with Civil Aviation Safety Regulation part 101 (CASR101) [118], followed by a white paper in 2009 [119] and Project OS 11/20 [118].

Use of UAVs is most likely to grow in farming and mining and in places that are difficult to access or dangerous for human workers. Rooftop inspections, for example, could be done with high-resolution thermal imaging cameras attached to a UAV [91]. Use of UAVs is invaluable at nuclear disaster sites or where earthquakes have left structures unstable and too hazardous for emergency workers to enter without prior assessment. TEPCO have already realised this opportunity, using UAVs and other robots to survey the damage and aid in the cleanup of the nuclear power station accident at Fukushima [120].

The application of Smart Autonomous Transport Systems also extends to the sea. The MUNIN (Maritime Unmanned Navigation though Intelligence in Networks) project, co-funded by the European Union, is an automated maritime transport system for driverless ships [121]. Another relevant maritime initiative in the US was the Autonomous Maritime Navigation (AMN) system [122].

4.5 SOCIAL/HUMAN ASPECTS

4.5.1 EDUCATION, SKILLS AND CAPACITY BUILDING

Interest in massive open online courses (MOOCs) continues to grow rapidly. Well-known platforms include Coursera, with more than 3 million users and 107 partners, and edXa, a partnership between Massachusetts Institute of Technology and Harvard University with over 1.7 million users. The technology required to support MOOCs includes lecture delivery platforms, web forums, online meetups, keystroke loggers to check identities, and powerful servers to handle the volumes [49].

IBM is developing a large-scale integrated solution for educational institutions. The program combines predictive modelling and content analytics with traditional classroom learning. When fully implemented, every student will have an electronic persona that will follow them throughout their academic careers. If a student has trouble with a certain skill, for example fractions, that will be recorded and will allow the next teacher to design a personalised curriculum to strengthen that weakness from day one of the new year level [87].

A high priority for nations will be highly skilled workers capable of a range of data competencies with the ability to understand complex and time-based data [21]. Policy and decision makers, through to the very highest levels of governments and NGOs, will need to be educated in the value of geospatial information as a building block of base infrastructure for nations [21]. Students educated in the use of geo services can expect 3% higher wages five years after graduation [6].

The US Department of Labour (2012) estimated that in 2010 there were about 165,000 GIS-related jobs in the US (cartographers, photogrammers, surveyors, technicians and geographers) [123]. The jobs outlook for the period 2010 to 2020 was set for growth of between 16% and 35% [6, 123].

In 2012 Boston Consulting estimated that the US geospatial industry employs at least 500,000 'high wage' geo-related jobs (geo-date providers, location-enabled device manufacturers, geo-App developers, and others including educators) [8]. In 2010 the Allen Consulting Group estimated there were approximately 51,000 people in the spatial information workforce in Australia and approximately 13,400 in the New Zealand workforce [124]. A 2013 report for Australia by ACIL Tasman and Spatial Information Services estimated that there would be a national shortfall of graduate or licensed surveyors of approximately 1,300 in 2025, and a shortfall of geospatial specialists with university degrees of approximately 500 in 2017 and 300 in 2025. Moreover, by 2025 the Australia-wide shortfall is estimated to be approximately 360 for surveying technicians with diplomas and associate degrees and 250 for surveying technicians with a Certificate I to IV qualification [125].

A December 2012 report released by Engine Advocacy and the Bay Area Council Economic Institute stated that, between 2002 and 2011, job growth in science, technology, engineering and mathematics (STEM) fields has outpaced many other occupations by a ratio of up to 27 to one. This demand is expected to continue through to 2020. High-tech and STEM employees are paid between 17 and 27% more than workers in many other fields [126, 127].

The US National Academy of Science identified five emergent academic research areas that could improve geospatial intelligence by adding new types of information and analysis methods as well as new capabilities to help anticipate future workforce needs and future threats [128]:

- GEOINT fusion – the aggregation, integration and conflation of geospatial data across time and space with the goal of removing the effects of data measurement systems and facilitating spatial analysis and synthesis across information sources.

- Crowd-sourcing – a process in which individuals gather and analyse information and complete tasks over the Internet, often using mobile devices such as cellular phones. Individuals with these devices form interactive, scalable sensor networks that enable professionals and the public to gather, analyse, share, and visualise local knowledge and observations and to collaborate on the design, assessment and testing of devices and results.

- Human geography – the science of understanding, representing and forecasting activities of individuals, groups, organisations and the social networks to which they belong within a geotemporal context. It includes the creation of operational technologies based on societal, cultural, religious, tribal, historical and linguistic knowledge; local economy and infrastructure; and knowledge about evolving threats within that geotemporal window.

- Visual analytics – the science of analytic reasoning, facilitated by interactive visual interfaces. The techniques are used to synthesise information and derive insight from massive, dynamic, ambiguous and often conflicting data.

- Forecasting – an operational research technique used to anticipate outcomes, trends or expected future behaviour of a system using statistics and modelling. A forecast is used as a basis for planning and decision making and is stated in less certain terms than a prediction.

4.5.2 MACHINE/HUMAN INTERACTIONS

Brainwave detectors can use signals to gain insight into a person's level of engagement. Interaxon's headband, for example, can tell whether the wearer is bored with the conversation or having trouble concentrating [129]. When combined with other data, eye scanning provides insight into a person's mood and interests. By studying someone's gaze, eye-tracking software such as Tobii can make myriad inferences about a person, including whether they ignore banner ads, like certain colours, or naturally tend to look at a particular area of a webpage [129].

4.5.3 PRIVACY VERSUS IDENTITY

Although Internet-enabled social networks offer tremendous opportunities, they also entail new risks and growing concerns. For example, social network users can be bullied, their status posts can reach unwanted audiences, or their pictures can be stolen. Even when profiles do not list specific information, population graphs can be analysed and personal information can be inferred. Risks relate to identity management, as profiles do not exist purely in the virtual world but have impact on real, offline life [49].

Jeramie Scott, of the Washington-based Electronic Privacy Information Centre, says 'biometric information is personal, identifiable information and the question is how will it be stored and who has access to it' [129]. Consumer devices are being equipped with the ability to measure biometric information such as iris configuration and walking gait and this heightens the issues of privacy versus identity [129].

Public concern about privacy has been raised by revelations of the National Security Agency's broad and secret surveillance of the Internet and mobile devices. FBI, Customs and other agencies are known to collect biometric information such as fingerprints, facial and voice data.

Commercial web-based firms such as Instagram, Apple, Google and Yahoo collect similar data, and privacy advocates suggest consumers may not realise how much sensitive information they are disclosing [129]. Consumers question the assurances of companies that biometric information will not find its way onto the Internet where outsiders could access it.

A new phone recently entered the market for users concerned about their privacy. Retailing at $629, the Blackphone runs a custom version of the Android operating system, encrypts communication and blocks tracking of the owner's activities, such as the sites they browse. It also blocks Wi-Fi tracking that shows the location of the phone (and the user). The inventor, Zimmerman, says, 'We are not a phone company adding a privacy feature. We are a privacy company selling a phone'. Secure communication can only work when the receiver of the call or message also has encrypted services. For this reason, the Blackphone's subscription plan includes subscriptions for three other non-Blackphone users [130].

Researchers from the International Computer Science Institute have designed a mobile App ('Ready or Not?') that gathers location information shared through a user's social media accounts to create a blueprint of the user's movements over a month. The App is intended as an educational tool to demonstrate, particularly to younger users, how easily geo-tagging can be used to create a map of one individual's movements [65].

Several countries are implementing legislation to provide greater protection for individual privacy in the face of growing concerns over the implications of social media. Calls are being made for a code of ethics to guide the use of personal information with a location component [21, 131].

4.5.4 PUBLIC ENGAGEMENT

Increasingly, Volunteered Geographic Information (VGI) and crowdsourced information will be used in combination with quality-assured government-produced information, such as that covered by the Australia and New Zealand Foundation Spatial Data Framework, to make useful information available to the public [132].

From commercial custom applications to Government initiatives, crowdsourcing is growing at a very fast rate [133, 134, 135]. 3D user-defined operational picture (3D UDOP) applications provide crowd-sourced information that is used by emergency responders [136]. The Federal Emergency Management Agency (FEMA) recently added crowdsourcing capabilities to their Disaster Relief App [137].

Tomnod is a crowd-sourcing platform for information from satellite imagery operated by Digital Globe [138, 139, 140]. It is estimated that up to 7 million people may have searched images for clues on missing flight MH370 based on the 800,000 registrations and 800 million map views [141]. BlackBridge also opened its Rapideye image archive via Mapbox to enable the public to search for the missing flight [142]. Other successful spatial crowd-sourcing platforms include Ushahidi and Open Street Map.

Location-based technology offers the opportunity to crowd-source information on everything from real-time traffic flow to road conditions [143] and makes innovation accessible to everyone anywhere [144].

Hackers are now using increasingly inexpensive sensors and open source hardware such as Arduino and Netduino to add intelligence to ordinary objects. For the digitally literate, new devices such as Koubachi, NEST and Twine can be easily connected to the Internet and controlled by mobile phones. Client services such as Cosm, Evrything and IfThisThenThat allow devices to be meshed together in unexpected ways [145].

Startups in the geospatial world are burgeoning. Australia is currently trying to encourage a startup ecosystem with the launch of Startup Victoria. In its Tin Alley Program, Melbourne University is assigning tech startups to students studying ICT in paid internships. Swinburne University announced their partnership with startup education events such as Startup Grind Melbourne. These program launch announcements are part of a national trend that is also being witnessed at Flinders University, University of the Sunshine Coast, Curtin University, The University of Sydney and The University of New South Wales [146].

Co-working spaces are an upcoming trend. In the US in 2013, 4.5 new co-working spaces were opened up each workday. Globally, co-working spaces have grown at a rate of 83% [147]. The way people work together is being redefined by technology, eliminating the need to work in a set place at a set time [147].

In a recent study it was found that 71% of people felt more creative, 62% believed their work improved significantly, 90% felt more confident and 70% felt healthier when working in a co-working space as opposed to a traditional office setting [147].

4.5.5 HEALTH

A new concept in the field of human machine interfaces and body area networks is the use of sensors placed around the body to monitor a variety of physical parameters such as stress, heart rate, position and motion. With these sensors the body area networks can collect information about the individual's fitness and energy expenditure as well as health. The system can also be used in gaming, where sensors measure the player's motion and allow an immersive experience. For ill and disabled people it offers the potential to provide assistive robotics. Physiotherapists may be able to conduct rehabilitation exercises with the patient under remote surveillance using robotics [148].

Designers are working to directly integrate sensors into the fabric of smart textiles and components to transmit information wirelessly. Key challenges are development of antenna systems that can handle environmental stressors as well as wireless protocols [148].

John Rogers, a material scientist at the firm MC10, has developed a flexible electronic biostamp that sticks to the skin like a temporary tattoo. The electronic circuit mesh stretches with the skin and measures temperature, hydration and strain. These data give insights into the wearer's health [149].

IBM predicts that in five years medical practitioners will sequence the DNA of patients in only one day. They will then access cloud-based systems like IBM Watson that will provide recommendations based on the most up-to-date clinical and research information, considering the patient's body at DNA level [87].

Interesting work has been conducted in the last few years in the field of brain machine interfaces. A recent study connected two brains via a computer [150]. The first human brain (the sender) was connected to a computer via an electroencephalogram (EEG)-based brain–computer interface. The second human brain (the receiver) was connected to another computer via a transcranial magnetic stimulation (TMS) machine, usually used for treating depression. Several trials showed that when the sender, playing a game, thinks about firing a cannon to a target, the EEG picks it up and sends a signal via the Internet to the second computer where the TMS stimulates the region of the receiver's motor cortex that controls hand movement. This causes the receiver's index fingers to twitch, firing the cannon and blowing up the target. Advances like these raise important consideration on ethics and security to ensure people's minds are not involuntarily 'hacked' [151].

The Aircasting App is a platform for recording, mapping and sharing (online via CrowdMap) personal health (heart rate) and environmental (temperature, humidity, carbon monoxide, nitrogen oxide) data using a smartphone. This data is uploaded via a map and the user plots their location manually [152]. Other health-related services include Patients Like Me (a data-centric social networking site), Cure Together (a health-tracking site) and Asthmapolis (a system that allows patients to connect to a mobile App via a sensor-enabled inhaler) [107]. These simple, wearable devices are set to expand rapidly [107].

In addition to work that focuses on individuals there is a significant increase in the use of intelligent systems for large-scale analysis of biomedical data, socially relevant data and metadata, such as information about the spread of disease or certain health habits in populations [49].

4.6 SPECULATION ON FUTURE DEVELOPMENTS

4.6.1 THE MOMENT OF SINGULARITY

Futurist Ray Kurzweil predicts 'technological singularity' by the year 2029 [153]. Technological singularity is the moment in time when artificial intelligence surpasses human intelligence. In view of the opportunities and challenges of this event, Kurzweil, together with Peter Diamandes, founded the Singularity University in 2008 with funding from Google and NASA among others [154]. The intensive Graduate Studies Program, based in Mountain View, California, is a ten-week program, typically hosting around 80 students from 36 countries. It aims to equip and train students to become high impact innovators, changing the lives of 1 billion people within ten years. Typical subjects taught include future studies and forecasting, policy law and ethics, entrepreneurship, design, networks and computing systems, biotechnology and bioinformatics, nanotechnology, medicine and neuroscience, artificial intelligence, robotics and cognitive computing, energy and ecological systems, and space and physical sciences [155].

Spatial information will play a significant role in future developments, as almost all activities are attached to a location. Every activity, human or machine, may be configured at some time in the future to leave a time-stamped and geo-referenced digital trail (Geoweb) and it will be possible to use this information (in IPv6 format) for user verification, operations certification, and forward modelling.

4.6.2 ROBOTICS

The convergence of robotics, artificial intelligence (quantum computing) and cyborg developments with spatial information will be a game changer for the real world, and will open up new virtual worlds to humankind.

Progress has been made with the advent of robots, such as Asimo, Nao, Icube, HRP C4, Roboy and Atlas just to name a few [156]. Organisations share progress on the open robotic platform and make robotic hardware available to the robotic community. Hardware component design is modular to optimise user applications. The robotic operating system (ROS) is today the standard software platform for robotic research institutes, dramatically speeding up developments [157].

The recent winner of the US Defense Advanced Research Project Agency (DARPA) Robotics Challenge, Team SCHAFT from Japan, has been bought by Google in an effort to focus on robotics over the next ten years. Google plans to develop the SCHAFT concept further for robotic responders in emergency situations [158].

Tele-operated robots offer great potential. These step-by-step human-remote-controlled robots are not autonomous, but prove very useful in situations where it is too dangerous or complex for humans to be present, such as at a nuclear waste site, or in deep-space operations. Humans initiate remote operations, typically via a joystick, Wii sensing technology, motion capture suits, exoskeletons or brain–machine interfaces. Repetitive tasks can be initiated via recorded instructions, but the remote-controlled robot is not able to respond to unknown situations such as an obstruction, so detailed BIMs will prove essential for the areas within which these robots operate.

It is anticipated that such a remote 'master–slave' robotic system will come down in price over time and become widely available to the public for purchase or hire for remote 'employment'. This will bring tele-working, across nations and time zones, to a whole new level. A time-poor working couple could employ a tele-robot to cook dinner, operated by robotic control centres similar to today's call centres. Advanced versions of tele-robots will allow medical staff to treat patients in remote areas. In this way, employment opportunities will be redefined.

4.6.3 ARTIFICIAL INTELLIGENCE AND QUANTUM COMPUTING

Alan Turing proposed a test in his 1950 paper to assess a machine's ability to behave indistinguishably from a human during a five-minute natural conversation with another human in text format [159]. Since then remarkable advances in the hardware and software components of artificial intelligence (AI) are promising breakthroughs in applications of AI to solve real life problems for users [160], with the semantic web underpinning these advances in the near term.

Kurzweil thinks that a new technology such as quantum computing will replace current technology permitting both Moore's law to gain additional life and proving Alan Turing 'test' – where a machine behaves indistinguishably from a human during a five-minute natural conversation with another human in text format [159]. Advances in the hardware and software components of artificial intelligence (AI) are promising breakthroughs in applications of AI to solve real life problems for users [160, 162], with the semantic web underpinning these advances in the near term.

The D-Wave 512-qubit-quantum computer [163] is the most advanced quantum computer in the world to date. This system needs a near absolute zero temperature and a magnetically-shielded environment to operate with a new type of superconductor processor that uses the principles of quantum mechanics to massively accelerate computation. It is built by the Canadian company D-Wave systems and is most suited to solving quantum-annealing problems, commonly found in optimisation, machine learning, pattern recognition, anomaly detection and financial analysis [163]. In 2011 Lockheed Martin and the University of Southern California (USC) bought a D-Wave ONE adiabatic quantum computer for the UCS Marina Del Ray campus. In 2013 Google announced a quantum artificial intelligence lab with a D-Wave quantum computer, co-owned and hosted by NASA at the Ames Research Centre, aimed primarily at advanced machine learning [164]. D-Wave has announced its intention to bring quantum computing to the cloud [165]. Quantum computing offers the potential for massive improvements in processing speeds, which will be critically important to a world deluged by data and almost certainly a requirement for complex near real-time decision making.

4.6.4 CYBORGS

A cyborg (cybernetic organism) has both organic and bio-mechatronic parts. Two different types of cyborgs exist: restorative and enhanced. Restorative technologies help restore lost human functions. For example pacemakers are interactive sensors that repair heart functionality and represent an early form of what some may consider a cyborg-like capability. Other examples of restorative cyborg technology include insulin pumps, artificial limbs operated with neural wiring, and epilepsy control using brain-machine interfaces. Brain-machine interfaces can provide extended memory, artificial extra limbs can perform functions that human limbs cannot [166], and extra-human sensor capabilities may be wired into the brain, such as thermal infrared sensing or infrared vision [167].

In 2006, DARPA invited proposals to develop innovative insect cyborg technology [168]. The listed requirements included reliable electromechanical interfaces to insects, locomotion control using microelectromechanical system (MEMS) platforms, demonstration of technology to scavenge power from insects, ability to fly 100 metres guided by a computer interface and ability to have a controlled landing within five metres of a specific endpoint. Today a RoboRoach kit [169] is available on the Internet for students to learn about neuroscience by experimenting on live cockroaches. Use of this technology on humans raises a whole new chapter of concerns regarding ethics and cybersecurity, warranting a thorough public debate.

4.6.5 VIRTUAL WORLDS

Technological advances have forever changed the world we live in. Virtual worlds are being built for gaming, remote interactions, modelling what-if-scenarios and more [170]. Augmented reality allows us to combine the virtual world with the real world. Information flows both ways: we receive information in the real world from the virtual world and adjust our decision-making with the given information overlays. On the other hand, in our daily life we constantly feed information back into the virtual world via spatially-enabled wearable sensor technology. In combination with advanced visualisation techniques, such as virtual reality glasses [171] and contact lenses or bionic vision implants; large display screens with user-interactive and personalised content [172]; and tele-presence through holograms [173], will allow users to live in a much smarter world.

As the seamless integration and accuracy of indoor and outdoor navigation rapidly improves over the next few years, so will the virtual worlds that we can access.

For example, shopping is likely to change dramatically. If you want to buy a new light pendant for your house, augmented reality will allow it to be viewed virtually 'in-situ' before purchase. Once selected, the digital model of the lamp will be delivered together with the real lamp and the virtual world model of your house (BIM) will be upgraded accordingly. Residential building companies may be required to hand over a digital model of the house (BIM) together with the house key upon building completion. A certified master digital mirror world will be created in order to avoid conflicting models. This virtual world will need specific spatial access rights for each user. This concept is embodied in initiatives like VANZI [161].

4.7 THE OUTLOOK

Most future developments will be built with location as a key component and identifier, thereby making spatial innovation vital to advancement of these technologies.
Key developments in spatial technology are likely to share these common elements:

- High precision location accuracy
- The 'always on' phenomenon (ubiquitous streaming and continuous analysis)
- A sentient presence (making us, and the world around us, 'smart')
- Universal accessibility irrespective of skill level, language, location or socio-demographic circumstances.

There are unprecedented opportunities for the spatial information industry in the next decade and beyond.

5 THE WORLD ECONOMY

This section summarises world economic growth, global debt, productivity and collaboration for countries and regions of relevance to the spatial industry and the aspirations of the Australia and New Zealand Cooperative Research Centre for Spatial Information (CRCSI).

5.1 THE WORLD IN OVERVIEW

5.1.1 GROWTH

The global economy is expanding at a moderate pace, with acceleration anticipated in 2014 and 2015. Global growth fell to around 2.0% in 2013 but is expected to grow to 2.9% in 2014 and 2015 then decline to 2.8% in 2016 and 2017 [174]. Weaker prospects in many emerging market economies (EMEs) have resulted in a downward revision of global growth forecasts for 2014 [175].

Three major events that have unsettled confidence and market stability in early 2014 are [175]:

- The reaction to the tapering of asset purchases by the US Federal Reserve;
- Increased concerns about developments in some EMEs leading to capital outflows; and
- The US brinkmanship and near crisis associated with its legislative ceiling on federal government debt.

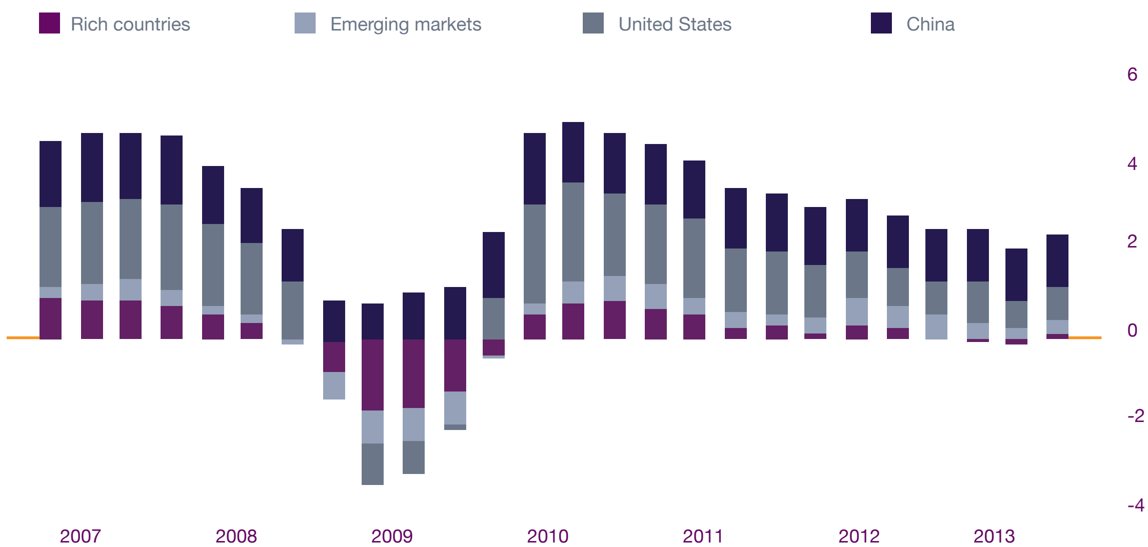
Political turmoil and social instability are also putting pressure on global growth. Russia's emerging economy has been threatened by its intervention in the Ukrainian crisis. Resulting sanctions from the West are, so far, modest in scope but significant in eroding investor and market confidence [174]. Ongoing political tensions in Turkey, Thailand and Venezuela, and to a lesser extent in India and Brazil, are also creating issues for regional economic expansion. The Economist Intelligence Unit (EIU) has reduced its outlook for real GDP growth in most of these countries in recent months, most notably in Russia in March 2014.

While growth in EMEs is weak, the EIU forecasts that in 2014 the economies of the US, euro zone and Japan, which have collectively accounted for about US$35 trillion in nominal output this year (just under half of the global total), will experience their first upturn since the 2010 recovery from the recession [174].

Coincident with these developments are concerns about China, whose growth is edging lower and whose manufacturing has been softer than expected [174]. World growth seems increasingly dependent on China. Since the beginning of 2010 China has contributed over one-third of global GDP growth, with another 40% coming from the rest of the emerging world. In 2013, China contributed 50% of global growth [176]. Since the financial crisis, the rich world has been weighed down by debt. As a result, its growth has been unpredictable and it has provided just 10% of global growth since 2010, with America contributing another 12.5% [176]. Allan Conway, Head of Emerging Markets Americas of Schroders, expects ‘emerging markets to bounce back in 2015’ [177].

The rate of change of global GDP and global GDP growth are shown in Figure 16 and Table 10 respectively [176].

FIGURE 16: RATE OF CHANGE OF GLOBAL GDP



Estimates based on 52 economies representing 90% of world GDP. Weighted by GDP at purchasing-power parity. Source: [176]

China is forecast to overtake the US to become the largest economy in the world around 2020, and India is likely to overtake Japan as the third-largest economy within a decade. The combined GDP of China and India is forecast to exceed that of the Organisation for Economic Cooperation and Development’s (OECD) major seven (G7) economies by around 2025, and by 2050 it is estimated to be 50% larger. Contrast that with 2010, when the combined GDP of these two countries equated to less than one-half of that of the G7 countries [178].

TABLE 10: GLOBAL GDP GROWTH

WORLD ECONOMY: FORECAST SUMMARY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
World (Market Exchange rates)	-2.3	3.9	2.6	2.2	2.0	2.9	2.9	2.8	2.8	2.9
US	-2.8	2.6	1.9	2.7	1.9	2.9	2.6	2.5	2.4	2.6
Japan	-5.5	4.7	-0.4	1.4	1.6	1.5	1.5	1.2	1.2	1.3
EURO area	-4.4	1.9	1.6	-0.6	-0.4	1.1	1.4	1.4	1.4	1.5
China	9.2	10.4	9.3	7.7	7.7	7.3	6.9	6.8	6.3	6.0
Eastern Europe	-5.6	3.4	3.9	2.1	1.6	2.6	3.5	3.8	4.0	4.1
Asia and Australasia (exc Japan)	5.1	8.5	6.5	5.3	5.5	5.7	5.7	5.7	5.5	5.5
Latin America	-1.5	5.9	4.4	3.0	2.7	2.4	3.2	3.7	3.8	3.8
Middle East & Africa	1.9	5.3	2.8	3.8	2.2	3.4	4.0	4.4	4.4	5.0
Sub-Saharan Africa	1.3	4.6	4.7	4.0	3.7	4.0	4.5	5.3	5.6	5.2

Source: [174]

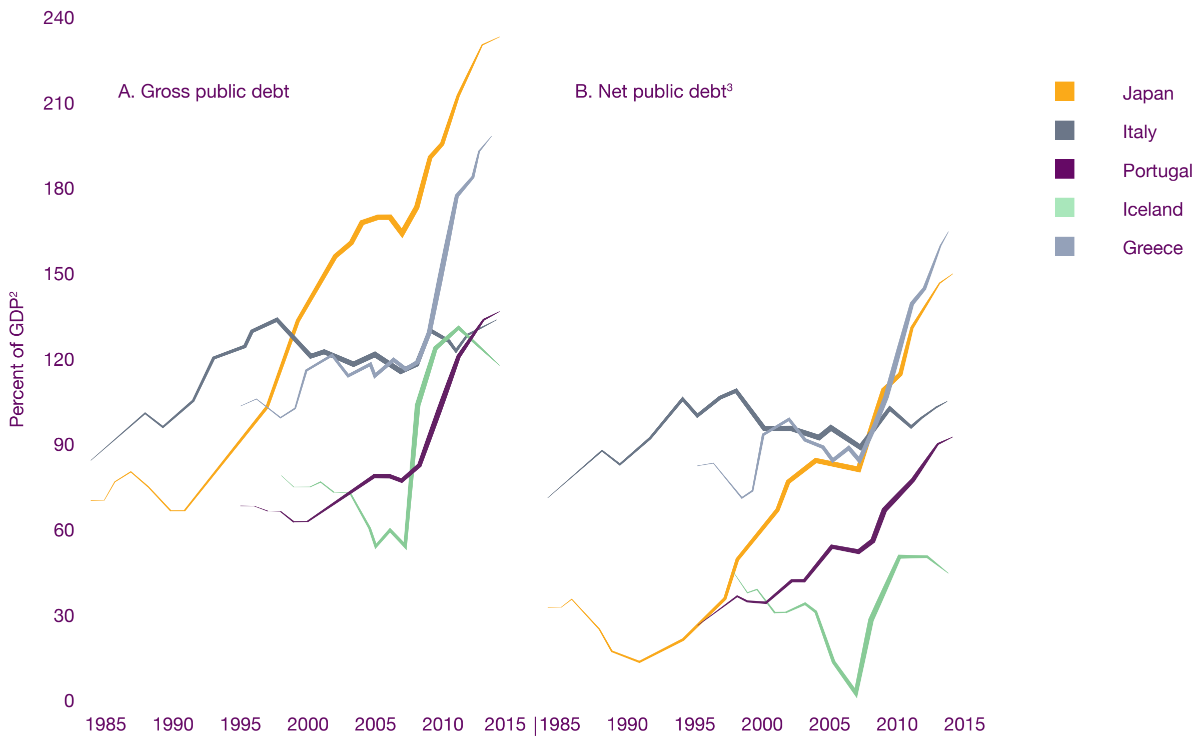
5.1.2 DEBT

Government debt ratios for the OECD are expected to grow or remain at high levels in the coming year. The global government debt-to-GDP ratio reached 111.4% in 2013. However, overall debt ratios are increasing more slowly than in the past, declining from an increase of 11.5% in 2008–2009 to a projected 1.1% increase in 2013–2014 [179].

Some forecasters predict that the scale of the current global account imbalances may increase to pre-crisis peaks by the late 2020s. In addition, in many OECD countries government debt will exceed thresholds beyond which interest rates, growth and economic stability will be adversely affected [180].

Management of public debt is a major issue for many countries (see Figure 17). For Japan, government debt is running at about 230% of GDP (see Figure 17) and steadying the debt-to-GDP ratio requires a fundamental improvement in the primary fiscal balance from a deficit of 9% of GDP in 2012 to a surplus as high as 4% by 2020. Controlling expenditures is essential, particularly in the social security sector, which faces the challenge of a rapidly ageing population. For the US, where government debt is about 102% of GDP, fiscal consolidation is currently 2.7% of GDP, whereas the total required to stabilise debt is about 6.5% [181, 182].

FIGURE 17: PUBLIC DEBT IN SELECTED OECD COUNTRIES OVER TIME



1. The five countries with the highest gross debt rations (gross liabilities divided by GDP) in the OECD area in 2010.
2. OECD estimates for 2012 and projections for 2013-14.
3. Net debt is gross debt less financial assets held by the government.

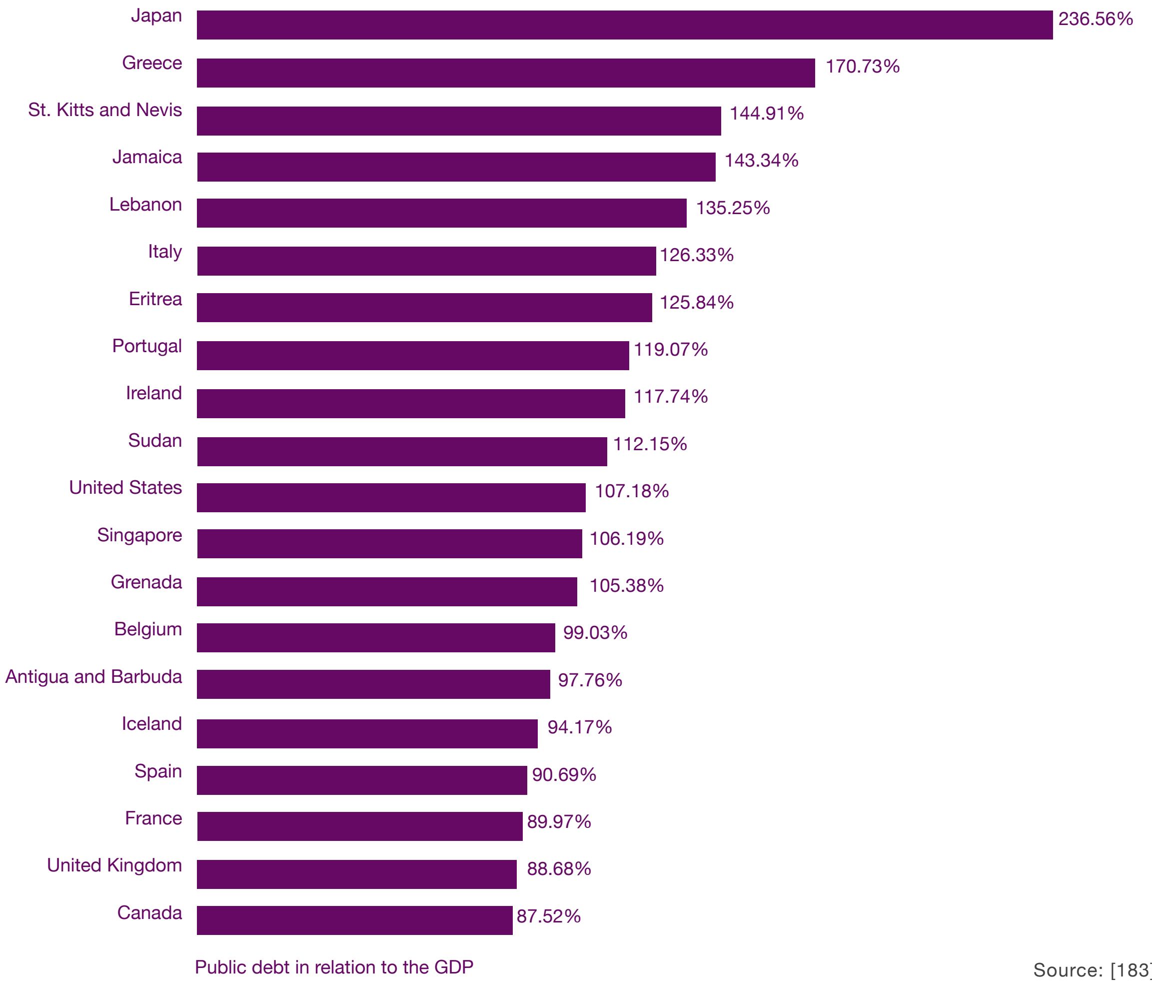
Source: *OECD Economic Outlook*, No 92, and revised OECD estimates and projections for Japan for 2012-14.

Source: [181]

Ireland, Italy, Iceland, Greece, Portugal and Spain among others also need to focus on debt management. To stabilise debt, most countries require a 4% to 7% GDP improvement in the underlying primary balance between 2011 and 2030, with the majority of the adjustment being planned for the next two years [179].

Other OECD countries requiring consolidation of more than 4% of GDP from 2011 include Poland, the Slovak Republic, Cyprus, Slovenia and the UK. In addition, for a typical OECD country, additional offsets of 3 to 4% of GDP will be required over the next 20 years to meet spending pressures due to increasing pension and health care costs [180]. Figure 18 shows government debt as a percentage of GDP for the twenty countries with the highest debt.

FIGURE 18: GOVERNMENT DEBT AS A PERCENTAGE OF GDP [183]



Source: [183]

5.1.3 PRODUCTIVITY

Global labour productivity growth is slow (see Table 11 and Table 12). Productivity growth as measured by GDP per employed person fell to 1.7% in 2013, compared to 1.8% in 2012 and 2.3% in 2011 [184]. The global financial crisis had a big impact. In China average productivity growth fell from 12% per annum between 2003 and 2007 to less than 9% between 2008 and 2013.

This declining productivity confirms that efficiency remains a problem for the global economy [184]. In 2014 a moderate improvement in global productivity growth to 2.3% is forecast, mainly as a result of improved growth performance in mature economies (1.5% in 2014 compared with 0.9% in 2013). Emerging and developing economies may see a moderate improvement in productivity growth. However, at 3.6% in 2014, these growth rates will stabilise at much lower levels than in the first decade of the century, when productivity growth rates ranged between 5% and 7% [185].

Christopher Vas notes that 'The productivity slowdown has been attributed to many things, predominantly weaker demand, a mismatch in resource allocation between labour and capital, and lesser than optimum innovation outcomes emerging despite technology advancements in mature economies' [184]. Emerging economies contributed 1.8% to global growth while mature economies contributed 0.4% [184].

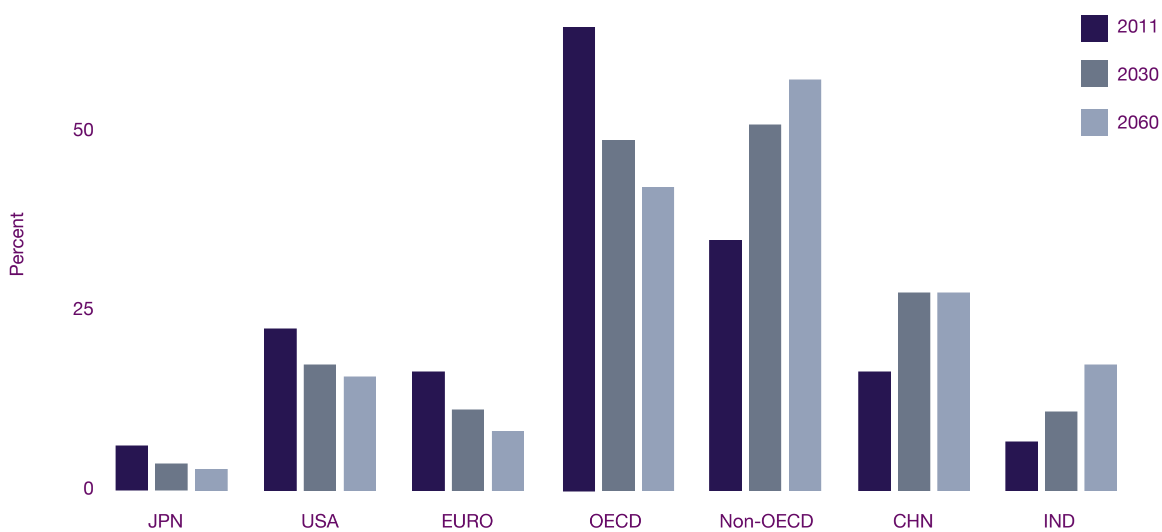
Some countries saw improvements in productivity last year. However, such gains may result from increased unemployment rather than increased GDP: a reflection of a faltering economy, in which fewer people are doing the work. In the euro area, for example, productivity growth has improved since 2012 from –0.1% to 0.4%, but both GDP and employment have fallen. Spain and Italy both showed positive productivity growth. The business cycle influences productivity because firms wary of another downturn tend to make employees work harder during an upturn instead of hiring new workers. Productivity increases until new workers are hired, and the cycle starts to repeat [184]. The next 50 years will see major changes in both productivity and GDP in many countries.

On the basis of purchasing power parities (PPPs), China is projected to surpass the US by 2020 with India overtaking Japan a few years later and then the euro area in about 20 years. China and India will experience a greater than seven-fold increase in their income per capita by 2060. By that time China will have a 25% greater income level than the US, while in India income per capita will be about half of the current US level [186].

Australia's productivity has steadily improved over the past 24 months by 2.7%; however, this is partly due to an increase in unemployment. Because they represent a ratio, productivity values should always be interpreted with caution [184].

The Gross Domestic Product normalised to Purchasing Power Parities (GDP (PPP)) per hour worked is a measure of the productivity of a country when not taking into account unemployment or hours worked per week: it normalises each country's GDP based upon its PPP (see Figure 19).

FIGURE 19: 2005 PPPS AS A PERCENTAGE OF GDP



Source: [186]

TABLE 11: GLOBAL LABOUR PRODUCTIVITY GROWTH

REGIONAL INDICATORS	2012	2013
NORTH AMERICA		
Labour productivity growth	0.9%	0.9%
GDP growth	2.8%	1.9%
Total Factor Productivity	0.7%	0.7%
EURO REGION		
Labour productivity growth	-0.1%	0.4%
GDP growth	-0.7%	-0.3%
Total Factor Productivity	0.8%	-0.6%
LABOUR PRODUCTIVITY GROWTH IN:		
Brazil	-0.4%	0.8%
China	7.3%	7.1%
India	3.1%	2.4%
Japan	1.2%	0.8%
Poland	5.6%	1.4%
Russia	3.1%	1.6%
Singapore	-2.5%	1.6%
Spain		1.4%
United Kingdom	-1/8%	0.5%
United States	0.7%	0.9%

Source: [184]

Australia’s productivity growth was 2% in 2012 and 0.6% in 2013 [184, 187]. In 2013, mining investment in Australia began a contraction that is set to continue beyond 2014, while mining output will keep growing as new mines and gas projects come on stream. All else being equal, this should result in an improvement in Australia's productivity growth [187].

TABLE 12: GLOBAL GROWTH INDICATORS, LABOUR PRODUCTIVITY AND REAL GDP 2012–2013

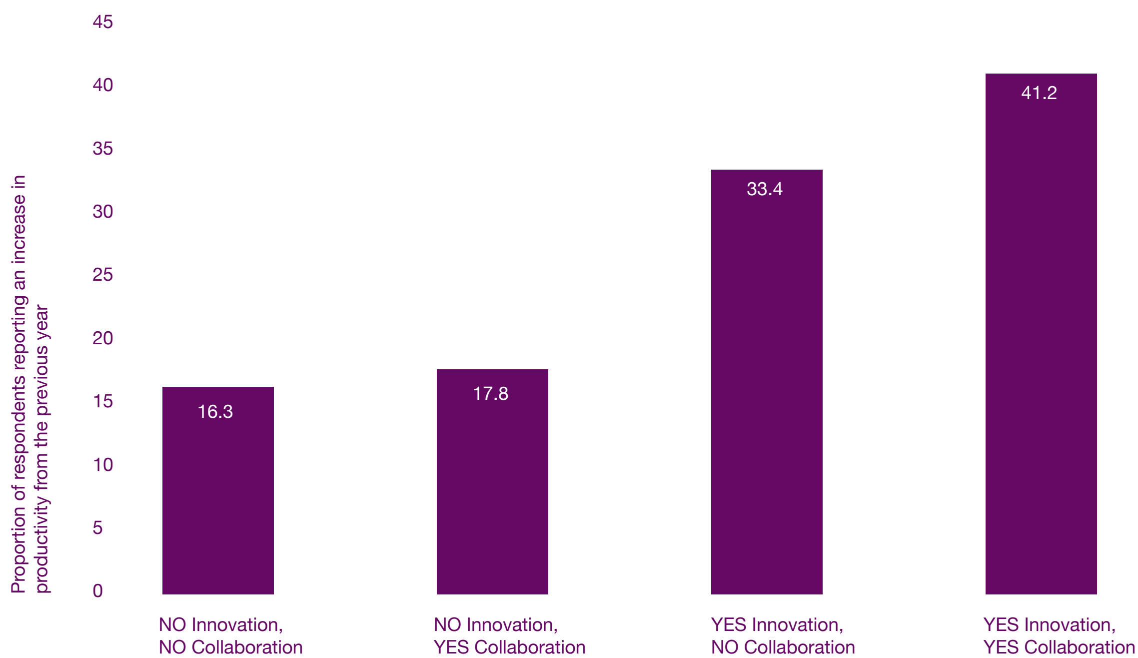
	2012	2013
GLOBAL GROWTH INDICATORS		
Employment growth	1.3%	1.2%
LABOUR PRODUCTIVITY (GLOBAL)	1.8%	1.7%
Emerging economies	3.7%	3.3%
Mature economies	0.9%	0.9%
REAL GDP (GLOBAL)	3.1%	2.9%
Emerging economies	5.2%	4.7%
Mature economies	1.4%	1.3%

Source: [184]

5.1.4 COLLABORATION

Effective global collaboration for the purpose of innovation relies on planned, interactive cross-border arrangements, international trade and competition. It also reflects the reality of the greater fragmentation of production processes along global value chains. Collaboration within firms, both domestically and internationally, increases the likelihood of improvements in productivity, as shown in Figure 20 [188]:

FIGURE 20: THE BENEFITS OF COLLABORATION TO ORGANISATION PRODUCTIVITY



Source: [188]

Australian businesses that collaborate are 55% more likely to report increased productivity. Innovation-active businesses are more than three times more likely to collaborate than their non-innovative counterparts [188].

In Cleveland, USA, non-traditional partners such as rival universities and hospitals now collaborate, pooling billions of dollars to improve efficiency. In Atlanta, ten counties and business groups joined together to raise regional taxes and issue a US$8 billion bond to promote economic growth. This approach of 'collaborative competition' helps organisations move up the value chain to highly productive activities [184].

International collaboration on innovation in many OECD countries exceeds national collaboration, except in a small number of countries including Australia, Korea, China and Chile. Australia ranks a poor 25th out of 26 OECD countries in international collaboration on innovation, with New Zealand outranking Australia at 17th [188].

Effective global collaboration on innovation is fuelled by cooperative research and development (R&D) among businesses. For example, businesses that make well-informed and targeted investments in global R&D, based on choice of sites and personnel and with good insights into customer demands, are more likely to secure a better return on their R&D investments than those that invest exclusively in home-grown R&D activities [188].

Global scientific and technological collaboration also provides access to a larger pool of expertise that enables international research partners to produce joint scientific publications and/or inventions with greater impact. Australia's contribution to the world's top 1% of highly cited publications is made up primarily of research publications involving international collaboration. Its overall contribution has grown over the last six years, from 2.14% in 2006 to 3.14% in 2011 [188].

5.2 COUNTRY BY COUNTRY ECONOMIC OUTLOOK

5.2.1 USA

In 2014 the American economic data continues to be distorted by unusually bad weather conditions, but the US economy is generally considered to be recovering without inflationary pressure. The debt ceiling has been suspended until 2015, removing an issue that created uncertainty in 2013. This has had a stabilising effect on markets.

GDP grew 2.4% in 2013, in line with expectations [189, 190]. The EIU is forecasting real GDP growth of 3% in 2014, the fastest rate since 2005 [174]. Labour market recovery, debt deleveraging and gains in asset prices will help to underpin consumption and residential investment growth [191].

In December 2013 consumer spending in the US rose at its fastest pace in three years, while its export performance has picked up firmly as the US shale energy revolution boosts domestic production [174].

The unemployment rate fell to 6.6% in January 2014, its lowest level since October 2008 [191]; however, this rate is still considered high. The US economy may be negatively impacted by the combination of high unemployment rates, persistently high debt levels, the expectation of gradually increasing market interest rates and a slowing housing market [174]. The OECD forecasts that the unemployment rate will rise to 6.9% in December 2014 and fall back to 6.3% in 2015 [191].

Europe's debt crisis has impacted on the US economy. US companies typically generate around 25% of their profits from foreign sales, and Europe has been an important source of income [192].

US government debt was 99% of GDP in in 2013, down slightly from 102% in 2012. It is forecast to increase to 106% by 2015 [193].

Productivity growth could more than double from 0.8% in 2013 to 1.8% in 2014. Productivity performance in 2014 will be important, as the US is likely to be among the first economies to show positive effects from a recovery in demand, because its markets show good ability to reallocate resources to the most productive industries and sectors [194].

5.2.2 CHINA

The Chinese economy grew by 7.7% in 2013 (lower than the forecast 8.4%). The EIU expects growth of 7.3% in 2014, supported by improving conditions in its two biggest export markets, the US and the Euro zone [174].

Economic growth continues to slow in China. Industrial production grew by 8.6% year-over-year in January and February 2014, the lowest growth rate in four years. Investment and exports have also been lower than expected. The government is now restricting credit availability with the aim of reducing investment-led growth, which has created overcapacity in China's economy and led to rising levels of debt and signs of stress among its banks [195].

China's unparalleled growth since 1979 has been created by two key factors: the influx of tens of millions of new workers from the countryside to power its industrial economy, and huge investments in factories, urban infrastructure and heavy machinery. However, China's population is rapidly ageing, and the size of the labour force is likely to plateau by 2016. Not only that, but the pace of capital investment growth is expected to slow as Beijing seeks to rebalance the economy in favor of more internal consumption and less reliance on exports [195].

The Chinese government recently undertook a major audit of debt and concluded that the economy was robust enough to forge ahead with interest rate liberalisation. China is comfortable with its economy's ability to withstand the rise in defaults associated with this approach [186]. Meanwhile, China's reform of state-owned enterprises (SOEs) continued when the China International Trust and Investment Group announced that it is listing all its operating assets outside of China. This has improved the perception of corporate governance in China and allowed more disclosure about the financials and strategic planning of a major China-run investor. SOE reforms will continue, providing comfort for investors [183].

Trust financing, part of China's $7.5 trillion shadow banking system, has been key to fuelling the nation's 10% annual growth rate in the past decade by providing easy credit to companies that banks considered too risky. Since trust loans to various industries, including property, solar and coal, tripled in the past three years to 10.9 trillion yuan ($1.8 trillion), bondholders have become increasingly alarmed as the government reins in lending, cooling housing demand and slowing the economy [196].

China's government debt is progressively taking up a greater portion of the national GDP but is not yet a problem, according to the International Monetary Fund (IMF). China's government debt in 2013 was 50% of GDP, up from 40% in 2012 and 37.8% in 2011 [183].

Some commentators consider that China does not have to accept slower growth as inevitable. But to avoid this, it must generate greater productivity from its people and more benefit from its yuan. Both are achievable if policymakers and company leaders start to make changes now [194].

In China average productivity growth fell from 12% a year between 2003 and 2007 to less than 9% between 2008 and 2012. Labour force participation rates remain above OECD averages and the difference in income per head essentially reflects lower capital per worker [194]. However, productivity growth in China has been and remains ahead of most other countries. Between 1990 and 2010, China's average annual productivity growth rate was 2.8%, far greater than that of the US and Japan (0.5% and 0.2% respectively). China's rate was greater than South Korea (2.1%), which has the best record for productivity performance among developed countries, and exceeded Brazil (0%), Russia (1.7%) and India (1.9%) [194].

5.2.3 JAPAN

Japan's recovery from the 2012 recession is driven by strong export growth; consumer spending amid rising confidence and employment; and a rebound in business investment. Its expansion, supported by strong monetary stimulus and a fiscal package, is expected to continue. However, fiscal consolidation, including the consumption tax increases in 2014 and 2015, is projected to slow output growth to around 1.5% in 2014 and 1% in 2015. The sustained recovery will help push inflation toward the 2% target [197].

GDP growth in Japan stagnated to 0.7% in 2013. Japan's industrialised free-market economy is the third biggest in the world, having been overtaken by China in 2011. Japan has the largest electronics industry and the third-largest automobile industry in the world. Japan's economy is well-known for efficiency and competitiveness in exports-oriented sectors, but its productivity is lower in areas such as agriculture, distribution and services [198].

The initial impact of new monetary, fiscal and structural policies has produced strong export growth, rising consumer spending and a rebound in business investment. The consumption tax rate is now 8% and is planned to increase to 10% by 2015. However, public debt is high. The tax increase leaves Japan's economic outlook in 2014 uncertain, as it will affect data for both GDP growth and inflation [174, 175].

Industrial production improved in January 2014, and retail sales increased by 4.4%. Unemployment remains at 3.7%. The Japanese Government's aggressive program to stimulate the economy and end the deflation era has been making progress, but the Bank of Japan has indicated that it will continue to provide liquidity to the economy until it has achieved its objective of 2% inflation [189].

The government's medium-term fiscal objectives, announced in June 2010, are aimed at halving the primary deficit of the central and local governments by fiscal year 2014/15, and eliminating it by 2020. As of 2013 Japan has one of the highest gross public debt levels in the world at around 230% of GDP, and reducing it is a priority [197].

Despite the large monetary and fiscal stimulus in Japan, productivity growth dropped from 1.2% in 2012 to 0.8% in 2013. Average labour productivity remains nearly a quarter below the leading OECD economies. Japan's total factor productivity growth grew modestly in 2013, at a rate somewhat higher than that in the US. However, Japan's productivity level remains lower than Europe's, reflecting the weak performance of Japan's services sector relative to other major mature economies [185].

Japan is forecast to experience only a moderate productivity improvement in 2014 to 1.2%. Efficiency gains in Japan are difficult as long as structural rigidities in Japan's labour market and in several services industries remain unresolved [185].

5.2.4 INDIA

India is expected to continue its economic recovery following a couple of difficult years. The EIU is forecasting GDP growth of 6% in fiscal year 2014/15, following GDP growth of 4.7% in 2013 [174, 199].

India's GDP growth slowed from 6.7% in 2012 to 5% in the year ending 31 March 2013, the slowest pace in a decade, as high inflation, borrowing costs and delayed project approvals forced companies to put investments on hold. Between July 2013 and December 2013, growth averaged 4.6% as consumer spending slowed [200].

Productivity growth in India fell to 2.4% in 2013, the slowest rate since 2002. In 2012 productivity had already slowed dramatically to 3.1% (from 5.8% in 2011). The slowdown in productivity occurred despite only a marginal decline in employment growth (from 1.8% in 2012 to 1.7% in 2013), as output declined much faster (from 5% in 2012 to 4.2% in 2013). The economy is going through a difficult time, as it suffers major macroeconomic challenges including high inflation, slowing exports, increasing current account and fiscal deficits, a falling exchange rate and a slowdown in structural reforms [185].

Persistent inflation has forced up interest rates. Inflation based on the wholesale price index has been around 7% and is above the central bank's preferred rate of 5% [200].

India recorded a government debt-to-GDP ratio of 67.7% of the country's GDP in 2013 [201]. Moody's Financial Services warns that the Indian financial system's ability to absorb rising government debt could diminish significantly if the combination of low economic growth and high inflation continues beyond June 2014, potentially weakening the country's sovereign credit profile [200]. India's government debt-to-GDP ratio was still the highest among major developing countries at 67.7% in 2013, compared with 60.3% for Brazil, 42.9% for the Philippines, 34.4% for Turkey and 24.5% for Indonesia [200].

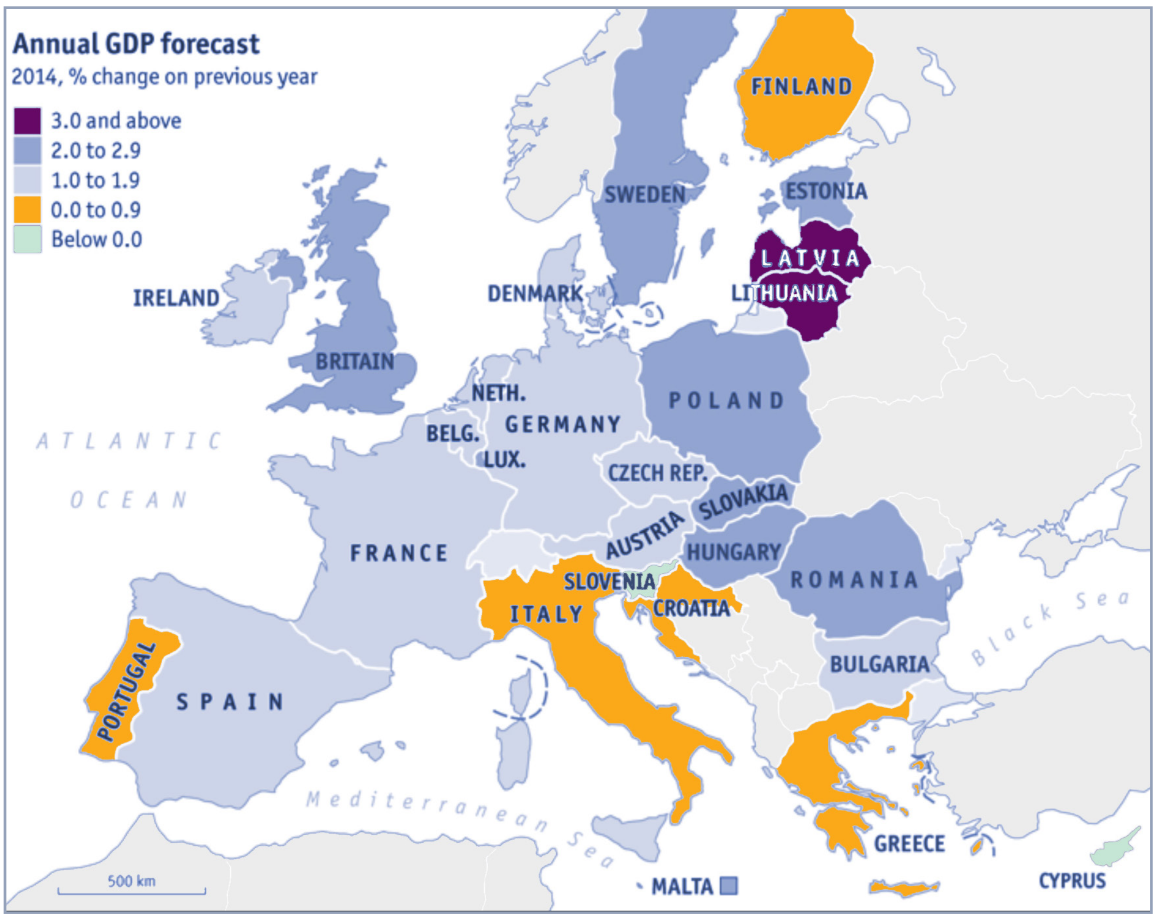
5.2.5 EUROPE

Growth in Europe was 0% for 2013, significantly lower than the previous OECD prediction for the euro area of 1.3% for 2013 [202, 175]. The expected growth in Europe is forecast to increase to 1% in 2014 and 1.6% in 2015 [175]. The GDP forecasts and government debt levels vary between European countries, as shown in Figure 21 and Figure 22.

As the political situation in Ukraine has become increasingly unstable, the financial markets have been negatively impacted. The direct economic impact of the turmoil in the Ukraine is likely to be relatively low, as Europe does not have major trade links with the country. However, geopolitical tension negatively impacts financial market sentiment [189].

Problems continue in Cyprus, where ongoing decreases in output will be associated with a 4.8% fall in GDP. The only other country forecast to go backward will be Slovenia, whose GDP will marginally contract by 0.1% [203]. In contrast, the best performing country is forecast to be Latvia, which will grow by over 4% per annum in both 2014 and 2015. Lithuania, which is expected to join the euro area next year, will grow by 3.5% in 2014 and 3.9% in 2015.

FIGURE 21: ANNUAL GDP FORECAST BY COUNTRY



Source: [203]

The euro has staged a good recovery and increased steadily during the past year and in recent months. After trading at around US$1.28:€1 in March 2013, the exchange rate rose to around US$1.39:€1 by mid-March 2014. As a result, the EIU has changed its 2014 exchange-rate forecast from US$1.29:€1 to US$1.34:€1, implying an appreciation of the dollar in the remaining nine months of this year. This change contradicted predictions [174].

Britain is at last experiencing a recovery, and the Bank of England has revised its forecasts of UK economic growth in 2014 from 2.8% to 3.4% [189]. GDP is also forecast to expand by around 2.5% in 2015 [203].

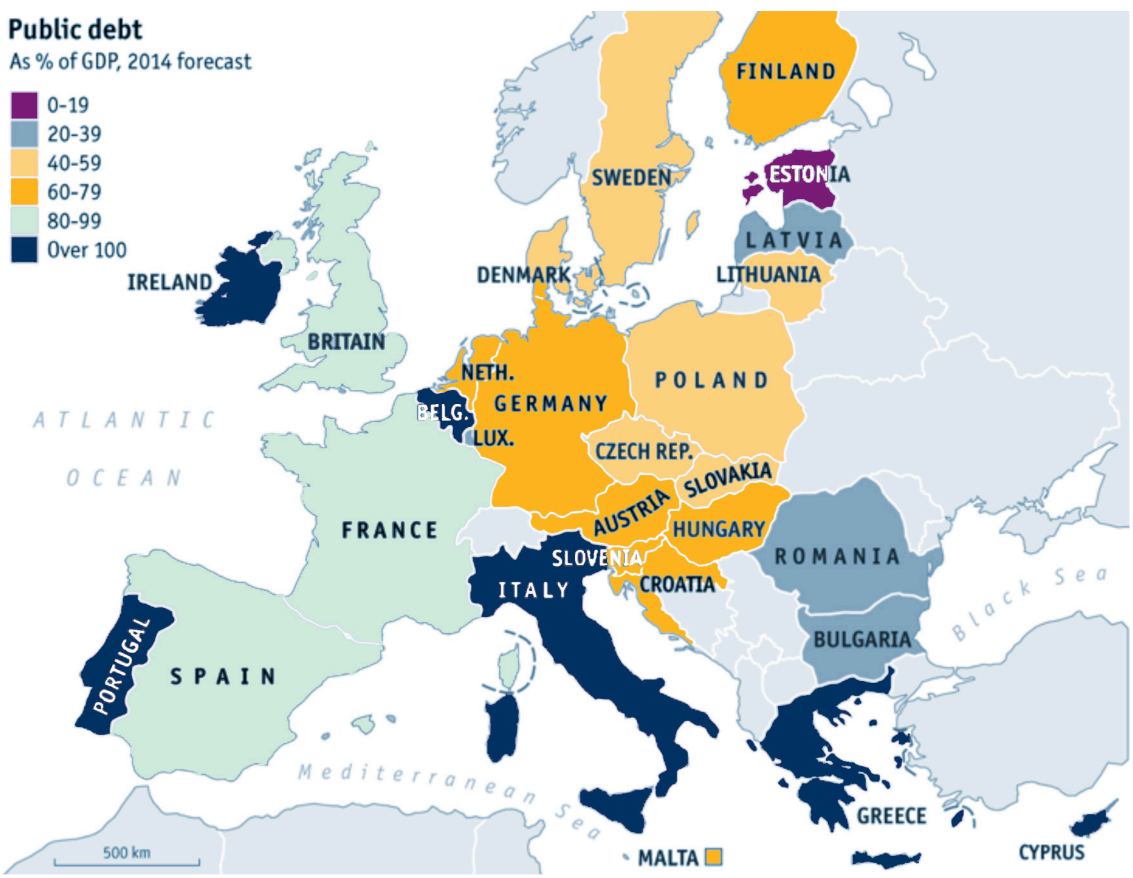
Italy is to introduce some long-needed reforms to the Italian economy. If successful, this will be of significant benefit not only to Italy but to the European economy as a whole [189].

The French economy faces significant adjustments in 2014 that will likely impact growth negatively [189].

The transition economies of Eastern Europe experienced another difficult year in 2013. The EIU estimates that GDP growth dropped to 1.6%, as a marked slowdown in Russia compounded ongoing weak conditions in eastern and central Europe. An improvement across the region is expected in 2014, although negative sentiment toward emerging markets, geopolitical tensions in Ukraine and sanctions against the Russian economy by the West all pose risks [174].

In Europe, recovery is lagging and uneven; unemployment, especially among the young, remains very high; and inflationary pressures are very subdued [175]. The unemployment rate was 12% in 2013, and is expected to rise to 12.1% in 2014, then drop to 11.8% in 2015 [175]. Inflation was at 1.4% in 2013, anticipated to fall to 1.2% by 2015 [175].

FIGURE 22: GOVERNMENT DEBT IN EUROPE AS A PERCENTAGE OF GDP



Source: [203]

Substantial debt consolidation is planned in Europe, especially in Greece, Ireland and Portugal, which have endured the greatest pressure from financial markets and requested assistance from the European Union and the IMF. The extent of the planned debt/GDP consolidation beyond 2013 should reduce the debt-to-GDP ratio [180]. Structural reforms in labour and product markets are considered necessary to boost growth and jobs, with emphasis upon completing the EU Single Market Program [180].

Europe is projected to come out of recession slowly in 2014, but as the labour market recovery typically lags, the growth in output per hour is expected to remain at 0.6% in 2014. More sustainable productivity improvement in Europe will need to come from acceleration in investment and a more efficient allocation and use of resources. Many of those potential gains will arise from the finalisation of a single market in Europe, where labour, capital, products and services can float freely through trade; banking rules are harmonised; and migration and cross-border investments abound. Such sustainable productivity gains will likely take longer to achieve in the wake of the recession [185].

The UK showed an improvement of 0.5% in labour productivity growth in 2013, after a substantial contraction in 2012 (-1.8%). However, its output per hour remains 76% below the USA and well below that of its main continental counterparts, France and Germany [185].

In 2014, Germany is expected to achieve GDP growth of 1.7%, with productivity growth of 1.2%. France is forecast to have a GDP growth of 0.9% and productivity growth of 0.4%. Productivity growth in Spain is expected to drop significantly to only 0.1% (compared to 1.4% in 2013), as the GDP will grow only marginally and hours are expected to grow at almost the same rate as GDP [185].

In Russia, productivity growth declined from 3.1% in 2012 to 1.6% in 2013. There exists much room for improvement, as it remains at only 34% of the US productivity growth [185].

In Spain the unemployment rate is expected to peak in 2014 before gradually declining as growth picks up [204]. Productivity has improved since 2007 but both GDP and employment have fallen, by 4.2% and 13.7% respectively [205]. Productivity in Spain increased in the third quarter of 2013 [206].

In 2013, productivity growth also contracted in Turkey with a decline of -0.6%, compared to -0.8% in 2012. Turkey seems to have suffered severely from the European crisis, but it is forging a difficult transition from a low-cost producing economy to a higher position in the value chain and raising its efficiency through productivity-enhancing investments in labour skills, technology and innovation [185].

5.2.6 SWEDEN

The Swedish economy lost momentum in 2013 with GDP growth slipping to 0.7%, but is set to recover gradually as world trade picks up, and stronger exports and improving business confidence spark a revival in business investment. The unemployment rate is expected to continue to fall, but inflation will remain at modest levels. The OECD forecasts that GDP growth will increase by 2.3% in 2014 and 3% in 2015 [207].

Sweden's growth in 2013 was held back by a weak international economy due to financial and debt crisis. Despite this, the labour market has developed more strongly than expected. In the face of ongoing world economic weakness, exports are only gradually recovering, while households are continuing to increase their consumption. The growth rate will strengthen and unemployment will decline slightly from 8% in 2013 to 7.8% in 2014 and 7.5% in 2015 [207]. However, weak growth remains a risk and the economic outlook remains uncertain [208].

5.2.7 ASIA (OTHER THAN CHINA, JAPAN AND INDIA)

The export-oriented economies of East Asia saw a sharp slowdown in growth through most of 2012 but conditions started to improve toward the end of 2012 and into early 2013, driven by an upturn in industrial output and exports [178].

Singapore continues to suffer from very low growth. In the first quarter of 2013, the economy contracted 0.6% year-over-year and 1.4% quarter-over-quarter, as exports and industrial production remained flat [209].

South Korea, the world's 15th largest economy [210], has maintained low budget deficits and government debt, which is running at 33% of GDP. GDP growth is estimated to be about 1.5% based on first quarter growth. South Korea is rapidly ageing, which will put pressure on government budgets. It is also dominated by a few large conglomerates including Samsung. Some of these have high debt levels and must continue to innovate to remain globally competitive [211].

Malaysia and Vietnam showed an improvement in productivity growth in 2013 while the Philippines and Thailand both suffered a decline. Indonesia's productivity growth slowed significantly, from 5.1% in 2012 to 3.6% in 2013. While the economies of the Association of Southeast Asian Nations (ASEAN) are all affected by the slowdown in global exports, the strengthening of the domestic sectors of most Southeast Asian economies has had strongly positive effects on productivity. Productivity growth in Singapore improved from -2.5% in 2012 to 1.6% in 2013 [185].

5.2.8 LATIN AMERICA

Forecast GDP growth in Latin America will accelerate to 3.2% in 2014, lifted by stronger global growth [174]. Latin America struggled in 2013 with regional growth dampened by less favourable conditions on global capital markets and weak demand in Europe and China. Capital flight prompted by the US Federal Reserve's tapering of its bond-buying program has intensified pressure on regional currencies, notably the Argentinian peso, although economic mismanagement also made this currency especially vulnerable [174].

Labour productivity growth in Latin America decelerated marginally to 0.7% in 2013 from 0.8% in 2012. Brazil and Mexico, the major economies in the region, have shown opposite trends. Brazil has recovered from a negative productivity growth of –0.4% in

2012 to 0.8% in 2013, whereas Mexico lost 0.1% of its productivity growth in 2013, down to 0.3%. The efficiency of resource use, as measured by total factor productivity, declined for both Brazil and Mexico. The main reasons for the brake on productivity include inadequate infrastructure, too little investment in new machinery and equipment, high payroll taxes, and slow improvements in worker skills and management practices [185].

Productivity growth in Latin America is considered the key to unlocking sustainable growth, as the terms of trade become less favourable and expansion of employment and credit dwindles. The importance of improved productivity is also highlighted by the latest annual macroeconomic report of the Inter-American Development Bank (IADB), released on 30 March 2014 [212].

Since 1960 Latin America has gone from being better off on average than the rest of the world to being worse off. The gap between the typical Latin American country and the US has also widened. It has expanded its labour force and its capital stock faster than the US. However, the region's total factor productivity (TFP), the efficiency with which the economy uses its capital and labour, has declined. Latin America's productivity problem looks even worse when compared with Asia. To improve productivity the region must focus on better infrastructure, a reduction in the size of the informal economy, and more efficient adoption of new technologies [212].

In Brazil, GDP grew by 2.5% in 2013, in line with the expectations of Standards & Poor's. This is an improvement on the 1% GDP growth in 2012. This growth is attributed to a recovery in investment and manufacturing (industrial production). GDP growth is forecast to be 2.2% in 2014 and 2.5% in 2015. Inflationary pressures are likely to remain until the effects of tighter monetary policy are felt. Unemployment remains at record low levels. Structural factors underlying weak manufacturing performance need to be addressed to improve growth further, notably by improving infrastructure and by reducing the tax burden and tax complexity [213].

5.2.9 AFRICA AND THE MIDDLE EAST

The EIU is forecasting real GDP growth of 4% for Sub-Saharan Africa in 2014, rising to 5.6% by 2017 [176]. However, the performance of sub-regions and individual states will vary substantially. Countries affected by political unrest or potentially contentious elections could register expansion of less than 2.5%, or even contraction. On the other hand, the strong investment of recent years in the extractive industries will see commodity production continue to rise strongly. More broadly, over the next few years expansion of the lower middle class will stimulate infrastructure spending, which will in turn positively influence regional GDP growth [174].

Political instability in several major economies in the Middle East and North Africa (MENA) are considered by some commentators to be likely to hold back economic performance across the region. The transition to civil authority has created real risks in several countries that experienced political upheavals in the Arab Spring in 2011. The ongoing civil war in

Syria is showing no signs of stopping and is leading to regional sectarian violence [174].

With international attention focused elsewhere (mainly on the crisis sparked by the Russian invasion of Ukraine), the government of the president, Bashar al Assad, may grow in confidence about its longevity and will maintain its military operations against rebel groups. Economic performance in the MENA region may improve in 2014–15 as Iran, among the largest regional economies, returns to growth after two years of contraction caused by international sanctions and a decline in oil production. Heavy capital expenditure among Gulf countries will also continue to move regional growth rates upward [174].

Productivity growth in the MENA region slowed as output growth declined in 2013, due to a combination of weakening oil prices and social and political unrest in the region, while employment growth remained stable [185].

Labour productivity growth in Sub-Saharan Africa has remained at 2.1% in 2013 due to stable output and increasing employment rates. Some African countries have very low levels of productivity (as low as 5% of the US level), but South Africa, the largest economy in the region, reaches 28% of the US productivity level. Estimates for South Africa suggest relatively stable labour productivity growth of over 3%, but there is still scope for more efficient use of resources since TFP growth is declining. There are also large variations in productivity growth between African economies, ranging from more than 4% expansions in large economies such as Ghana and Côte d'Ivoire to contractions in economies such as Zimbabwe and Madagascar [185].

Western aid agencies, Chinese mining companies and UN peacekeepers have helped the economy, but the main contributor to growth is the African population, which has embraced modern technology [214].

Links between Africa and China continue to deepen [215].

Africa's citizens are already striving to become more productive as the Internet changes the way the continent does business. For example, some farmers have been using hand-held devices to get weather reports. Even slum dwellers are using technology. In Kenya, a third of GDP flows through a mobile money-transfer system set up by a private telecommunications company [214].

According to Goldman Sachs' projections, Africa is one of the fast-growing parts of the world, where GDP growth is most likely to accelerate. Education of the young and adoption of technology appear to be transforming Africa [216].

5.2.10 AUSTRALIA

Australia is the world's 12th largest economy by real GDP [217]. The Commonwealth Bank is forecasting real GDP growth of 3% for 2014 and 3% for 2015 [218]. Overall, the economy is lifting and heading back to a 'normal' 3% trend pace. Recent data on consumer spending and dwelling approvals show improvement. Economic momentum is likely to lift over 2014. GDP growth of 2.4% was achieved in 2013 [219].

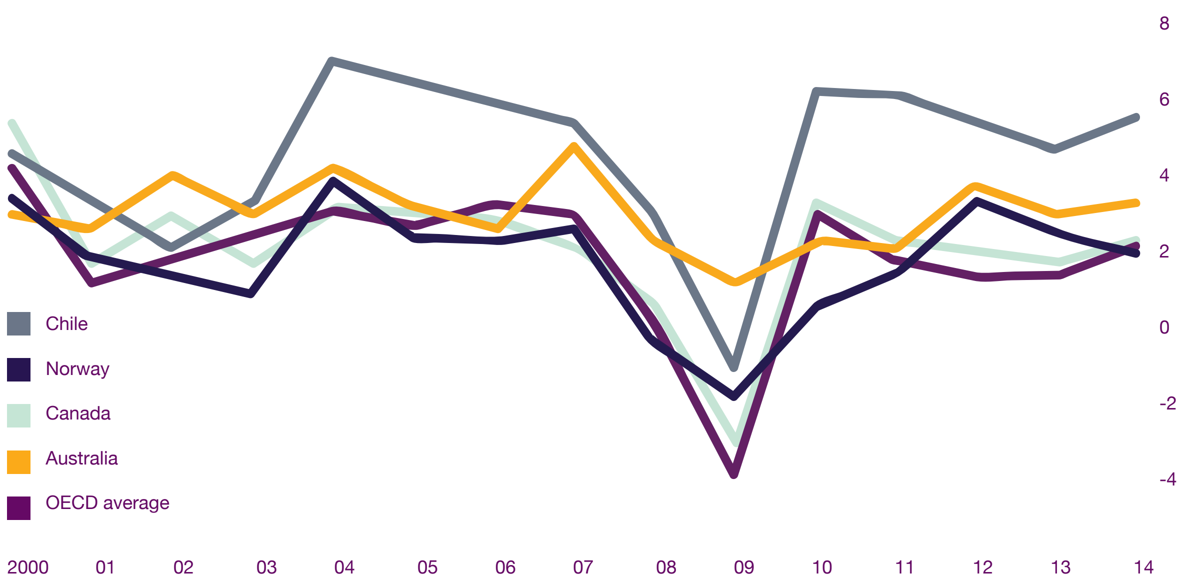
Australia's economy has experienced 22 years of uninterrupted annual growth, low inflation and low unemployment largely due to structural reforms made in the early 1980s and strong demand from Asia, particularly China, for the country's mineral and energy resources. The export-led mining boom has helped to strengthen the Australian dollar. So too have relatively high interest rates and a triple-A credit rating [219]. However, a potential slowdown in China could damage Australia's export economy, and large consumer and financial institution debt means neither the average citizen nor the country's large banks are well prepared for another global economic downturn [211].

Within Australia the economy is generally considered patchy and the Reserve Bank considers that a key challenge facing the economy is managing the rebalancing away from mining investment. The housing sector continues to lift and will help to fill part of the void left by the reduction in mining activity [219].

Since early 2009 the dollar has risen by two-thirds against the American dollar, to above $0.90; however, last year the USD was around $1.05 [219]. The Australian dollar is firmer due to positive local economic growth figures and renewed global risk appetite [220].

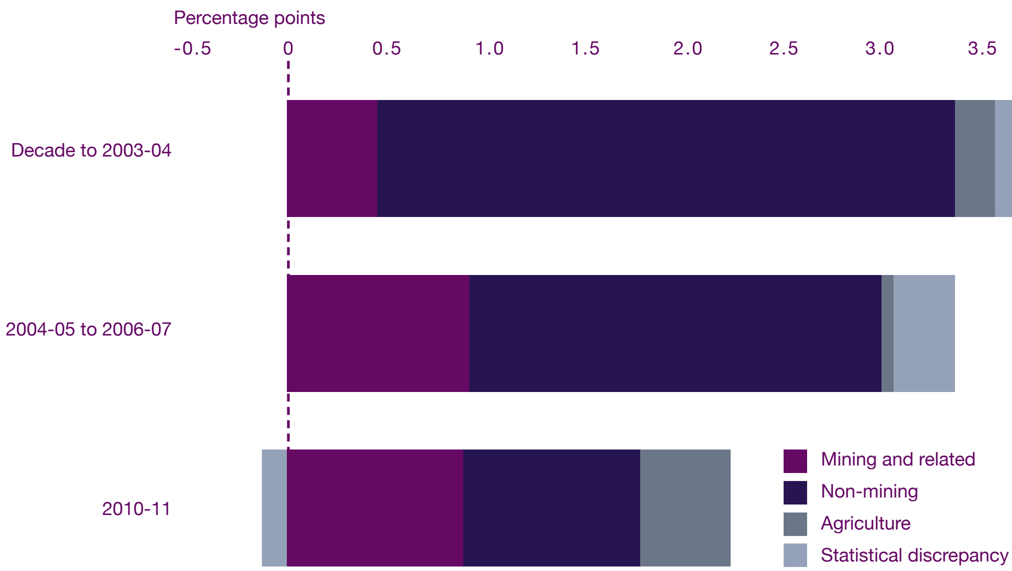
GDP growth through time is shown in Figure 23 and Figure 24:

FIGURE 23: GDP GROWTH OVER TIME



Source: [205]

FIGURE 24: CONTRIBUTIONS TO GDP GROWTH IN AUSTRALIA



Source: [205]

The Australian government's debt-to-GDP ratio was 17.5% in 2013 and 20.7% in 2012. By 2015 this is forecast to fall to 16.6% [221]. The IMF is not overly concerned about Australia's weaker fiscal position because of its relatively low level of debt [211].

Australia's productivity has steadily improved over the past 24 months by 2.7% but has also shown an increase in unemployment.

The unemployment rate rose to 6% in January 2014, the highest level since July 2003. Toyota, Ford and GMH-Holden have all announced they will be shutting down local manufacturing by 2017. Qantas have announced plans to cut 5,000 jobs. These job cuts will impact Australian households and highlight the pressures faced by large companies in Australia. The Reserve Bank left the cash rate unchanged at 2.5% at its board meeting on 4 March 2014. The Bank commented that economic conditions remained mixed and that unemployment will probably rise further before it improves [222]. The OECD predicts that unemployment will rise to 6.1% in December 2014 and 6.3% in December 2015, matching the USA [223].

In 2013, exports to China hit a record $96.7 billion and the trade surplus hit a record $49.1 billion. China accounts for a record 36.3% of exports. The trade surplus is now the highest it has been in over two years [219].

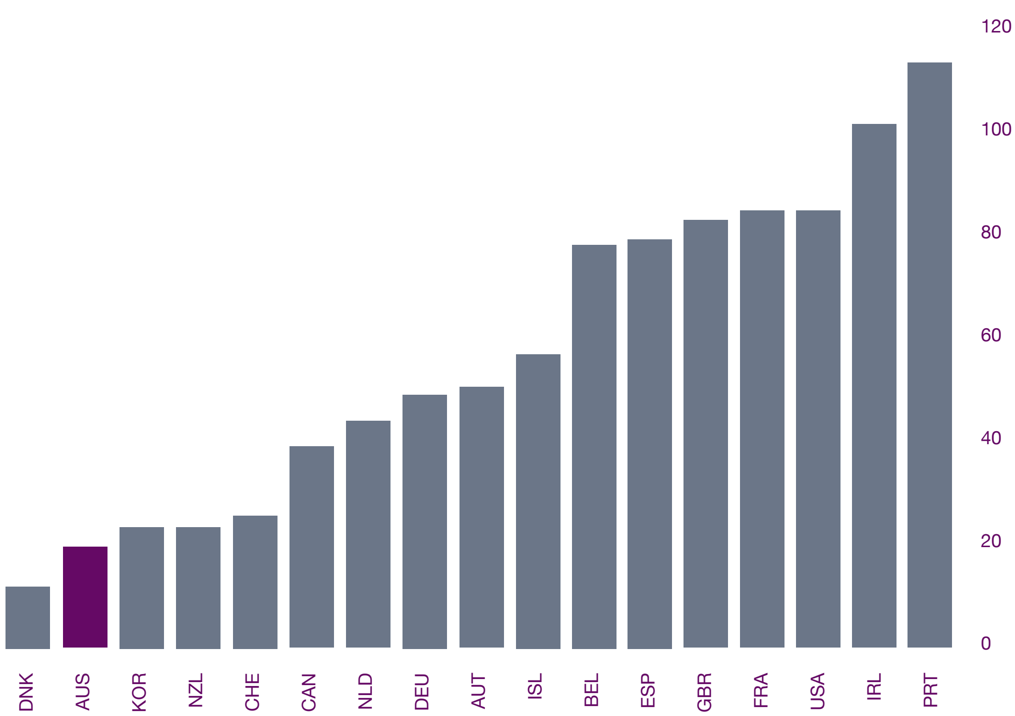
The Productivity Commission has explained much of Australia's slowdown by looking at trends in particular industries. The resource sector has led the fall in productivity, partly because high commodity prices have encouraged miners to chase lower grade or less accessible ore bodies. As mining projects come on stream, productivity should rise. Other resource-rich advanced countries, including Norway and Canada, have experienced similar productivity changes [224].

Business R&D expenditure accounts for about 60% of all Australian R&D activity. On average, public companies in Australia spend over 3% of their turnover on R&D. Small and medium enterprises with up to 200 employees spend an average of 1.5% and those with fewer than 20 employees spend less than 1% [225].

Australia has progressively had its World Economic Forum global competiveness ranking reduced from 15th in 2010/11 to 20th in 2011/12 and finally to 21st in 2012/13. New Zealand, at 18th, has now overtaken Australia. The main areas of concern are the rigidity of the labour market, where Australia is ranked 54th; hiring and firing practices (137th); wage setting (135th); and the burden of government regulations (128th). The business community considers the labour market and bureaucratic red tape as the most problematic aspects of doing business in Australia [225].

Australia currently has a relatively low debt-to-GDP ratio compared to most other developed countries (see Figure 25). In May 2014 the Australian government announced an austerity budget designed to reduce government debt and restore sustainable surpluses over time. The key areas of the budget included funding a National Disability Insurance Scheme and paid parental leave; ending carbon taxation and the mineral resource rent tax; cutting company tax; tightening eligibility for welfare; privatising and merging government agencies; increasing provision for new infrastructure spending; resuming petrol excise indexation; tightening eligibility for welfare; reducing subsidisation of health and education; reducing indexation for age and disability pensioners; reducing public sector employment; and reducing industry assistance [195].

FIGURE 25: GENERAL GOVERNMENT NET DEBT, 2013 (AS A PERCENTAGE OF GDP)

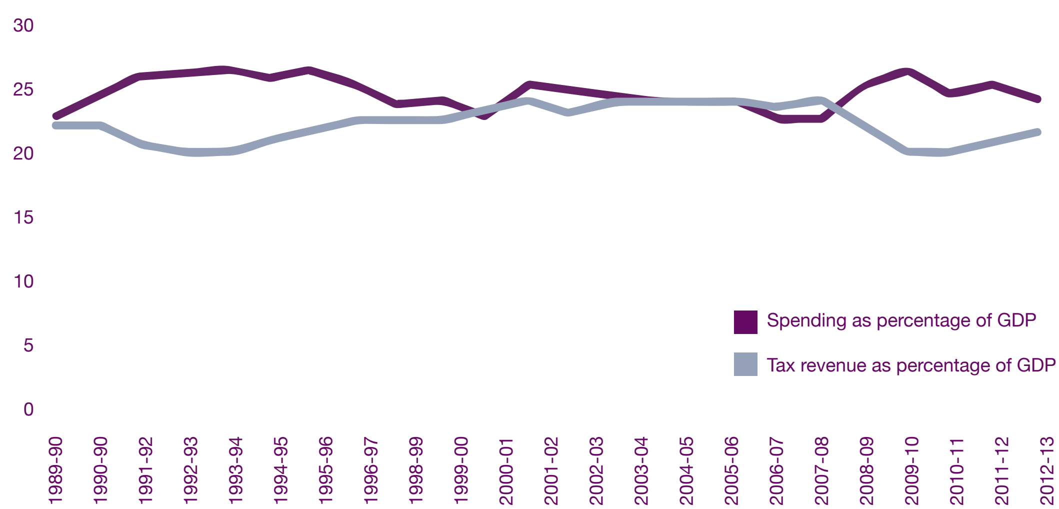


Source: [187]

The budget reduced commercialisation subsidies and R&D tax incentives. A $20 billion sovereign Medical Research Future Fund was established. Agribusiness will have access to a farm finance package of $320 million for debt and drought pressures as well as funds for research in partnership with rural research and development corporations. Higher education fees will be deregulated, potentially leading to increased tuition fees [195]. The Cooperative Research Centre's Program budget was reduced by 12% over the four-year forward estimates period and cuts were also made to CSIRO and the ARC program.

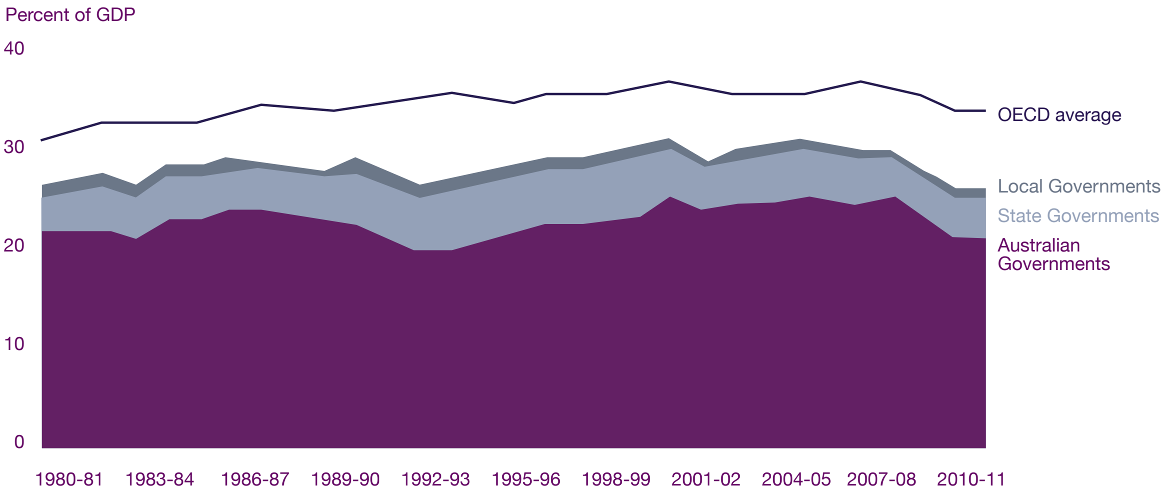
The IMF is of the view that 'gross debt in Australia is expected to peak at around 32% of GDP in 2015 and is among the lowest in advanced nations' [226]. Saul Eslake, chief economist at Bank of America Merrill Lynch, noted that Australia will continue to enjoy relatively low government debt-to-GDP ratio among developed countries up until 2018 [226]. The National Australia Bank predicts that the impact of the federal budget will be to reduce growth in Australia by 0.5% over the next three years [226].

FIGURE 26: AUSTRALIAN FEDERAL GOVERNMENT SPENDING AND TAX REVENUE



Source: [225]

FIGURE 27: AUSTRALIA'S TAX-TO-GDP RATIO BY LEVEL OF GOVERNMENT



Source: [225]

Figure 26 and Figure 27 show that Australians are paying less tax to the Federal Government as a proportion of GDP than they were a decade ago. This is attributable to a series of tax cuts and the global financial crisis. The Federal Government collects around 80% of tax paid in Australia [225].

The 2013–14 budget papers noted that the average tax-to-GDP ratio in the last five years was lower than in any other period since the mid-1990s (see Figure 27) [225].

5.2.11 NEW ZEALAND

The New Zealand economy is beginning to improve, with post earthquake reconstruction, business investment and household spending all increasing. Risks to growth include high private debt levels, weak foreign demand, large external imbalances, volatile terms of trade, a recent drought and an exchange rate that appears overvalued. The main structural challenge will be to create conditions that encourage resources to move toward more sustainable sources of prosperity. Average income per head is well below the OECD average, and productivity growth has been sluggish for a long time. Lifting living standards sustainably and equitably will require structural reforms to improve productivity performance and the quality of human capital [227, 228]. New Zealand's government debt-to-GDP ratio was 37.5% in 2013 and is expected to drop to 35.9% in 2014 [229].

New Zealand became the first developed nation to raise its interest rates in March 2014. It plans to remove stimulus faster than previously forecast to contain inflation [231]. GDP growth in 2013 was 3.2%, higher than the 2.5% in 2012. It is forecast that the GDP growth will increase to 3.3% in 2014 and 2.9% in 2015 [230].

However, GDP per capita is still lower than the top half of OECD nations, primarily as a result of lower than desired labour productivity [231].

The New Zealand Government has identified a number of areas for priority action including health care reforms, improving support for education and R&D and more efficient public spending. An emissions trading scheme has been introduced and personal and corporate income tax rates are being reduced [231].

New Zealand's business confidence dipped slightly in March 2014 but remains at the second-highest rate in 20 years according to the ANZ Bank's business outlook survey [232].

6 CONCLUDING REMARKS

Accelerating developments in spatial and related technologies are occurring. These are driving substantial growth with estimates of up to 30% per annum for the geoservices industries. On the other hand global GDP growth is forecast to average around 2.9% in 2014. These big picture trends suggest that there is ample opportunity for the spatial sciences and the spatial industry to expand its contribution to the economies of the world.

GLOSSARY OF TERMS

BIM	Building Information Models
CAGR	Compound annual growth rate
CRCSI	The Australia New Zealand Cooperative Research Centre for Spatial Information. CRCSI is an international R&D centre set up in 2003 under the Australian Government's CRC Program. CRCSI conducts user-driven research in emerging areas of spatial information that address issues of national importance. The CRCSI also undertakes commissioned research for key clients. Around 100 partnering organisations, drawn from Australian federal and state government agencies, the New Zealand Government, universities and over 50 companies, cumulatively provide $160 million (cash and in kind) over 2010–18 to the activities of the CRCSI.
G7	The G7 is a group consisting of the finance ministers of seven industrialised nations: the US, the UK, France, Germany, Italy, Canada and Japan. They are seven of the eight wealthiest nations on Earth, not by GDP but by global net wealth (China is the eighth). The G7 represents more than the 66% of net global wealth ($223 trillion) according to the September 2012 Credit Suisse Global Wealth Report.
CSIRO	Commonwealth Scientific and Industrial Research Organisation. Australia's national science agency and one of the largest and most diverse research agencies in the world.
GDP	Gross Domestic Product, the market value of all officially recognised final goods and services produced within a country in a given period of time. GDP per capita is often considered an indicator of a country's standard of living.
GNSS	Global Navigation Satellite System, a satellite navigation system with global coverage. As of April 2014, only the US NAVSTAR Global Positioning System and the Russian GLONASS are globally operational GNSSs. China is in the process of expanding its regional BeiDou navigation system into the global Compass navigation system by 2020. The European Union's Galileo positioning system is a GNSS in its initial deployment phase, scheduled to be fully operational by 2020 at the earliest. India and Japan are in the process of developing regional navigation systems.
GPS	Global Positioning System, the US space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the US government and is freely accessible to anyone with a GPS receiver.

IMF	International Monetary Fund, which describes itself as ‘an organisation of 188 countries, working to foster global monetary cooperation, secure financial stability, facilitate international trade, promote high employment and sustainable economic growth, and reduce poverty around the world’. The organisation’s stated objectives are to promote international economic cooperation, international trade, employment, and exchange rate stability, including by making financial resources available to member countries to meet balance of payments needs.
IoT	Internet of Things
LBS	Location-based services
NASA	National Aeronautics and Space Administration, an agency of the US government that is responsible for the nation’s civilian space program and for aeronautics and aerospace research.
OECD	The Organisation for Economic Cooperation and Development, promotes policies that will improve the economic and social wellbeing of people around the world. The OECD provides a forum in which governments can work together to share experiences and seek solutions to common problems; understand what drives economic, social and environmental change; measure productivity and global flows of trade and investment; analyse and compare data to predict future trends; and set international standards on a wide range of issues, from agriculture and tax to the safety of chemicals.
Productivity	A measurement of economic growth of a country. Labour productivity measures the amount of goods and services, or more specifically the amount of real GDP, produced by one hour of labour. Growing labour productivity depends on three main factors: investment and saving in physical capital, new technology and human capital.
PPP	Purchasing Power Parity, an economic theory that estimates the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to each currency's purchasing power. In other words, the exchange rate adjusts so that an identical good in two different countries has the same price when expressed in the same currency.
Real GDP	An inflation-adjusted measure that reflects the value of all goods and services produced in a given year, expressed in base-year prices. Often referred to as ‘constant-price’, ‘inflation-corrected’ or ‘constant dollar’ GDP.

Total Factor Productivity (Multi-Factor Productivity)	Total factor productivity (TFP), also called multi-factor productivity, is a variable that accounts for effects in total output not caused by traditionally measured inputs of labour and capital. If all inputs are accounted for, then total factor productivity (TFP) can be taken as a measure of an economy's long-term technological change or technological dynamism.
UAVs	Unmanned Aerial Vehicles, colloquially known as drones, are aircraft without a human pilot on board. Their flight is controlled either autonomously by computers in the vehicle or under the remote control of a pilot on the ground or in another vehicle. A wide variety of UAV shapes, sizes, configurations, and characteristics exists. Historically, UAVs were simple remotely piloted aircraft, but autonomous control is being employed more frequently.
WEF	The World Economic Forum is an independent international organisation committed to improving the state of the world by engaging business, political, academic and other leaders of society to shape global, regional and industry agendas.

REFERENCES

[1] World Economic Forum, 'Global Information Technology Report', accessed May 8, 2013, http://www.weforum.org/reports/global-information-technology-report-2013

[2] Strategy&, 'Digitization', accessed April 15, 2013, http://www.booz.com/global/home/what-we-think/digitization

[3] Elliot M, 'Megatrends and what's on the horizon', accessed February 19, 2014, http://www.ey.com/Publication/vwLUAssets/EY_-_Megatrends_and_what's_on_the_horizon/$FILE/EY-com_gl_state_of_mining_and_metals.pdf

[4] PriceWaterhouseCoopers, 'Five global megatrends', accessed February 19, 2014, http://www.pwc.com/gx/en/annual-review/megatrends/index.jhtml

[5] McKee L, 'OGC Identifies Geospatial Megatrend and Some Ripe Issues', Directions Magazine, published December 19, 2013, http://www.directionsmag.com/articles/ogc-identifies-geospatial-megatrend-and-some-ripe-issues/373566

[6] Oxera, 'What is the economic impact of Geo services? A report prepared for Google', accessed May 8, 2013, http://www.oxera.com/Oxera/media/Oxera/downloads/reports/What-is-the-economic-impact-of-Geo-services_1.pdf

[7] Federal Geographic Data Committee, 'National Spatial Data Infrastructure Strategic Plan 2014–2016', accessed February 19, 2014, http://www.fgdc.gov/nsdi-plan/nsdi-strategic-plan-2014-2016-FINAL.pdf

[8] Boston Consulting Group, 'Geospatial Services: A $1.6 Trillion Growth Engine for the US Economy', accessed May 8, 2013, http://www.bcg.com/documents/file109372.pdf

[9] Teal Group Corporation, 'Teal Group Analysts Identify 3,164 Space Payloads Proposed For Launch To 2032 With An Estimated Value Of More Than $235 Billion', accessed April 9, 2014, http://tealgroup.com/index.php/about-teal-group-corporation/press-releases/104-teal-group-analysts-identify-3-164-space-payloads-proposed-for-launch-to-2032-with-an-estimated-value-of-more-than-235-billion

[10] Union of Concerned Scientists, 'UCS Satellite Database', accessed April 9, 2014, http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html

[11] BCC Research, 'Remote Sensing Technologies and Global Markets', last modified September 2013, accessed April 16, 2014, http://www.bccresearch.com/market-research/instrumentation-and-sensors/remote-sensing-technologies-ias022d.html

[12] Euroconsult, 'Earth Observation Industry Remains Buoyant Despite Challenging Economic Environment', accessed April 16, 2014, http://www.euroconsult-ec.com/news/press-release-33-7/52.html

[13] Euroconsult, 'Satellite-Based Earth Observation', accessed April 30, 2014, http://www.euroconsult-ec.com/research-reports/space-industry-reports/satellite-based-earth-observation-38-42.html

[14] BBC Research LLC, 'BCC Research Publishes a New Report on Global Markets for Remote Sensing Products, Directions Magazine, accessed April 16, 2014, http://www.directionsmag.com/pressreleases/bcc-research-publishes-a-new-report-on-global-markets-for-remote-sensi/356450

[15] Berkenstock D, 'The World is One Big Data Set', accessed April 30, 2014, http://www.ted.com/talks/dan_berkenstock_the_world_is_one_big_dataset_now_how_to_photograph_it

[16] Selding PB, 'Planet Lab Secures Funding to Launch Another 72 Satellites', accessed April 30, 2014, http://www.spacenews.com/article/financial-report/39883planet-labs-secures-funding-to-launch-another-72-satellites

[17] Kumagai J, '9 Earth Imaging Startups to Watch' (published in IEEE Spectrum), accessed June 4, 2014, http://spectrum.ieee.org/aerospace/satellites/9-earthimaging-startups-to-watch

[18] PlanetiQ, 'Why PlanetiQ?', accessed April 30, 2014, http://www.planetiq.com/why-planet-iq/

[19] GeoOptics, 'Overview', accessed April 30, 2014, http://geooptics.com

[20] National Research Council, 'Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey', National Academies Press, Washington DC, 2012

[21] UN Initiative on Global Geospatial Information Management, 'Future trends in geospatial information management: the five to ten year vision', accessed April 30, 2014, http://ggim.un.org/docs/Future-trends.pdf

[22] Barker G, 'Apple iBeacon: signs of new direction' (published in the Sydney Morning Herald), accessed April 30, 2014, http://www.smh.com.au/digital-life/digital-life-news/apple-ibeacon-signs-of-new-direction-20140402-35x1j.html

[23] Kahn J, ‘MFi Sunglasses w/ embedded iBeacon notify you when lost, act as beacons in retail’ (published in 9to5mac), accessed April 30, 2014, http://9to5mac.com/2014/04/28/mfi-sunglasses-w-embedded-ibeacon-notify-you-when-lost-act-as-beacons-in-retail/

[24] Ball M, ‘Interior Location and Mapping: Prompted by Innovations that Improve Position and Navigation’ (published in Informed Infrastructure), accessed January 30, 2013, ‘http://informedinfrastructure.com/2668/interior-location-and-mapping-prompted-by-innovations-that-improve-position-and-navigation/

[25] European Global Navigation Satellite Systems Agency, ‘Market Report’, accessed April 16, 2014, http://www.gsa.europa.eu/market/market-report

[26] Shankland S, ‘With Firefox OS, Mozilla begins the $25 smartphone push’ (published in CNET), accessed April 16, 2014, http://www.cnet.com/news/with-firefox-os-mozilla-begins-the-25-smartphone-push/

[27] Wikipedia, ‘Satellite Navigation’, accessed April 30, 2014, http://en.wikipedia.org/wiki/Satellite_navigation

[28] Dr Phil Collier, Research Director CRCSI, personal communication, April 2014

[29] Ramirez E and Wolf G, ‘The State of Self-Tracking’ (published in The Health Care Blog based on a report by the ABI Marketing Group), accessed March 31, 2013, http://thehealthcareblog.com/blog/2013/03/17/the-state-of-self-tracking/

[30] Leavitt N, ‘2013 Mobile Marketing/Technology Trends’ (published in iMedia Connection), accessed April 6, 2013, http://blogs.imediaconnection.com/blog/2012/12/26/2013-mobile-marketingtechnology-trends/

[31] Victorian Information and Communications Technology Advisory Committee, ‘Victorian Government ICT Strategy’, accessed May 8, 2013, http://digital.vic.gov.au/wp-content/uploads/2013/02/Victorian-Government-ICT-Strategy-web.pdf

[32] Nielsen, ‘The Mobile Consumer Report’, accessed May 8, 2014, http://www.nielsen.com/us/en/reports/2013/mobile-consumer-report-february-2013.html

[33] Insead, ‘Press Releases – 2013’, accessed May 2, 2013, http://www.insead.edu/media_relations/press_release/2013_ATT-INSEAD-productivity-report.cfm

[34] Cisco, ‘Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013–2018’, accessed April 2, 2014, http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html

[35] Open Mobile Media, ‘Smart Homes Connect to Europe’s power grid, part I’, accessed April 16, 2014, ihttp://analysis.openmobilemedia.com/apps-mobile-tech/smart-homes-connect-europe’s-power-grid-part-i

[36] Vandrico Inc, ‘Wearable Tech Market’, accessed April 30, 2014, http://vandrico.com/database

[37] Whitney L, ‘Apple iWatch could trigger sales as high as $17.5B – analyst’ (published in CNET), accessed February 5, 2014, http://news.cnet.com/8301-13579_3-57618292-37/apple-iwatch-could-trigger-sales-as-high-as-$17.5b-analyst/

[38] Pebble, Home Page, accessed February 5, 2014, https://getpebble.com/

[39] Brooks R, ‘Mercedes Teams Up With Pebble Smartwatch To Create A Fleet Of Connected Cars’ (published in PSFK), accessed February 19, 2014, http://www.psfk.com/2014/01/mercedes-pebble-watch-smart-cars.html#!vn8tn

[40] Wikipedia, ‘Samsung Galaxy Gear’, accessed February 5, 2014, http://en.wikipedia.org/wiki/Samsung_Galaxy_Gear

[41] Fitbit, Home Page, accessed February 5, 2014, http://www.fitbit.com/au

[42] Jawbone, ‘Up’, accessed May 8, 2014, https://jawbone.com/up#up24

[43] Nike, ‘Nike+ FuelBand’, accessed February 5, 2014, http://www.nike.com/us/en_us/c/nikeplus-fuelband

[44] Sony, ‘SmartBand SWR10’, accessed February 5, 2014, http://www.sonymobile.com/au/products/smartwear/smartband-swr10/

[45] Wikipedia, ‘Google Glass’, accessed February 5, 2014, http://en.wikipedia.org/wiki/Google_Glass

[46] Panzarino M, ‘Facebook To Buy Oculus VR, Maker Of The Rift Headset, For Around $2B In Cash And Stock’ (published in Tech Crunch), accessed April 16, 2014, http://techcrunch.com/2014/03/25/facebook-to-buy-oculus-vr-maker-of-the-rift-headset-for-around-2b-in-cash-and-stock/

[47] Lomas N, ‘Wearables Market Heating Up, With More Than 17M Bands Forecast To Ship This Year, Says Canalys’ (published in Tech Crunch), accessed April 29, 2014, ‘http://techcrunch.com/2014/02/12/wearables-market-heating-up/

[48] Tucker RS, ‘The Rise and Fall of Australia’s $44 Billion Broadband Project’ (published in IEEE Spectrum), accessed April 2, 2014, http://spectrum.ieee.org/telecom/internet/the-rise-and-fall-of-australias-44-billion-broadband-project

[49] IEEE Computer Society, 'Top Technology Trends for 2010', accessed February 19, 2014, http://www.computer.org/portal/web/membership/Top-10-Tech-Trends-in-2014

[50] Murray M, '2014 Tech Predictions' (published in PC Mag), accessed April 16, 2014, http://www.pcmag.com/article/print/319291

[51] PR Newswire, 'Wireless Sensor Networks: Market Shares Strategies, and Forecasts, Worldwide, 2013 to 2019', accessed March 31, 2014, http://www.prnewswire.com/news-releases/wireless-sensor-networks-market-shares-strategies-and-forecasts-worldwide-2013-to-2019-233305991.html

[52] Silicon Labs, 'Overcoming Challenges of Connecting Intelligent Nodes to the Internet of Things', published 2012, accessed February 19, 2014, http://www.silabs.com/Support%20Documents/TechnicalDocs/bringing-the-internet-of-things-to-life.pdf

[53] Sense-T, 'Public Lecture: The World Bank eye on Tasmanian technology disrupters', accessed April 16, 2014, http://www.sense-t.org.au/latest-news/news-items/public-lecture-with-chris-vein-of-the-world-bank

[54] Taggle, 'Revolutionising Low Cost Monitoring for Australian Water Utilities', accessed March 31, 2014, http://www.taggle.com.au

[55] Rose A, 'The internet of things is set to change security priorities' (published in Computer Weekly), accessed February 19, 2014, http://www.computerweekly.com/feature/The-internet-of-things-is-set-to-change-security-priorities

[56] Wikipedia, 'Heartbleed', accessed May 8, 2014, http://en.wikipedia.org/wiki/Heartbleed

[57] Cervantes E, 'Google acquires SlickLogin – the quest to improve the annoying password issue' (published in Chrome Spot), accessed February 19, 2014, http://chromespot.com/2014/02/17/google-acquires-slicklogin-password-authentication/

[58] Gartner, 'Gartner Identifies the Top 10 Strategic Technology Trends for 2014', accessed February 5, 2014, http://www.gartner.com/newsroom/id/2603623

[59] Basulto D, '10 bold predictions for 2014' (published by the Washington Post), accessed February 19, 2014, http://www.washingtonpost.com/blogs/innovations/wp/2014/01/07/10-bold-predictions-for-2014/

[60] University of Sheffield Institution of Mechanical Engineers, 'Sheffield University produces 3D printed UAV', accessed May 8, 2014, http://www.imeche.org/news/engineering/sheffield-university-produces-3d-printed-uav-280314-1

[61] PR Newswire, '"The Human Face of Big Data" Large Format Illustrated Book is Being Delivered Today by FedEx to 100,000 of the World's Most Influential People, Including World Leaders, Fortune 500 CEOs, and Nobel Laureates', accessed May 7, 2014, http://www.prnewswire.com/news-releases/the-human-face-of-big-data-large-format-illustrated-book-is-being-delivered-today-by-fedex-to-10000-of-the-worlds-most-influential-people-including-world-leaders-fortune-500-ceos-and-nobel-laureates-181982991.html

[62] Brock J, Souza R, Platt J and Dreishmeier R, 'Big Data's Five Routes to Value', accessed May 7, 2014, (published in BCG perspectives), https://www.bcg perspectives.com/content/articles/information_technology_strategy_digital_economy_opportunity_unlocked_big_data_five_routes_value/

[63] Sourabh, 'Business Software Alliance (BSA) Global Cloud Computing Scorecard' (published by Source Digit), accessed April 2, 2014, http://sourcedigit.com/493-business-software-alliance-bsa-global-cloud-computing-scorecard/

[64] Computerworld India staff, 'Gartner: Big data to drive $34 billion of IT spending in 2013' (published in IT World), accessed April 16, 2014, http://www.itworld.com/it-managementstrategy/304206/gartner-big-data-drive-34-billion-it-spending-2013

[65] LBx Journal, 'Location SmartBrief', accessed April 16, 2014, http://www2.smartbrief.com/servlet/ArchiveServlet?issueid=DD2E9EAC-75C4-4AF1-A667-1115F4FB0F2D&lmid=archives

[66] IEEE Computer Society, 'IEEE Computer Society Announces 13 Technology Trends for 2013', accessed April 16, 2014, http://www.computer.org/portal/web/pressroom/IEEE-Computer-Society-Announces-13-Technology-Trends-for-2013

[67] McKinsey Global Institute, 'Big Data: The next frontier for innovation, competition and productivity', published May 2011

[68] Steve Jacoby (Queensland Government), personal communication June 23, 2014

[69] Lateral Economics, 'Open for Business: How Open Data Can Help Achieve the G20 Growth Target', June 2014 http://www.omidyar.com/sites/default/files/file_archive/insights/ON%20Report_061114_FNL.pdf

[70] Steudler D and Rajabifard A (Eds.), 'Spatially Enabled Society' (published in FIG publication no. 58), accessed May 8, 2014, http://www.fig.net/pub/figpub/pub58/figpub58.pdf

[71] Houghton J, 'Costs and Benefits of Data Provision', accessed May 8, 2014, http://ands.org.au/resource/houghton-cost-benefit-study.pdf

[72] Clarke T, 'Just do it: Nike opens access to customer data', accessed January 22, 2013, http://www.theage.com.au/it-pro/business-it/just-do-it-nike-opens-access-to-customer-data-20130122-2d3tt.html#ixzz2IlX3zt2m

[73] Van Oosterom P, Zlatanova P, Penninga F and Fendel E (Eds.), 'Advances in 3D geoinformation systems', Springer Verlag, 2008

[74] Abdul-Rahman A and Pilouk M, 'Spatial data modeling for 3D GIS', Springer Verlag, 2008

[75] Mallet JL, 'Geomodelling', Oxford University Press, New York, USA, 2002, p 599

[76] Mäntylä M, 'An introduction to solid modeling', Computer Science Press , New York, USA, 1988

[77] Cheney LM, 'Geographical and Building Information Systems Integration', accessed May 8, 2014, http://ufdcimages.uflib.ufl.edu/UF/E0/04/16/58/00001/cheney_l.pdf

[78] Pitney Bowes Software, 'A Golden Opportunity: Truly Integrated 3D GIS', accessed April 29, 2014, http://www.mapinfo.com/wp-content/uploads/2014/01/CDLI_GLBL_3DGIS_WhitePaper.pdf

[79] Zeiss G, 'Mobile scanning interiors of buildings with automatic feature extraction for energy performance modeling' (In: Between the Poles), accessed April 29, 2014, http://geospatial.blogs.com/geospatial/bim/page/2/

[80] BuildingSMART Australasia, 'National Building Information Modelling Initiative Volume 1: Strategy', accessed April 6, 2013, http://buildingsmart.org.au/nbi-folder/NationalBIMIniativeReport_6June2012.pdf updated August 2012

[81] Surveying and Spatial Sciences Institute, '2013 GIS in local government benchmark study', August 2013, https://esriaustralia.com.au/u/lib/cms/2013-gis-in-local-government-benchmark-study.pdf

[82] Song C, Qu Z, Blumm N and Barabasi A, 'Limits of predictability in human mobility', Science 327 (2010): 1018–21

[83] Scoble R and Israel S, 'Age of Context: Mobile, Sensors, Data and the Future of Privacy', Creative Space Independent Publishing Platform, September 2013

[84] Hiner J, 'CES 2014: Four mega-trends for the professionals' (published in ZDNet), accessed February 19, 2014, http://www.zdnet.com/ces-2014-four-mega-trends-for-the-professionals-7000024727/

[85] Google, 'Google now', accessed April 30, 2014, http://www.google.com.au/landing/now/#

[86] Percivall G, ‘The Power of Location’ (published in OGC), accessed February 19, 2014, http://www.opengeospatial.org/blog/1817

[87] IBM, ‘IBM Reveals Five Innovations That Will Change Our Lives within Five Years’, accessedApril16,2014,http://www-03.ibm.com/press/us/en/pressrelease/42674.wss

[88] LBx Journal, ‘Location SmartBrief’, accessed April 16, 2014, http://www2.smartbrief.com/servlet/ArchiveServlet?issueid=99038395-D494-4EF9-B3C8-D90FE1A295D1&lmid=archives

[89] PredPol, ‘Scientifically Proven Field Results’, accessed February 5, 2014, http://www.predpol.com/results/

[90] Cett H, ‘Berg launches insight into retail M2M market’, accessed May 7, 2014, http://www.gomonews.com/berg-launches-insight-into-retail-m2m-market/

[91] Bilton N, ‘Disruptions: Coming in 2014: Extremely Smart Watches and Wearable TVs’, accessed February 5, 2014, http://bits.blogs.nytimes.com/2013/12/29/disruptions-coming-in-2014-extremely-smart-watches-and-wearable-tvs/?_php=true&_type=blogs&_r=0

[92] Percivall G, ‘Mobile Development’, accessed February 19, 2014, http://www.opengeospatial.org/blog/1826

[93] Google, ‘Google Goggles’, accessed April 16, 2014, https://play.google.com/store/apps/details?id=com.google.android.apps.unveil

[94] Red Orbit, ‘Researchers Create New Augmented Reality Chip for Head-Mounted Display’, accessed February 19, 2014, http://www.redorbit.com/news/technology/1113073697/k-glass-developed-by-kaist-021814/

[95] Wikipedia, ‘Augmented reality’, accessed February 19, 2014, http://en.wikipedia.org/wiki/Augmented_reality

[96] Open Geographical Consortium, ‘ARML 2.0 SWG’, accessed April 16, 2014, http://www.opengeospatial.org/projects/groups/arml2.0swg

[97] Barter P, ‘Is 30% of traffic actually searching for parking?’, accessed March 31, 2014, http://www.reinventingparking.org/2013/10/is-30-of-traffic-actually-searching-for.html

[98] Harper SF, ‘Introduction to “Big Data” (and Friends)’, accessed April 2, 2014, http://www.eli.org/sites/default/files/docs/big_data/harper_presentation.pdf

[99] SmartSantander Project, ‘Smart Santander Testbeds’, accessed April 2, 2014, http://smartsantander.eu/wiki/index.php/Experimentation/Testbeds

[100] Bielsa A, ‘Wireless Applications: The Smart City Project in Santander’, accessed March 31, 2014, http://www.sensorsmag.com/wireless-applications/smart-city-project-santander-11152

[101] IBM, ‘Smarter Cities’, accessed April 16, 2014, https://www.ibm.com/smarter planet/au/en/smarter_cities/ideas/index.html?re=sph

[102] Mitchell B, ‘DC Autonomous Car Proposal’, accessed April 16, 2014, http://www.scribd.com/doc/216865192/DC-Autonomous-Car-Proposal

[103] Ross PE, ‘California to Issue Driving Licences to Robots’, IEEE Spectrum, accessed June 4, 2014, http://spectrum.ieee.org/cars-that-think/transportation/advanced-cars/california-driving-licenses-autonomous-cars

[104] Senate Majority Caucus, ‘Legislation Introduced on Autonomous Vehicles’, accessed April 12, 2012, http://democrats.senate.ca.gov/news/2012-03-02-legislation-introduced-autonomous-vehicles

[105] Reynolds E, ‘Motoring bosses weigh up new laws to steer use of driverless cars’, accessed April 30, 2014, http://www.theaustralian.com.au/executive-living/motoring-bosses-weigh-up-new-laws-to-steer-use-of-driverless-cars/story-e6frg9zo-1226852390434

[106] Mack E, ‘Elon Musk: Tesla Will Be First With Autonomous Driving; Admits To Apple Meeting’, accessed April 30, 2014, http://www.forbes.com/sites/ericmack/2014/02/19/elon-musk-tesla-will-be-first-with-autonomous-driving-admits-to-apple-meeting/

[107] Frog, Co.Design, ’20 Tech Trends That Will Define 2013, Selected By Frog’, accessed April 7, 2013, http://www.fastcodesign.com/1671397/20-tech-trends-that-will-define-2013-selected-by-frog#7

[108] Driverless car market watch, ‘Key Players’, accessed April 16, 2014, http://www.driverless-future.com/?page_id=155

[109] ‘Driverless car legalized in California’ (published in The Australian), accessed April 30, 2014, http://www.theaustralian.com.au/technology/driverless-car-legalised-in-california/story-e6frgakx-1226481740630

[110] Eno Transportation Foundation, Inc., ‘Preparing a Nation for Autonomous Vehicles’, published October 2013, accessed April 30, 2014, https://www.eno trans.org/wp-content/uploads/wpsc/downloadables/AV-paper.pdf

[111] Clark Estes A, ‘What’s Keeping Self-Driving Cars Off the Road?’, accessed 30 April, 2014, http://www.gizmodo.com.au/2013/10/whats-keeping-self-driving-cars-off-the-road/

[112] ‘Autonomous vehicles – the next revolution’, accessed April 30, 2013, http://www.globalskm.com/Insights/Achieve-Articles/Items/2013/Autonomous-vehicles-the-next-revolution-the-road-ahead.aspx

[113] ITS Australia, ‘Cooperative Intelligent Transport Systems close to reality: ITS Australia’, accessed May 8, 2014, http://www.its-australia.com.au/wp-content/uploads/ITS-ARelease02EC7Mar13-2.pdf

[114] Research and Innovative Technology Administration, ‘Vehicle-to-Vehicle (V2V) Communications for Safety’, accessed May 5, 2014, http://www.its.dot.gov/factsheets/v2v_factsheet.htm

[115] Terrafugia, Home Page, accessed April 30, 2014, http://www.terrafugia.com

[116] Teal Group Corporation, ‘Teal Group Predicts Worldwide UAV Market Will Total $89 Billion in Its 2013 UAV Market Profile and Forecast’, accessed May 8, 2014, http://tealgroup.com/index.php/about-teal-group-corporation/press-releases/94-2013-uav-press-release

[117] Association for Unmanned Vehicle Systems International, ‘Economic Report’, accessed June 4, 2014, http://www.auvsi.org/econreport

[118] Civil Aviation Safety Authority, ‘Review of Regulations and Guidance Material relating to Unmanned Aircraft Systems (UAS)’, accessed April 30, 2014, http://www.casa.gov.au/scripts/nc.dll?WCMS:PWA::pc=PC_100532

[119] Australian Government, National Aviation Policy: White Paper’, published December 2009, accessed May 9, 2014 http://www.infrastructure.gov.au/aviation/publications/pdf/Aviation_White_Paper_final.pdf

[120] Strickland E, ‘Meet the Robots of Fukushima Daiichi’ (In: IEEE Spectrum), accessed May 4, 2014, http://spectrum.ieee.org/slideshow/robotics/industrial-robots/meet-the-robots-of-fukushima-daiichi

[121] Maritime Unmanned Navigation through Intelligence in Networks’, Home Page, accessed March 31, 2014, http://www.unmanned-ship.org/munin/

[122] Jet Propulsion Laboratory, California Institute of Technology, ‘Intelligent Autonomy for Maritime Navigation on Unmanned Surface Vehicles’, accessed April 30, 2014, http://www-robotics.jpl.nasa.gov/tasks/showTask.cfm?FuseAction=showTask&TaskID=164&tdaID=103765

[123] US Department of Labour, ‘Occupational Outlook Handbook 2012–13’, accessed May 13, 2013, http://www.bls.gov/ooh/

[124] The Allen Consulting Group (2010) 'Spatial Market Infrastructure', briefing note to the Department of Sustainability and Environment, accessed May 5, 2013, http://crcsi.com.au.stage.gs/getattachment/e686d67f-a9b0-438f-b32f-eae 495165d6e/Briefing-Note--Spatial-Market-Infrastructure.aspx

[125] ACIL Tasman and Spatial Information Services, 'Surveying and geospatial workforce modelling: Potential skills gap analysis for Queensland in particular with estimates extrapolated up for Australia', published 2013, accessed May 9, 2014 http://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=w eb&cd=1&cad=rja&uact=8&ved=0CBwQFjAA&url=http%3A%2F%2Fwww.crcsi. com.au%2Fgetattachment%2F5680d69c-dcd2-4c87-a821-051161e2d501%2F Queensland-surveying-and-geospatial-skills-gap-fin.aspx&ei=l5bYU-iXCsGm8A WdyIHYDw&usg=AFQjCNHfwRBQGw4_1M0m8afeLxjF54bywA&sig2=IBsrdcDx 1EgwK3ymPSpOeg

[126] Bay Area Council, 'New Study: For Every New, High-Tech Job, Four More Created', accessed April 7, 2013, http://www.bayareacouncil.org/news/2012/12/10/new-study-for-every-new-high-tech-job-four-more-created/

[127] Patel P, 'Early Signs Show Tech Jobs Doing Well', accessed January 24, 2013, http://spectrum.ieee.org/tech-talk/at-work/tech-careers/early-signs-show-tech-jobs-doing-well

[128] US National Academy of Science, 'Future U.S. Workforce for Geospatial Intelligence', published 2013, accessed May 8, 2014, http://www.nap.edu/catalog.php?record_id=18265

[129] Kang C, 'Consumer Electronics Show will highlight new ways to collect biometric data' (In: The Washington Post), accessed February 19, 2014, http://www.washingtonpost.com/business/technology/consumer-electronics-show-will-highlight-new-ways-to-collect-biometric-data/2014/01/05/e8eac584-74c4-11e3-8def-a33011492df2_story.html

[130] Rozenfeld M, 'The First Phone Designed With Privacy in Mind', accessed April 16, 2014, http://theinstitute.ieee.org/ieee-roundup/opinions/ieee-roundup/the-first-phone-designed-with-privacy-in-mind

[131] The Location Forum, 'Location Data Privacy Guidelines', accessed June 17, 2014, http://www.thelocationforum.org/location-data-privacy-guidelines/

[132] Australian Government Department of Resources, Energy and Tourism, 'ANZ Foundation Spatial Data Framework', published November 2012

[133] Lynch A, '5 New Stars of Australian Crowdsourcing', accessed March 31, 2014, http://e27.co/5-new-stars-of-australian-crowdsourcing/

[134] Burns R and Shanley LA, Wilson Center, ‘Connecting Grassroots to Government for Disaster Management: Workshop Summary’, accessed March 31, 2014, http://www.wilsoncenter.org/sites/default/files/STIP_Connecting-Grassroots-Workshop-Summary_Final2.pdf

[135] Wikipedia, ‘List of crowdsourcing projects’, accessed March 31, 2014, http://en.wikipedia.org/wiki/List_of_crowdsourcing_projects

[136] Thermopylae Sciences + Technology, ‘3D UDOP’, accessed April 16, 2014, http://www.gsdi.org/gsdiconf/gsdi12/slides/4.3d.pdf

[137] Kuriakose D, ‘FEMA App Adds Crowdsourcing for Disaster Relief’, accessed March 31, 2014, http://mashable.com/2013/07/29/fema-app-disaster-relief/

[138] Ralston N, ‘Search for Malaysia Airways plane turns to crowdsourcing for clues’, accessed March 31, 2014, http://www.smh.com.au/technology/technology-news/search-for-malaysia-airlines-plane-turns-to-crowdsourcing-for-clues-20140311-34ja9.html

[139] Zielinski C, ‘Malaysia Airways plane is in Malacca Strait, says crowd of 3 million’ (In: The Age), accessed March 31, 2014, http://www.theage.com.au/technology/technology-news/malaysia-airlines-plane-is-in-malacca-strait-says-crowd-of-3-million-20140319-hvkcp.html

[140] Tomnod, Home Page, accessed March 31, 2014, http://www.tomnod.com/nod/

[141] Ellery D, ‘Tomnod, Google Earth and MH370 change the world’, accessed April 9, 2014, http://www.smh.com.au/technology/technology-news/tomnod-google-earth-and-mh370-change-the-world-20140407-369cg.html

[142] BlackBridge, ‘Malaysia Airways – Flight 370’, accessed April 16, 2014, http://www.blackbridge.com/rapideye/news/action/malaysiaair.html

[143] ‘Victorian Government ICT Strategy Consultation’, accessed April 20, 2014, http://www.digital.vic.gov.au/2014/01/victorian-government-ict-strategy-consultation-2014/

[144] Vu T, ‘The Internet of Things: Why Does it Matter?’, accessed Feburary 19, 2014, http://makezine.com/2014/02/06/the-internet-of-things-why-does-it-matter/

[145] Percivall G, ‘Internet of Things’, accessed February 19, 2014, http://www.opengeospatial.org/blog/1818

[146] Powell R, ‘Melbourne universities launch programs to tap into evolving start-up scene', accessed February 19, 2014, http://www.startupsmart.com.au/growth/business-advice-and-education/melbourne-university-and-swinburne-university-programs-tap-into-start-up-scene/2013100910895.html

[147] Global Trends, '10 Key Trends to Watch For in 2014 (Trends 1 to 5)', accessed March 31, 2014, http://www.globaltrends.com/monthly-briefings/60-monthly-briefings/198-10-key-trends-to-watch-for-2014-trends-1-to-5

[148] Peiris V, 'Highly integrated wireless sensing for body area network applications', accessed March 31, 2014, http://spie.org/x105127.xml

[149] MC10 Inc., Home Page, accessed April 30, 2014, http://www.mc10inc.com

[150] Rao RPN and Stocco A, 'Direct Brain-to-Brain Communication in Humans: A Pilot Study', accessed February 19, 2014, http://homes.cs.washington.edu/~rao/brain2brain/experiment.html

[151] Science Channel, 'Can Our Minds Be Hacked?', accessed April 30, 2014, http://www.sciencechannel.com/tv-shows/through-the-wormhole/videos/can-our-minds-be-hacked.htm

[152] AirCasting, Home Page, accessed April 6, 2014, http://aircasting.org/

[153] Khomani N, '2029: the year when robots will have the power to outsmart their makers' The Observer, accessed June 4, 2014, http://www.theguardian.com/technology/2014/feb/22/computers-cleverer-than-humans-15-years

[154] Singularity University, Home Page, accessed June 4, 2014, http://singularityu.org

[155] Wikipedia, 'Singularity University', accessed June 4, 2014, http://en.wikipedia.org/wiki/Singularity_University

[156] YouTube, '10 Amazing Robots That Will Change the World', accessed June 4, 2014, http://www.youtube.com/watch?v=6feEE716UEk robots-10

[157] Robotic Open Platform, Home Page, accessed June 4, 2014, http://www.roboticopenplatform.org

[158] Ackerman E and Guizzo E, 'SCHAFT staying in DARPA Robotics Challenge, More Team Joining DRC Finals', accessed June 4, 2014, http://spectrum.ieee.org/automaton/robotics/military-robots/schaft-darpa-robotics-challenge-finals-more-teams

[159] Wikipedia, 'Turing test', accessed June 4, 2014, http://en.wikipedia.org/wiki/Turing_test

[160] Basulto D, 'Artificial intelligence is the next big tech trend. Here's why.', The Washington Post, accessed June 4, 2014, http://www.washingtonpost.com/blogs/innovations/wp/2014/03/25/artificial-intelligence-is-the-next-big-tech-trend-heres-why/

[161] VANZI: http://www.vanzi.com.au/ accessed August 28, 2014

[162] Kurzweil R, 'The Law of Accelerating Returns', accessed June 4, 2001, http://www.kurzweilai.net/the-law-of-accelerating-returns

[163] D-Wave, 'Quantum Computing', accessed June 4, 2014, http://www.dwavesys.com/quantum-computing

[164] Wikipedia, 'Quantum computer', accessed June 4, 2014, http://en.wikipedia.org/wiki/Quantum_computer

[165] Courtland R, 'D-Wave Aims to Bring Quantum Computing to the Cloud', accessed June 4, 2014, http://spectrum.ieee.org/podcast/computing/hardware/dwave-aims-to-bring-quantum-computing-to-the-cloud

[166] Ackerman E, 'Cyborg Drumming Arm Makes Amputee Into Superhuman Musician', accessed June 4, 2014, http://spectrum.ieee.org/automaton/robotics/robotics-hardware/cyborg-drumming-arm-makes-amputee-into-superhuman-musician

[167] Burks R, 'Brain implant could turn you into one of the X-Men', accessed July 16, 2014,http://www.dvice.com/2013-8-13/brain-implant-could-turn-you-one-x-men

[168] Anthes E, 'The race to create "insect cyborgs"', The Observer, accessed June 4, 2014 http://www.theguardian.com/science/2013/feb/17/race-to-create-insect-cyborgs

[169] Backyard Brains, 'Experiment: Neural Interface Surgery', accessed June 4, 2014, https://backyardbrains.com/experiments/roboRoachSurgery

[170] Rainie L and Anderson J, 'Scenario 5: The Evolution of Augmented Reality and Virtual Reality', accessed June 4, 2014, http://www.pewinternet.org/2008/12/14/scenario-5-the-evolution-of-augmented-reality-and-virtual-reality/

[171] Eveleth R, 'Augmented Reality System Goes From Military to Market', The Daily Beast, accessed June 4, 2014, http://www.thedailybeast.com/articles/2014/05/27/augmented-reality-system-goes-from-military-to-market.html

[172] Enplug, Home Page, accessed June 4, 2014, https://www.enplug.com/displays/

[173] Musion, Home Page, accessed June 4, 2014, http://musion.co.uk

[174] The Economist, 'Economic Intelligence Unit', accessed 19 March 2014, http://www.eiu.com/home.aspx

[175] Gurria A and Padoan PC, OECD Economic Outlook Press Conference, accessed June 4, 2014, http://www.oecd.org/economy/outlook/Handout_English.pdf

[176] The Economist, ‘World GDP’, accessed March 6, 2014, http://www.economist.com/news/economic-and-financial-indicators/21586611-world-gdp

[177] Rapoza K, ‘Why China Is Not Dead Yet’, Forbes, accessed April 1, 2014, http://www.forbes.com/sites/kenrapoza/2014/03/31/why-china-is-not-dead-yet

[178] National Australia Bank, ‘Global and Australian Forecasts’, accessed March 24, 2014, http://business.nab.com.au/wp-content/uploads/2013/03/global-australian-forecasts-march-2013.pdf

[179] OECD, ‘OECD government borrowing set to rise slightly in 2013’, accessed March 25, 2014, http://www.oecd.org/daf/fin/public-debt/oecdgovernmentborrowingsettoriseslightlyin2013.htm

[180] OECD, ‘Medium and Long-Term Scenarios for Global Growth and Imbalances’, OECD Economic Outlook 2012/1, accessed March 25, 2014, http://www.oecd.org/eco/outlook/50381011.pdf

[181] OECD, ‘OECD Economic Surveys Japan April 2013’, accessed March 25, 2014, http://www.oecd.org/eco/surveys/Overview%20Japan%202013%20English.pdf

[182] Trading Economics, ‘United States Government Debt to GDP’, accessed March 25, 2014, http://www.tradingeconomics.com/united-states/government-debt-to-gdp

[183] Rapoza K, ‘IMF Warns China On Rising Government Debt’, accessed April 1, 2014, http://www.forbes.com/sites/kenrapoza/2013/05/29/imf-warns-china-on-rising-government-debt/

[184] Vas C, ‘Demystifying the global productivity puzzle’, accessed March 27, 2014, http://theconversation.com/demystifying-the-global-productivity-puzzle-22041

[185] The Conference Board, ‘Global Productivity Slowdown Moderated in 2013–2014 May See Better Performance’, 2014 Productivity Brief—Key Findings, accessed March 27, 2014, http://static.tijd.be/upload/global_productivity-269819.pdf

[186] OECD, ‘Productivity and long-term growth: Policy challenges for the next 50 years’, accessed March 28, 2014, http://www.oecd.org/eco/growth/lookingto2060.htm

[187] ABC News, ‘Global competitiveness, government regulation and productivity growth: Where does Australia rank?’ accessed May 7, 2014, http://www.abc.net.au/news/2014-04-09/competitiveness-regulation-productivity-where-australia-ranks/5359694

[188] Australian Government Department of Industry Innovation, Science, Research and Tertiary Education, Australian Innovation System Report 2012, accessed March 27, 2014, http://www.industry.gov.au/Science/Policy/AustralianInnovationSystemReport/AISReport2012.pdf

[189] FMD Group Pty Ltd, 'FMD Economic Snapshot', published February 2014, accessed March 24, 2014, http://www.fmd.com.au

[190] Trading Economics, 'United States GDP Growth Rate', accessed March 25, 2014, http://www.tradingeconomics.com/united-states/gdp-growth

[191] OECD, 'United States – Economic forecast summary (May 2014)', accessed March 28, 2014, http://www.oecd.org/eco/outlook/united-states-economic-forecast-summary.htm

[192] Economic Intelligence Unit, 'US growth outlook is continuing to improve', accessed March 28, 2014, http://gfs.eiu.com/Article.aspx?articleType=gef&articleId=200297204&secID=10, accessed 28/3/14.

[193] Trading Economics, 'Forecast Government Debt to GDP', accessed March 31, 2014, http://www.tradingeconomics.com/forecast/government-debt-to-gdp

[194] Purdy M, Li G and Light D, 'The view from China's productivity frontier', Accenture, accessed April 1, 2014, http://www.accenture.com/us-en/outlook/Pages/outlook-journal-2014-beyond-capital-and-labor-china-productivity-frontier.aspx

[195] Brooker R, NAB Federal Budget Presentation, May 14, 2014

[196] Bloomberg News, 'China Defaults Sow Property Cash Crunch Concern: Distressed Debt', accessed April 1, 2014, http://www.bloomberg.com/news/2014-03-30/china-defaults-sow-property-cash-crunch-concern-distressed-debt.html

[197] OECD, 'Japan – Economic forecast summary (May 2014), accessed March 27, 2014, http://www.oecd.org/eco/outlook/japan-economic-forecast-summary.htm

[198] Trading Economics, 'Japan GDP Growth Rate', accessed March 24, 2014, http://www.tradingeconomics.com/japan/gdp-growth

[199] Trading Economics, 'India GDP Growth Rate', accessed March 24, 2014, http://www.tradingeconomics.com/india/gdp-growth

[200] Nair R and Ranjan Mishra A, 'Moody's warns India on structure of government debt', last accessed May 20, 2014, http://www.livemint.com/Politics/3wFRVd6Lgl3Tszyla54AKK/Moodys-warns-India-on-structure-of-government-debt.html

[201] Trading Economics, 'India Government Debt to GDP', accessed May 20, 2014, http://www.tradingeconomics.com/india/government-debt-to-gdp

[202] Trading Economics, Home Page, accessed March 24, 2014, http://www.tradingeconomics.com/

[203] The Economist, 'Taking Europe's pulse', accessed April 1, 2014, http://www.economist.com/blogs/graphicdetail/2014/05/european-economy-guide

[204] OECD, 'Spain – Economic forecast summary (May 2014)', accessed April 1, 2014, http://www.oecd.org/economy/spain-economic-forecast-summary.htm

[205] The Economist, 'Labour productivity', accessed February 19, 2013, http://www.economist.com/blogs/graphicdetail/2013/02/focus-3

[206] Trading Economics, 'Spain Productivity', accessed April 1, 2014, http://www.tradingeconomics.com/spain/productivity

[207] OECD, 'Sweden – Economic forecast summary (May 2014)', accessed April 1, 2014, http://www.oecd.org/economy/sweden-economic-forecast-summary.htm

[208] Government Offices of Sweden, 'Economic forecast July 2014', accessed April 1, 2014, http://www.government.se/sb/d/9513

[209] Trading Economics, 'Singapore | Economic Indicators', accessed April 25, 2014, http://www.tradingeconomics.com/singapore/indicators

[210] International Monetary Fund, 'World Economic Outlook Database', accessed April 1, 2014, http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/index.aspx

[211] Matthews C, 'Which Advanced Economy Has the Most Debt?' Time, accessed April 25, 2012, http://business.time.com/2012/05/23/which-advanced-economy-has-the-most-total-debt/slide/south-korea/

[212] The Economist, 'Grist to the Mill', accessed April 1, 2014, http://www.economist.com/blogs/americasview/2014/03/productivity-latin-america, 31 March 2014

[213] OECD, 'Brazil: Economic forecast summary (May 2014)', accessed March 28, 2014, http://www.oecd.org/eco/outlook/brazil-economic-forecast-summary.htm

[214] The Economist, 'Aspiring Africa', accessed March 24, 2014, http://www.economist.com/news/leaders/21572773-pride-africas-achievements-should-be-coupled-determination-make-even-faster

[215] Economic Intelligence Unit, 'China and Africa: a maturing relationship', accessed March 24, 2014, http://country.eiu.com/article.aspx?articleid=760356060&Country=China&topic=Economy&subtopic=Forecast&mkt_tok=3RkMMJWWfF9wsRoiuqrPZKXonjHpfsX96OUtXq%20g38431UFwdcjKPmjr1YcERMN0dvycMRAVFZl5nQlRD7I=

[216] The Economist, 'Gems from Jim', accessed March 24, 2014, http://www.economist.com/blogs/baobab/2013/04/africa%E2%80%99s-economic-prospects-0

[217] Knoema, 'World GDP Ranking 2014 | Data and Charts', accessed March 31, 2014, http://knoema.com/nwnfkne/gdp-ranking-2013-data-and-charts

[218] Commonwealth Bank of Australia, 'Global Markets Report, economics perspectives', published February 2013

[219] CommSec, 'Economic Insights', published March 5, 2014

[220] The Age, 'Strong GDP continues to lift $A', last modified March accessed March 31, 2014, http://www.theage.com.au/business/markets/currencies/strong-gdp-continues-to-lift-a-20140306-3486k.html?utm_source=outbrain&utm_medium=cpc&utm_campaign=outbrainamplify

[221] Trading Economics, 'Australia | Economic Forecasts |2014–2030 Outlook', accessed March 31, 2014, http://www.tradingeconomics.com/australia/forecast

[222] IHS, 'IHS Top 10 Economic Predictions for 2013', accessed April 17, 2014, http://www.ihs.com/info/ecc/a/economic-predictions-2013.aspx

[223] OECD, 'Australia – Economic forecast summary (May 2014)', accessed March 28, 2014, http://www.oecd.org/eco/outlook/australia-economic-forecast-summary.htm

[224] The Australian, 'Signs of productivity turning the corner', accessed April 1, 2014, http://www.theaustralian.com.au/business/opinion/signs-of-productivity-turning-the-corner/story-e6frg9qo-1226594291686

[225] ABC News, 'Does Australia have a revenue problem, as ACOSS chief executive Cassandra Goldie claims?', accessed May 20, 2014, http://www.abc.net.au/news/2014-05-08/does-australia-have-a-revenue-problem/5420474

[226] ABC News, 'Joe Hockey correct on Australia's debt, spending', accessed May 20, 2014, http://www.abc.net.au/news/2014-03-13/joe-hockey-correct-on-australia-debt-and-spending/5310736

[227] OECD, 'New Zealand – Economic forecast summary (May 2014)', accessed April 1, 2014, http://www.oecd.org/eco/surveys/new-zealand-2013.htm ,

[228] New Zealand Treasury, 'New Zealand Economic Outlook', accessed April 1, 2014, http://www.treasury.govt.nz/budget/forecasts/befu2013/006.htm

[229] Trading Economics, 'New Zealand Government Debt to GDP', accessed June 23, 2014, http://www.tradingeconomics.com/new-zealand/government-debt-to-gdp

[230] Withers T, ‘N.Z. Raises Key Rate to Become First Developed Nation to Tighten’, Bloomberg News, accessed April 1, 2014, http://www.bloomberg.com/news/2014-03-12/n-z-raises-key-rate-to-become-first-developed-nation-to-tighten.html

[231] Trading Economics, ‘New Zealand GDP Growth Rate’, accessed April 1, 2014, http://www.trading economics.com/new-zealand/gdp-growth

[232] MarketWatch, ‘New Zealand business confidence dips slightly’, accessed March 31, 2014, http://www.marketwatch.com/story/new-zealand-business-confidence-dips-slightly-2014-03-31?link=MW_story_latest_news

APPENDIX A

LIST OF NAVIGATION AND GLOBAL POSITIONING SATELLITES AS OF 31 JANUARY 2014 [10]

NORAD Number	Name of Satellite, Alternate Names	Country of Operator/ Owner	Operator/Owner	Date of Launch
39199	IRNSS-1A (Indian Regional Navigation Satellite System)	India	Indian Space Research Organization (ISRO)	1/07/2013
37158	QZS-1 (Quazi-Zenith Satellite System, Michibiki)	Japan	Japan Aerospace Exploration Agency (JAXA)	11/09/2010
27436	Parus 93 (Cosmos 2389)	Russia	Ministry of Defense	28/05/2002
27818	Parus 94 (Cosmos 2398)	Russia	Ministry of Defense	4/06/2003
25590	Parus-90 (Cosmos 2361)	Russia	Ministry of Defense	24/12/1998
25892	Parus-91 (Cosmos 2366)	Russia	Ministry of Defense	26/08/1999
26818	Parus-92 (Cosmos 2378)	Russia	Ministry of Defense	8/06/2001
28380	Parus-95 (Cosmos 2407)	Russia	Ministry of Defense	22/07/2004
28521	Parus-96 (Cosmos 2414)	Russia	Ministry of Defense	20/01/2005
32052	Parus-97 (Cosmos 2429)	Russia	Ministry of Defense	11/09/2007
35635	Parus-98 (Cosmos 2454)	Russia	Ministry of Defense	21/07/2009
36519	Parus-99 (Cosmos 2463)	Russia	Ministry of Defense	27/04/2010
36287	Compass G-1 (Beidou G1)	China (PR)	Chinese Defense Ministry	16/01/2010
37948	Compass G-10 (Beidou ISGO-5)	China (PR)	Chinese Defense Ministry	1/12/2011
38091	Compass G-11 (Beidou G5)	China (PR)	Chinese Defense Ministry	24/02/2012
36590	Compass G-3 (Beidou G3)	China (PR)	Chinese Defense Ministry	2/06/2010
37210	Compass G-4 (Beidou G4)	China (PR)	Chinese Defense Ministry	31/10/2010
36828	Compass G-5 (Beidou IGSO-1)	China (PR)	Chinese Defense Ministry	31/07/2010
38953	Compass G-6 (Beidou 2-16)	China (PR)	Chinese Defense Ministry	25/10/2012
37256	Compass G-7 (Beidou IGSO-2)	China (PR)	Chinese Defense Ministry	17/12/2010
37384	Compass G-8 (Beidou IGSO-3)	China (PR)	Chinese Defense Ministry	9/04/2011
37763	Compass G-9 (Beidou ISGO-4)	China (PR)	Chinese Defense Ministry	26/07/2011
31115	Compass M1 (Beidou M1)	China (PR)	Chinese Defense Ministry	14/04/2007
38250	Compass M3 (Beidou 2-12)	China (PR)	Chinese Defense Ministry	28/04/2012
38251	Compass M4 (Beidou 2-13)	China (PR)	Chinese Defense Ministry	28/04/2012
38774	Compass M5 (Beidou 2-14)	China (PR)	Chinese Defense Ministry	18/09/2012

38775	Compass M6 (Beidou 2-15)	China (PR)	Chinese Defense Ministry	18/09/2012
37847	Galileo IOV-1 FM2	ESA	European Space Agency	21/10/2011
37846	Galileo IOV-1 PFM	ESA	European Space Agency	21/10/2011
38857	Galileo IOV-2 FM3	ESA	European Space Agency	12/10/2012
38858	Galileo IOV-2 FM4	ESA	European Space Agency	12/10/2012
37372	Glonass 701 (Glonass-K, Cosmos 2471)	Russia	Ministry of Defense	26/02/2011
28509	Glonass 712 (Glonass M, Cosmos 2413)	Russia	Ministry of Defense	26/12/2004
28915	Glonass 714 (Cosmos 2419)	Russia	Ministry of Defense	25/12/2005
29672	Glonass 715 (Glonass 35-1, Cosmos 2424)	Russia	Ministry of Defense	25/12/2006
29670	Glonass 716 (Glonass 35-2, Cosmos 2425)	Russia	Ministry of Defense	25/12/2006
29671	Glonass 717 (Glonass 35-3, Cosmos 2426)	Russia	Ministry of Defense	25/12/2006
32276	Glonass 719 (Glonass 36-2, Cosmos 2432)	Russia	Ministry of Defense	26/10/2007
32275	Glonass 720 (Glonass 36-3, Cosmos 2433)	Russia	Ministry of Defense	26/10/2007
32393	Glonass 721 (Glonass 37-1, Cosmos 2434)	Russia	Ministry of Defense	25/12/2007
32394	Glonass 722 (Glonass 37-2, Cosmos 2435)	Russia	Ministry of Defense	25/12/2007
32395	Glonass 723 (Glonass 37-3, Cosmos 2436)	Russia	Ministry of Defense	25/12/2007
33378	Glonass 724 (Glonass 38-1, Cosmos 2442)	Russia	Ministry of Defense	25/09/2008
33379	Glonass 725 (Glonass 38-2, Cosmos 2443)	Russia	Ministry of Defense	25/09/2008
33380	Glonass 726 (Glonass 38-3, Cosmos 2444)	Russia	Ministry of Defense	25/09/2008
33466	Glonass 727 (Glonass 39-1, Cosmos 2447)	Russia	Ministry of Defense	25/12/2008
33467	Glonass 729 (Glonass 39-3, Cosmos 2449)	Russia	Ministry of Defense	25/12/2008
36111	Glonass 730 (Glonass 41-1, Cosmos 2456)	Russia	Ministry of Defense	14/12/2009
36400	Glonass 731 (Glonass 42-1, Cosmos 2459)	Russia	Ministry of Defense	1/03/2010
36402	Glonass 732 (Glonass 42-3, Cosmos 2460)	Russia	Ministry of Defense	1/03/2010

36112	Glonass 733 (Glonass 41-2, Cosmos 2457)	Russia	Ministry of Defense	14/12/2009
36113	Glonass 734 (Glonass 41-3, Cosmos 2458)	Russia	Ministry of Defense	14/12/2009
36401	Glonass 735 (Glonass 42-2, Cosmos 2461)	Russia	Ministry of Defense	1/03/2010
37139	Glonass 736 (Glonass 43-1, Cosmos 2464)	Russia	Ministry of Defense	2/09/2010
37138	Glonass 737 (Glonass 43-2, Cosmos 2465)	Russia	Ministry of Defense	2/09/2010
37137	Glonass 738 (Glonass 43-3, Cosmos 2466)	Russia	Ministry of Defense	2/09/2010
37829	Glonass 742 (Glonass-M, Cosmos 2474)	Russia	Ministry of Defense	2/10/2011
37867	Glonass 743 (Glonass 44-2, Cosmos 2476)	Russia	Ministry of Defense	4/11/2011
37868	Glonass 744 (Glonass 44-3, Cosmos 2477)	Russia	Ministry of Defense	4/11/2011
37869	Glonass 745 (Glonass 44-1, Cosmos 2475)	Russia	Ministry of Defense	4/11/2011
37938	Glonass 746 (Glonass-M, Cosmos 2478)	Russia	Ministry of Defense	27/11/2011
39155	Glonass 747 (Glonass-M, Cosmos 2485)	Russia	Ministry of Defense	26/04/2013
20959	Navstar GPS II-10 (Navstar SVN 23, PRN 32, USA 66)	USA	DoD/US Air Force	26/11/1990
22014	Navstar GPS II-14 (Navstar SVN 26, PRN 26, USA 83)	USA	DoD/US Air Force	7/07/1992
22700	Navstar GPS II-21 (Navstar SVN 39, PRN 09, USA 92)	USA	DoD/US Air Force	26/06/1993
22877	Navstar GPS II-23 (Navstar SVN 34, PRN 04, USA 96)	USA	DoD/US Air Force	26/10/1993
23027	Navstar GPS II-24 (Navstar SVN 36, PRN 06, USA 100)	USA	DoD/US Air Force	10/03/1994
23833	Navstar GPS II-25 (Navstar SVN 33, PRN 03, USA 117)	USA	DoD/US Air Force	28/03/1996
23953	Navstar GPS II-26 (Navstar SVN 40, PRN 10, USA 126)	USA	DoD/US Air Force	16/07/1996
25030	Navstar GPS II-28 (Navstar SVN 38, PRN 08, USA 135)	USA	DoD/US Air Force	6/11/1997
22779	Navstar GPS II-35 (Navstar SVN 35, PRN 30, USA 94)	USA	DoD/US Air Force	30/08/1993
36585	Navstar GPS IIF-1 (Navstar SVN 62, PRN 25, USA 213)	USA	DoD/US Air Force	28/05/2010

37753	Navstar GPS IIF-2 (Navstar SVN 63, PRN 01, USA 232)	USA	DoD/US Air Force	16/07/2011
38833	Navstar GPS IIF-3 (Navstar SVN 65, USA 239)	USA	DoD/US Air Force	4/10/2012
39166	Navstar GPS IIF-4 (Navstar SVN 66, USA 242)	USA	DoD/US Air Force	15/05/2013
28129	Navstar GPS IIR-10 (Navstar SVN 47, PRN 22, USA 175)	USA	DoD/US Air Force	21/12/2003
28190	Navstar GPS IIR-11 (Navstar SVN 59, PRN 19, USA 177)	USA	DoD/US Air Force	20/03/2004
28361	Navstar GPS IIR-12 (Navstar SVN 60, PRN 23, USA 178)	USA	DoD/US Air Force	23/06/2004
28474	Navstar GPS IIR-13 (Navstar SVN 61, PRN 02, USA 180)	USA	DoD/US Air Force	6/11/2004
24876	Navstar GPS IIR-2 (Navstar SVN 43, PRN 13, USA 132)	USA	DoD/US Air Force	23/07/1997
25933	Navstar GPS IIR-3 (Navstar SVN 46, PRN 11, USA 145)	USA	DoD/US Air Force	7/10/1999
26360	Navstar GPS IIR-4 (Navstar SVN 51, PRN 20, USA 150)	USA	DoD/US Air Force	11/05/2000
26407	Navstar GPS IIR-5 (Navstar SVN 44, PRN 28, USA 151)	USA	DoD/US Air Force	16/07/2000
26605	Navstar GPS IIR-6 (Navstar SVN 41, PRN 14, USA 154)	USA	DoD/US Air Force	10/11/2000
26690	Navstar GPS IIR-7 (Navstar SVN 54, PRN 18, USA 156)	USA	DoD/US Air Force	30/01/2001
27663	Navstar GPS IIR-8 (Navstar SVN 56, PRN 16, USA 166)	USA	DoD/US Air Force	29/01/2003
27704	Navstar GPS IIR-9 (Navstar SVN 45, PRN 21, USA 168)	USA	DoD/US Air Force	31/03/2003
28874	Navstar GPS IIR-M-1 (Navstar SVN 53, PRN 17, USA 183)	USA	DoD/US Air Force	26/09/2005
29486	Navstar GPS IIR-M-2 (Navstar SVN 52, PRN 31, USA 190)	USA	DoD/US Air Force	25/09/2006
29601	Navstar GPS IIR-M-3 (Navstar SVN 58, PRN 12, USA 192)	USA	DoD/US Air Force	17/11/2006
32260	Navstar GPS IIR-M-4 (Navstar SVN 55, PRN 15, USA 196)	USA	DoD/US Air Force	17/10/2007
32384	Navstar GPS IIR-M-5 (Navstar SVN 57, PRN 29, USA 199)	USA	DoD/US Air Force	20/12/2007
32711	Navstar GPS IIR-M-6 (Navstar SVN 48, PRN 07, USA 201)	USA	DoD/US Air Force	15/03/2008
35752	Navstar GPS IIR-M-8 (Navstar SVN 50, PRN 05, USA 206)	USA	DoD/US Air Force	17/08/2009

LIST OF SATELLITES IN THE CATEGORIES: EARTH OBSERVATION, EARTH SCIENCE, METEOROLOGY, RECONNAISSANCE, REMOTE SENSING AND SURVEILLANCE AS AT 31 JANUARY 2014 [10]

NORAD Number	Name of Satellite, Alternate Names	Country of Operator/Owner	Operator/Owner	Date of Launch
36798	Alsat-2A (Algeria Satellite 2A)	Algeria	Centre National des Techniques Spatiales (CNTS)	12/07/2010
37673	SAC-D (Satellite for Scientific Applications)	Argentina/ USA	National Space of Activities Commission - Argentina/NASA	10/06/2011
32382	Radarsat-2	Canada	Radarsat International	14/12/2007
38011	SSOT (Sistema Satelital para la Observación de la Tierra)	Chile	Chilean Air Force	17/12/2011
28890	BeijinGalaxy-1 (Beijing 1 [Tsinghua], Tsinghau-2, China DMC+4)	China (PR)	Beijing Landview Mapping Information Technology Co. Ltd (BLMIT)	27/10/2005
33434	Chuangxin 1-2 (Innovation 1-2)	China (PR)	Chinese Academy of Sciences	5/11/2008
37930	Chuangxin 1-3 (Innovation 1-3)	China (PR)	Chinese Academy of Sciences	20/11/2011
36985	Tianhui 1-01	China (PR)	China Aerospace Science and Technology Corporation (CASTC)	24/08/2010
38256	Tianhui 1-02	China (PR)	China Aerospace Science and Technology Corporation (CASTC)	6/05/2012
38038	Ziyuan 1-02C	China (PR)	China Centre for Resources Satellite Data and Application (CRESDA)	22/12/2011
38046	Ziyuan 3 (ZY-3)	China (PR)	China Centre for Resources Satellite Data and Application (CRESDA)	9/01/2012
36508	Cryosat-2	ESA	European Space Agency (ESA)	8/04/2010
39159	Proba V (Project for On-Board Autonomy)	ESA	European Space Agency (ESA)	7/05/2013
36036	SMOS (Soil Moisture and Ocean Salinity satellite)	ESA	Centre National d'Etudes Spatiales (CNES)/European Space Agency	2/11/2009

39019	Pléiades HR1B	France	Ministry of Defense/Centre National d'Etudes Spatiales (CNES) - cooperation with Austria, Belgium, Spain, Sweden	2/12/2012
27421	Spot 5 (Système Probatoire d'Observation de la Terre)	France	Spot Image	4/05/2002
38755	Spot 6 (Système Probatoire d'Observation de la Terre)	France/ Belgium/ Sweden	Spot Image	9/09/2012
38012	Pléiades HR1A	France/Italy	Ministry of Defense/Centre National d'Etudes Spatiales (CNES) - cooperation with Austria, Belgium, Spain, Sweden	17/12/2011
33314	RapidEye-1 (RapidEye-C)	Germany	RapidEye AG	29/08/2008
33312	RapidEye-2 (RapidEye A)	Germany	RapidEye AG	29/08/2008
33315	RapidEye-3 (RapidEye D)	Germany	RapidEye AG	29/08/2008
33316	RapidEye-4 (RapidEye E)	Germany	RapidEye AG	29/08/2008
33313	RapidEye-5 (RapidEye B)	Germany	RapidEye AG	29/08/2008
36605	TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurement)	Germany	German Aerospace Center (DLR)/Astrium	21/06/2010
37839	Jugnu	India	Indian Institute of Technology Kanpur	12/10/2011
37387	Resourcesat 2	India	Indian Space Research Organization (ISRO)	20/04/2011
32376	COSMO-Skymed 2 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	9/12/2007
33412	COSMO-Skymed 3 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	25/10/2008
37216	COSMO-Skymed 4 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	6/11/2010
33493	Prism (Pico-satellite for Remote-sensing and Innovative Space Missions, Hitomi)	Japan	University of Tokyo	23/01/2009
39423	WNISat-1 Weather News Inc. Satellite 1)	Japan	Weathernews, Inc.	21/11/2013

25063	TRMM (Tropical Rainfall Measuring Mission)	Japan/USA	National Space Development Agency(NASA)/Japan Aerospace Exploration Agency (JAXA)	27/11/1997
37789	NigeriaSat-2	Nigeria	National Space Research and Development Agency (NASRDA)	17/08/2011
29228	Resurs-DK1 (Resurs - High Resolution 1)	Russia	TsSKB Progress (State Research & Production Space Rocket Center)	15/06/2006
39186	Resurs-P1	Russia	Russian Space Agency (RKA)/Ministry of Defense	25/06/2013
37389	X-Sat	Singapore	Centre for Research in Satellite Technology (CREST)	20/04/2011
38338	Kompsat-3 (Arirang 3, Korean Multipurpose Satellite-3)	South Korea	Korea Aerospace Research Institute (KARI)	17/05/2012
39227	Kompsat-5 (Arirang 5, Korean Multipurpose Satellite-4)	South Korea	Korea Aerospace Research Institute (KARI)	22/08/2013
35681	Deimos 1	Spain	Deimos Imaging/DMC International Imaging (DMCII)	29/07/2009
33396	THEOS (Thailand Earth Observation System)	Thailand	Geo-Informatics and Space Technology Development Agency (GISTDA)	1/10/2008
39030	Göktürk 2	Turkey	Turkish Ministry of National Defense	18/12/2012
37791	RASAT	Turkey	Space Technologies Research Institute	17/08/2011
35682	DubaiSat-1	UAE	Emirates Institution for Advanced Science & Technology (EIAST)	29/07/2009
39419	DubaiSat-2	UAE	Emirates Institution for Advanced Science & Technology (EIAST)	21/11/2013
37794	Sich 2	Ukraine	State Space Agency of Ukraine (NKAU)	17/08/2011
35683	UK-DMC-2 (BNSCSat-2, British National Science Center Satellite 2)	United Kingdom	UK/DMC International Imaging (DMCII)	29/07/2009
24920	FORTÉ (Fast On-orbit Recording of Transient Events)	USA	Los Alamos National Labs/ DOE	29/08/1997
26953	Quickbird 2	USA	DigitalGlobe Corporation	18/10/2001

32060	Worldview 1	USA	DigitalGlobe Corporation	18/09/2007
35946	Worldview 2	USA	DigitalGlobe Corporation	8/10/2009
27424	EOS-PM Aqua (Advanced Microwave Scanning Radiometer for EOS, EOS PM-1)	USA/ Japan/Brazil	NASA - Earth Science Enterprise/Japan Meteorological Agency/ Brazilian Space Agency	4/05/2002
39160	VNREDSat 1A (Vietnam Natural Resources Environment and Disaster monitoring small Satellite)	Vietnam	Space Technology Institute-Vietnam Academy of Science and Technology (STI-VAST)	7/05/2013
26620	SAC-C (Satellite for Scientific Applications)	Multinational	National Commission of Space Activities (CONAE) (with NASA, Denmark, Italy, Spain, France, Brazil)	21/11/2000
31118	Saudisat-3	Saudi Arabia	Riyadh Space Research Institute	17/04/2007
36744	COMS-1 (Communication, Ocean and Meteorological Satellite; Cheollian)	South Korea	Korea Aerospace Research Institute (KARI)	26/06/2010
26619	EO-1 (Earth Observing 1)	USA	NASA Earth Science Office	21/11/2000
29709	LAPAN-Tubsat	Indonesia	Indonesian National Aeronautics and Space Agency (Lembaga Penerbangan dan Antariksa Nasional - LAPAN)	10/01/2007
37790	Nigeriasat-X	Nigeria	National Space Research and Development Agency (NASRDA)	17/08/2011
38735	MiR (Mikhail Reshetnev [MiR], Yubileiny-2/RS-40)	Russia	Joint Stock Company-Information Satellite Systems	28/07/2012
29268	Kompsat-2 (Arirang 2, Korean planned Multipurpose Satellite-2)	South Korea	Korea Aerospace Research Institute (KARI)	28/07/2006
39265	Cassiope (CAScade SmallSat and Ionospheric Polar Explorer)	Canada	Canadian Space Agency	29/09/2013
29640	Fengyun 2D (FY-2D)	China (PR)	China Meteorological Administration	8/12/2006
33463	Fengyun 2E (FY-2E)	China (PR)	China Meteorological Administration	23/12/2008
38049	Fengyun 2F (FY-2F)	China (PR)	China Meteorological Administration	12/01/2012
32958	Fengyun 3A (FY-3A)	China (PR)	China Meteorological Administration	27/05/2008
37214	Fengyun 3B (FY-3B)	China (PR)	China Meteorological Administration	4/11/2010
39260	Fengyun 3C (FY-3C)	China (PR)	China Meteorological	23/09/2013

25635	Ørsted	Denmark	Administration Danish Meteorological Institute (DMI)	23/02/1999
39452	SWARM-A	ESA	European Space Agency (ESA)	22/11/2013
39451	SWARM-B	ESA	European Space Agency (ESA)	22/11/2013
59453	SWARM-C	ESA	European Space Agency (ESA)	22/11/2013
28498	PARASOL (Polarization and Anistropy of Reflectances for Atmospheric Science coupled with Observations from LIDAR)	France	Centre National d'Etudes Spatiales (CNES)	18/12/2004
29108	Calipso (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation)	France/USA	Centre National d'Etudes Spatiales (CNES)/NASA	28/04/2006
25757	DLR Tubsat	Germany	Deutsches Zentrum für Luft- und Raumfahrt	26/05/1999
27391	Grace 1 (Gravity Recovery and Climate Experiment, "Tom and Jerry")	Germany/USA	GeoForschungsZentrum (GFZ)/Center for Space Research, University of Texas	17/03/2002
27392	Grace 2 (Gravity Recovery and Climate Experiment, "Tom and Jerry")	Germany/USA	GeoForschungsZentrum (GFZ)/Center for Space Research, University of Texas	17/03/2002
37838	Megha-Tropiques	India/France	Indian Space Research Organization (ISRO)/Centre National d'Etudes Spatiales (CNES)	12/10/2011
39086	SARAL (Satellite with ARGOS and ALTIKA)	India/France	Indian Space Research Organization (ISRO)/Centre National d'Etudes Spatiales (CNES)	25/02/2013
33492	Greenhouse Gases Observing Satellite (Ibuki, GoSAT)	Japan	Japan Aerospace Exploration Agency (JAXA)	23/01/2009
31304	AIM (Aeronomy of Ice in Mesosphere)	USA	Center for Atmospheric Sciences, Hampton University/NASA	25/04/2007
29107	Cloudsat	USA	NASA/Colorado State University	28/04/2006
39395	Firefly	USA	NASA/Sienna College/ Univ. of Maryland	19/11/2013
25682	Landsat 7	USA	NASA/US Geological Survey	15/04/1999
39084	Landsat 8	USA	NASA/US Geological Survey	11/02/2013

38752	Van Allen Probe A (RBSP-A, Radiation Belt Storm Probes)	USA	NASA/Johns Hopkins University Applied Physics Laboratory	30/08/2012
38753	Van Allen Probe B (RBSP-B, Radiation Belt Storm Probes)	USA	NASA/Johns Hopkins University Applied Physics Laboratory	30/08/2012
25994	EOS-AM Terra	USA/ Canada/ Japan	(NASA) Earth Sciences Enterprise	18/12/1999
33105	Jason 2	USA/France	NASA/Centre National d'Etudes Spatiales (CNES) /NOAA/EUMETSAT	20/06/2008
38337	Global Change Observation Mission - 1 Water (GCOM-1, Shikuzu)	USA/Japan	Japan Aerospace Exploration Agency (JAXA)	17/05/2012
38552	Meteosat 10 (MSGalaxy-3, MSG 3)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	5/07/2012
24932	Meteosat 7 (MTP 1)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	2/09/1997
27509	Meteosat 8 (MSGalaxy-1, MSG-1)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	21/08/2002
28912	Meteosat 9 (MSGalaxy-2, MSG 2)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	21/12/2005
29499	MetOp-A (Meteorological Operational satellite)	Multinational	ESA/EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	19/10/2006
38771	MetOp-B (Meteorological Operational satellite)	Multinational	ESA/EUMETSAT (European Organization for the Exploitation of Meterological Satellites)	17/09/2012
23533	DMSP 5D-2 F13 (Defense Meteorological Satellites Program, USA 109)	USA	DoD/NOAA	24/03/1995
24753	DMSP 5D-2 F14 (Defense Meteorological Satellites Program, USA 131)	USA	DoD/NOAA	4/04/1997
25991	DMSP 5D-3 F15 (Defense Meteorological Satellites Program, USA 147)	USA	DoD/NOAA	12/12/1999
28054	DMSP 5D-3 F16 (Defense Meteorological Satellites Program, USA 172)	USA	DoD/NOAA	18/10/2003

29522	DMSP 5D-3 F17 (Defense Meteorological Satellites Program, USA 191)	USA	DoD/NOAA	4/11/2006
35951	DMSP 5D-3 F18 (Defense Meteorological Satellites Program, USA 210)	USA	DoD/NOAA	18/10/2009
29155	GOES 13 (Geostationary Operational Environmental Satellite, GOES-N)	USA	NOAA (National Oceanographic and Atmospheric Administration)	24/05/2006
35491	GOES 14 (Geostationary Operational Environmental Satellite, GOES-O)	USA	NOAA (National Oceanographic and Atmospheric Administration)	27/06/2009
36411	GOES 15 (Geostationary Operational Ennvironmental Satellite, GOES-P)	USA	NOAA (National Oceanographic and Atmospheric Administration)	4/03/2010
25338	NOAA-15 (NOAA-K)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	13/05/1998
26536	NOAA-16 (NOAA-L)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	21/09/2000
37344	Electro-L1 (GOMS 2 [Geostationary Ioperational Meteorological Satellite 2]	Russia	Roshydromet - Planeta	20/01/2011
31113	Haiyang 1B (HY 1B, Ocean 1B)	China (PR)	State Oceanic Administration (SOA)	11/04/2007
37781	Haiyang 2A (HY 2A)	China (PR)	State Oceanic Administration (SOA)	15/08/2011
27714	INSAT 3A (Indian National Satellite)	India	Indian Space Research Organization (ISRO)	9/04/2003
39216	INSAT 3D (Indian National Satellite)	India	Indian Space Research Organization (ISRO)	25/07/2013
28937	MTSAT-2 (Multi-Functional Transport Satellite)	Japan	Japan Meteorological Agency/Meteorological Satellite Center (MSC)	18/02/2006
35865	Meteor-M (Meteor-M1)	Russia	Russian Federal Service For Hydrometeorology and Environmental Monitoring (ROSHYDROMET)	17/09/2009
28654	NOAA-18 (NOAA-N, COSPAS-SARSAT)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	20/05/2005

33591	NOAA-19 (NOAA-N Prime, COSPAS-SARSAT)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	6/02/2009
37849	NPP (National Polar-orbiting Operational Environmental Satellite System [NPOESS])	USA	National Oceanographic and Atmospheric Administration (NOAA)/NASA	28/10/2011
22490	SCD-1 (Satélite de Coleta de Dados)	Brazil	Instituto Nacional de Pesquisas Espaciais (INPE)	9/02/1993
25504	SCD-2 (Satélite de Coleta de Dados)	Brazil	Instituto Nacional de Pesquisas Espaciais (INPE)	23/10/1998
28622	MTSAT-1R (Himawari 6)	Japan	Japanese Ministry of Transport/Japan Meteorological Agency	26/02/2005
27525	Kalpana-1 (Metsat-1)	India	Indian Space Research Organization (ISRO)	12/09/2002
37179	Shijian 6G (SJ6-04A)	China (PR)	Chinese Academy of Space Technology (CAST)	6/10/2010
37180	Shijian 6H (SJ6_04B)	China (PR)	Chinese Academy of Space Technology (CAST)	6/10/2010
28470	Zhangguo Ziyuan 2C (ZY-2C, JB-3C)	China (PR)	Chinese Academy of Space Technology	4/11/2004
28492	Helios 2A	France/Italy/ Belgium/ Spain/ Greece	Centre National d'Etudes Spatiales (CNES)/ Délégation Générale de l'Armement (DGA)	18/12/2004
36124	Helios 2B	France/Italy/ Belgium/ Spain/ Greece	Centre National d'Etudes Spatiales (CNES)/ Délégation Générale de l'Armement (DGA)	18/12/2009
32476	TecSAR (Polaris)	Israel	Defense Ministry	21/01/2008
27698	IGS-1A (Information Gathering Satellite 1A)	Japan	Cabinet Satellite Intelligence Center (CSIC)	28/03/2003
29393	IGS-3A (Information Gathering Satellite 3A)	Japan	Cabinet Satellite Intelligence Center (CSIC)	11/09/2006
36104	IGS-5A (Information Gathering Satellite 5A, IGS Optical 3)	Japan	Cabinet Satellite Intelligence Center (CSIC)	28/11/2009
37813	IGS-6A (Information Gathering Satellite 6A, IGS Optical 4)	Japan	Cabinet Satellite Intelligence Center (CSIC)	23/09/2011
37954	IGS-7A (Information Gathering Satellite 7A, IGS Radar 3)	Japan	Cabinet Satellite Intelligence Center (CSIC)	12/12/2011

39061	IGS-8A (Information Gathering Satellite 8A, IGS Radar 4)	Japan	Cabinet Satellite Intelligence Center (CSIC)	27/01/2013
39062	IGS-8B (Information Gathering Satellite 8B, IGS Optical Demonstrator)	Japan	Cabinet Satellite Intelligence Center (CSIC)	27/01/2013
39194	Kondor	Russia	Ministry of Defense	27/06/2013
36095	Lotos-S (Cosmos 2455)	Russia	Ministry of Defense	20/11/2009
39177	Persona-2 (Cosmos 2486)	Russia	Ministry of Defense	7/06/2013
37162	FIA Radar 1 (Future Imagery Architecture (FIA) Radar 1, NROL-41, USA 215, Topaz)	USA	National Reconnaissance Office (NRO)	21/09/2010
38109	FIA Radar 2 (Future Imagery Architecture (FIA) Radar 2, NROL-25, USA 234, Topaz)	USA	National Reconnaissance Office (NRO)	3/04/2012
39462	FIA Radar 3 (Future Imagery Architecture (FIA) Radar 3, NROL-39 , USA 247, Topaz)	USA	National Reconnaissance Office (NRO)	6/12/2013
25744	Keyhole 3 (Advanced KH-11, KH-12-4, Advanced Keyhole, Misty-2, EIS-1, 8X Enhanced Imaging System, USA 144)	USA	National Reconnaissance Office (NRO)	22/05/1999
26934	Keyhole 4 (Advanced KH-11, Advanced Keyhole, Improved Crystal, EIS-2, 8X Enhanced Imaging System, NROL 14, USA 161)	USA	National Reconnaissance Office (NRO)	5/10/2001
28888	Keyhole 5 (Advanced KH-11, KH-12-5, Improved Crystal, EIS-3, USA 186)	USA	National Reconnaissance Office (NRO)	19/10/2005
37348	Keyhole 6 (NRO L49, Advanced KH-11, KH-12-6, Improved Crystal, USA 224)	USA	National Reconnaissance Office (NRO)	20/01/2011
39232	Keyhole 7 (NRO L65, Advanced KH-11, Improved Crystal, USA 245)	USA	National Reconnaissance Office (NRO)	28/08/2013
37728	ORS-1 (Operationally Responsive Space One, USA 231)	USA	U.S. Air Force/ DoD	30/06/2011
37168	SBSS-1 (Space Based Space Surveillance Satellite, SBSS Block 10 SV1, USA 216)	USA	Strategic Space Command/ Space Surveillance Network	26/09/2010
38708	BKA (BelKA 2)	Belarus	National Academy of Sciences	22/07/2012
39150	Gaofen 1	China (PR)	Shanghai Academy of Spaceflight Technology (SAST)	26/04/2013

33320	HJ-1A (Huan Jing 1A)	China (PR)	National Remote Sensing Center (NRSCC)	5/09/2008
33321	HJ-1B (Huan Jing 1B)	China (PR)	National Remote Sensing Center (NRSCC)	5/09/2008
38997	HJ-1C (Huan Jing 1C)	China (PR)	National Committee for Disaster Reduction and State Environmental Protection	18/11/2012
39262	Kuaizhou-1 (KZ-1)	China (PR)	National Academy of Sciences	25/09/2013
28220	Shiyan 1 (SY 1, Tansuo 1, Experimental Satellite 1)	China (PR)	Chinese Academy of Space Technology (CAST)	18/04/2004
36834	Yaogan 10 (Remote Sensing Satellite 10)	China (PR)	People's Liberation Army (C41)	9/08/2010
37165	Yaogan 11 (Remote Sensing Satellite 11)	China (PR)	People's Liberation Army (C41)	22/09/2010
37875	Yaogan 12 (Remote Sensing Satellite 12)	China (PR)	People's Liberation Army (C41)	9/11/2011
37941	Yaogan 13 (Remote Sensing Satellite 13)	China (PR)	People's Liberation Army (C41)	29/11/2011
38257	Yaogan 14 (Remote Sensing Satellite 14)	China (PR)	People's Liberation Army (C41)	10/05/2012
38354	Yaogan 15 (Remote Sensing Satellite 15)	China (PR)	People's Liberation Army (C41)	29/05/2012
39011	Yaogan 16A (Remote Sensing Satellite 16A, Yaogan Weixing 16)	China (PR)	People's Liberation Army (C41)	25/11/2012
39012	Yaogan 16B (Remote Sensing Satellite 16B)	China (PR)	People's Liberation Army (C41)	25/11/2012
39013	Yaogan 16C (Remote Sensing Satlelite 16C)	China (PR)	People's Liberation Army (C41)	25/11/2012
39239	Yaogan 17A (Remote Sensing Satellite 17A, Yaogan Weixing 17)	China (PR)	People's Liberation Army (C41)	1/09/2013
39240	Yaogan 17B (Remote Sensing Satellite 17B)	China (PR)	People's Liberation Army (C41)	1/09/2013
39241	Yaogan 17C (Remote Sensing Satellite 17C)	China (PR)	People's Liberation Army (C41)	1/09/2013
39363	Yaogan 18 (Remote Sensing Satellite 18)	China (PR)	People's Liberation Army (C41)	29/10/2013
39410	Yaogan 19 (Remote Sensing Satellite 19)	China (PR)	People's Liberation Army (C41)	20/11/2013
31490	Yaogan 2 (Remote Sensing Satellite 2, Jian Bing 5-2, JB 5-2)	China (PR)	People's Liberation Army (C41)	25/05/2007

32289	Yaogan 3 (Remote Sensing Satellite 3, Jian Bing 5-3, JB 5-3)	China (PR)	People's Liberation Army (C41)	11/11/2007
33446	Yaogan 4 (Remote Sensing Satellite 4)	China (PR)	People's Liberation Army (C41)	1/12/2008
33456	Yaogan 5 (Remote Sensing Satellite 5, JB 5-C, Jian Bing 5-C)	China (PR)	People's Liberation Army (C41)	15/12/2008
34839	Yaogan 6 (Remote Sensing Satellite 6, Jian Bing 7-A)	China (PR)	People's Liberation Army (C41)	22/04/2009
36110	Yaogan 7 (Remote Sensing Satellite 7)	China (PR)	People's Liberation Army (C41)	9/12/2009
36121	Yaogan 8 (Remote Sensing Satellite 8)	China (PR)	People's Liberation Army (C41)	15/12/2009
36413	Yaogan 9A (Remote Sensing Satellite 9A)	China (PR)	People's Liberation Army (C41)	5/03/2010
36414	Yaogan 9B (Remote Sensing Satellite 9B)	China (PR)	People's Liberation Army (C41)	5/03/2010
36415	Yaogan 9C (Remote Sensing Satellite 9C)	China (PR)	People's Liberation Army (C41)	5/03/2010
27550	Zhangguo Ziyuan 2B (ZY-2B, JB-3B)	China (PR)	Chinese Academy of Space Technology	27/10/2002
31698	TerraSAR-X 1 (Terra Synthetic Aperture Radar X-Band)	Germany	German Aerospace Center (DLR)/Infoterra	15/06/2007
28649	CartoSat 1 (IRS P5)	India	Indian Space Research Organization (ISRO)	5/05/2005
29710	CartoSat 2 (IRS P7, CartoSat 2AT)	India	Indian Space Research Organization (ISRO)	10/01/2007
32783	CartoSat 2A	India	Indian Space Research Organization (ISRO)	28/04/2008
36795	CartoSat 2B	India	Indian Space Research Organization (ISRO)	12/07/2010
32786	IMS 1 (Indian Mini-Satellite, TWSat)	India	Indian Space Research Organization (ISRO)	28/04/2008
28051	IRS-P6 (Resourcesat-1)	India	Indian Space Research Organization (ISRO)	17/10/2003
35931	Oceansat-2	India	Indian Space Research	23/09/2009
26631	EROS A1 (Earth Resources Observation Satellite)	Israel	ImageSat International, NV/Ministry of Defense	5/12/2000
29079	EROS B1 (Earth Resources Observation Satellite)	Israel	ImageSat International, NV/Ministry of Defense	25/04/2006
35578	RazakSat (MACSat)	Malaysia	Malaysian National Space Agency	14/07/2009

38707	Canopus-B (Kanopus Vulcan 1)	Russia	Scientific Production Corporation (joint stock creation of Russian Space Agency)	22/07/2012
28254	Formosat-2 (ROCSAT-2, Republic of China Satellite 2)	Taiwan	National Space Program Office (NSPO)	21/05/2004
29047	COSMIC-A (Formosat-3A, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29048	COSMIC-B (Formosat-3B, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29050	COSMIC-D (Formosat-3D, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29051	COSMIC-E (Formosat-3E, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29052	COSMIC-F (Formosat-3F, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
28376	EOS-CHEM Aura	USA	Goddard Space Flight Center/EOS Data and Operations System	15/07/2004
33331	GeoEye-1 (Orbview 5)	USA	GeoEye	6/09/2008
25919	Ikonos-2	USA	GeoEye	24/09/1999
39418	SkySat-1	USA	Skybox Imaging	21/11/2013
39386	STARE-B (Horus [Space-Based Telescopes for Actionable Refinement of Ephemeris])	USA	National Reconaissance Office	19/11/2013
38782	VRSS-1 (Venezuelan Remote Sensing Satellite, Francisco Miranda)	Venezuela	Bolivarian Agency for Space Activities	28/09/2012
38711	MKA-FKI-1 (Zond PP)	Russia	Lavochkin Research and Production Association (Lavochkin NPO)	22/07/2012
31598	COSMO-Skymed 1 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	8/06/2007
26957	TES (Technology Experiment Satellite)	India	Indian Space Research Organization	22/10/2001
27434	Ofeq 5	Israel	Ministry of Defense	28/05/2002

31601	Ofeq 7	Israel	Ministry of Defense	10/06/2007
36608	Ofeq 9	Israel	Ministry of Defense	22/06/2010
33433	Shiyan 3 (SY3, Experimental Satellite 3)	China (PR)	Chinese Academy of Space Technology (CAST)	5/11/2008
37931	Shiyan 4 (SY4, Experimental Satellite 4)	China (PR)	Chinese Academy of Space Technology (CAST)	20/11/2011
39455	Shiyan 5 (SY5, Experimental Satellite 5)	China (PR)	Chinese Academy of Space Technology (CAST)	25/11/2013
28371	Saudisat-2	Saudi Arabia	Riyadh Space Research Institute	29/06/2004
26959	Bird 2 (Bispectral InfraRed Detector 2)	Germany	Institute of Space Sensor Technology and Planetary Exploration	22/10/2001
27003	Badr 2 (Badr B)	Pakistan	Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)	10/12/2001
29658	SAR-Lupe 1	Germany	German Federal Armed Forces	19/12/2006
31797	SAR-Lupe 2	Germany	German Federal Armed Forces	2/07/2007
32283	SAR-Lupe 3	Germany	German Federal Armed Forces	1/11/2007
32750	SAR-Lupe 4	Germany	German Federal Armed Forces	27/03/2008
33244	SAR-Lupe 5	Germany	German Federal Armed Forces	22/07/2008
38248	RISat-1 (Radar Imaging Satellite 1)	India	Ministry of Defense	25/04/2012
34807	RISat-2 (Radar Imaging Satellite 2)	India	Ministry of Defense	20/04/2009
25017	Lacrosse/Onyx 3 (Lacrosse-3, USA 133)	USA	National Reconnaissance Office (NRO)	24/10/1997
26473	Lacrosse/Onyx 4 (Lacrosse-4, USA 152)	USA	National Reconnaissance Office (NRO)	17/08/2000
28646	Lacrosse/Onyx 5 (Lacrosse-5, NROL 16, USA 182)	USA	National Reconnaissance Office (NRO)	30/04/2005
23223	Mercury 1 (Advanced Vortex 1, USA 105)	USA	National Reconnaissance Office (NRO)/USAF	27/08/1994
23855	Mercury 2 (Advanced Vortex 2, USA 118)	USA	National Reconnaissance Office (NRO)/USAF	24/04/1996
28891	Topsat	United Kingdom	Ministry of Defence/British National Space Centre	27/10/2005

ACCESS AND AVAILABILITY

The report is available in PDF format at http://www.crcsi.com.au

We welcome your comments regarding the readability and usefulness of this report.
To provide feedback, please contact us at info@crcsi.com.au

CITING THIS REPORT

Woodgate, P. W., Coppa, I. and Hart, N. (2014), 'Global Outlook 2014: Spatial Information Industry'. Published by the Australia and New Zealand Cooperative Research Centre for Spatial Information.

ISBN 978-0-994-301994

COPYRIGHT

All material in this publication is licensed under a Creative Commons Attribution 3.0 Australia Licence, save for content supplied by third parties, and logos. Creative Commons Attribution 3.0 Australia Licence is a standard form licence agreement that allows you to copy, distribute, transmit and adapt this publication provided you attribute the work.

The full licence terms are available from creativecommons.org/licenses/by/3.0/au/legalcode. A summary of the licence terms is available from creativecommons.org/licenses/by/3.0/au/deed.en.

DISCLAIMER

While every effort has been made to ensure its accuracy, the CRCSI does not offer any express or implied warranties or representations as to the accuracy or completeness of the information contained herein. The CRCSI and its employees and agents accept no liability in negligence for the information (or the use of such information) provided in this report.

ACKNOWLEDGEMENTS

Wendy Jackson

INDEX OF TABLES

INDEX OF FIGURES

TABLE OF CONTENTS

1 PURPOSE OF THIS PAPER

This paper presents a summary for 2014 of the global trends in the spatial industry in the context of global economic drivers.

2 EXECUTIVE SUMMARY

This paper contains a scan of published material on three interconnected trends: global technology developments; global spatial markets and their technologies; and the global economic picture.

Evidence is emerging to support broadly Oxera's (2012) estimate that the geoservices industries are growing at 30% per annum. Starting at the early phase of the global supply chain, estimates suggest that over 3000 satellite payloads (including communications, imaging and positioning) are scheduled for launch or under consideration for the period 2013 to 2032, almost tripling the number of satellites that are currently in orbit. Companies like Skybox Imaging and Planet Lab are planning to launch over 100 satellites between them, some as small as shoeboxes. The global remote sensing market is forecast to grow at an 8% compound annual growth rate between now and 2019.

In 2015 the US Federal Aviation Administration will open the market for commercial Unmanned Aerial Vehicles (UAVs). Costs are expected to fall rapidly as use increases. Similar developments in a number of US states are expected to power growth in autonomous vehicles.

Globally, Global Navigation Satellite System (GNSS)-enabled smartphones account for over half of all smartphone-enabled devices in 2014, and are experiencing a usage growth rate of 22%. Significant growth in indoor positioning devices and applications is being fueled by Apple iBeacon, Google Maps Indoors, SkyHook, IndoorAtlas, Nokia-HERE, Ubisence and Broadcom, among others.

Estimates suggest that investment in mobility will grow from 17% three years ago to 31% two years from now (82% growth); the cloud will more than double from 12% to 30% (150% growth); and collaboration tools will increase from 18% to 26% (44% growth).

By the end of this decade, 50 billion 'things', such as clothes, cars, trains, tractors and body sensors, will connect to the mobile network. They will consume 1000 times as much data as today's mobile devices and at rates 10 to 100 times faster than existing networks can support. Metcalfe's law, that the value of a telecommunications network is proportional to the square of the number of connected users of the system (n2), will be tested.

There are now 178 wearable devices on the market or soon to be launched for a range of uses including industrial, medical, gaming, fitness, lifestyle and entertainment. Augmented reality devices like Google Glass are among them. In particular, rapid growth is expected in wearable medical devices for disease diagnosis through the advent of continuous monitoring of a person's vital signs and lifestyle choices. More than half these devices have an inertial measurement unit (accelerometers, gyroscopes and/or magnetometers).

The market for wireless sensor networks (WSNs) was $552.4 million in 2012, and is growing rapidly towards an expected $14.6 billion in 2019. WSNs aid many applications, including geo-targeted mobile advertisements. Spending on these ads reached $725 million in 2013 and is forecast to more than triple to $2.74 billion by 2017.

New algorithms are being developed that analyse the history of movement of any individual and predict behaviours. These are being powerfully aided by the 'always online whether we know it or not' phenomenon.

Thus, enabling of technologies, data-rich content and accessibility of information products, as well as the willingness of consumers to cooperate, seems set to contribute to accelerated growth of the spatially-related markets over the next year. However, cybersecurity, privacy and the ethics of data and information management will be important issues in moderating this growth.

Developments in global technology are set against the backdrop of the global economy. Global GDP growth is expected to be 2.9% in 2014, up from the 2% experienced in 2013. Good growth of 7% is expected in China, which contributed 50% of the world's growth in 2013. Growth rates for other countries include India at 6%, New Zealand at 3.3%, Sub-Saharan Africa at 3.2%, Latin America at 3.2% and Australia at 3%. The US grew by 2.4% in 2013 and is forecast to increase to 3.0% in 2014. Europe languishes at 1%.

Government debt levels are expected to grow in 2014, but less rapidly than in 2013. Japan has the highest forecast debt-to-GDP ratio at 230%; the US is at around 100% and growing. China sits at around 50%, New Zealand at about 36% and Australia at 17.5%.

Global productivity growth is considered to be slow at a forecast 2.3% for 2014 as a result of predominantly weaker demand, a mismatch in resource allocation between labour and capital, and suboptimal innovation outcomes despite technology advancements in mature economies.

3 GLOBAL MEGATRENDS

The mass adoption of connected digital services by consumers, enterprises and governments is known as digitisation. Digitisation is a fundamental driver of world growth. The World Economic Forum (WEF) [1] and Booz & Company [2] estimate that digitisation has added US$200 billion to the world economy since 2011. The WEF has created a Digitisation Index to score a country's digitisation level, permitting measurement of its impact on economic and social factors. The WEF has found that a 10% increase in the index for any given country yields a 0.75% growth in GDP per capita and a 1.02% drop in unemployment.

Ernst & Young [3] and PriceWaterhouseCoopers [4] have independently published their views on global megatrends. These are compared in Table 1.

TABLE 1: GLOBAL MEGATRENDS ACCORDING TO ERNST & YOUNG AND PRICE-WATERHOUSECOOPERS

ERNST & YOUNG [3]	PRICEWATERHOUSECOOPERS [4]
Global rebalancing	Demographic shifts
Resourceful planet	Resource scarcity and climate change
Reconfiguring the financial system	Shift in global economic power
Digital transformation	Technological breakthroughs
Rethinking government	Accelerating urbanisation
Future of work	

In the geospatial sector, the 'ripe issues' according to the Open Geospatial Consortium (OGC) [5] are:

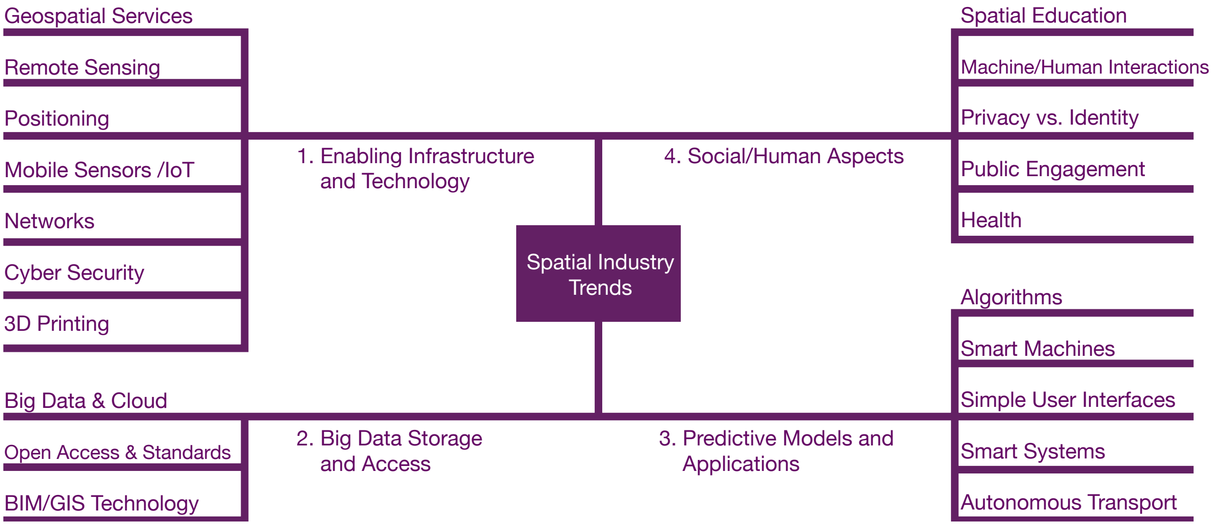
- The Power of Location
- Internet of Things
- Mobile Development
- Indoor Frontier
- Cartographers of the Future
- Big Processing of Geospatial Data
- Smart Cities Depend on Smart Location

4 SPATIAL INDUSTRY TRENDS

4.1 INTRODUCTION

This chapter is structured to cover interconnected aspects of technology and society as shown in Figure 1:

FIGURE 1: INTERCONNECTED ASPECTS OF TECHNOLOGY AND SOCIETY



4.2 ENABLING INFRASTRUCTURE AND TECHNOLOGY

4.2.1 GEOSPATIAL SERVICES

Geospatial services are now a substantial part of the global economy. Worldwide, the geospatial services sector generates $150 to $270 billion annually according to a 2012 study by Oxera (commissioned by Google) [6]. They estimate that the geoservices industries are growing globally at 30% annually with a Gross Value Add (GVA) of US$113 billion or 0.2% of the estimated US$70 trillion global GVA [6].

On the basis of the Oxera estimates, the revenue of the geospatial services industry is greater than the $25 billion generated by the video games industry, roughly equivalent to the $140 billion from the global security services industry, and about one third of the global airline industry's annual revenue of $594 billion [7].

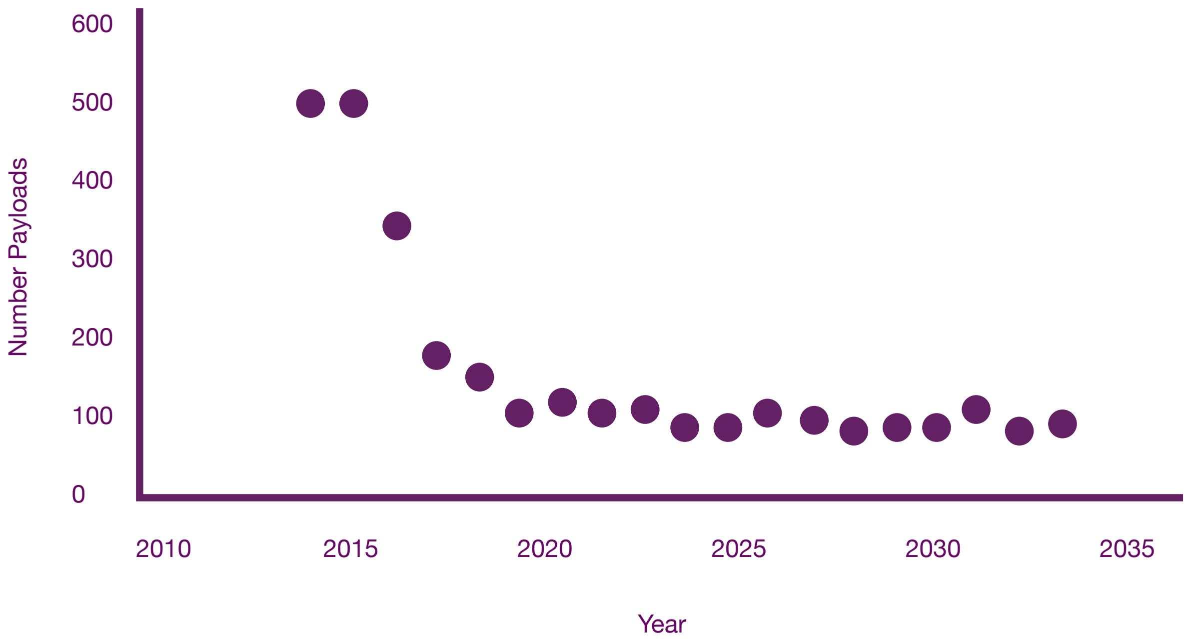
Boston Consulting (2012) estimates that the US geospatial industry generated US$73 billion in revenue in 2011 and helped generate $1.6 trillion in revenue for the rest of the US economy. It also produced US$1.4 trillion in cost savings, and made a significant contribution to improved efficiency gains. Further, Boston Consulting estimates that the geospatial services industry is currently in a high-growth phase [8].

4.2.2 REMOTE SENSING

4.2.2.1 SATELLITES

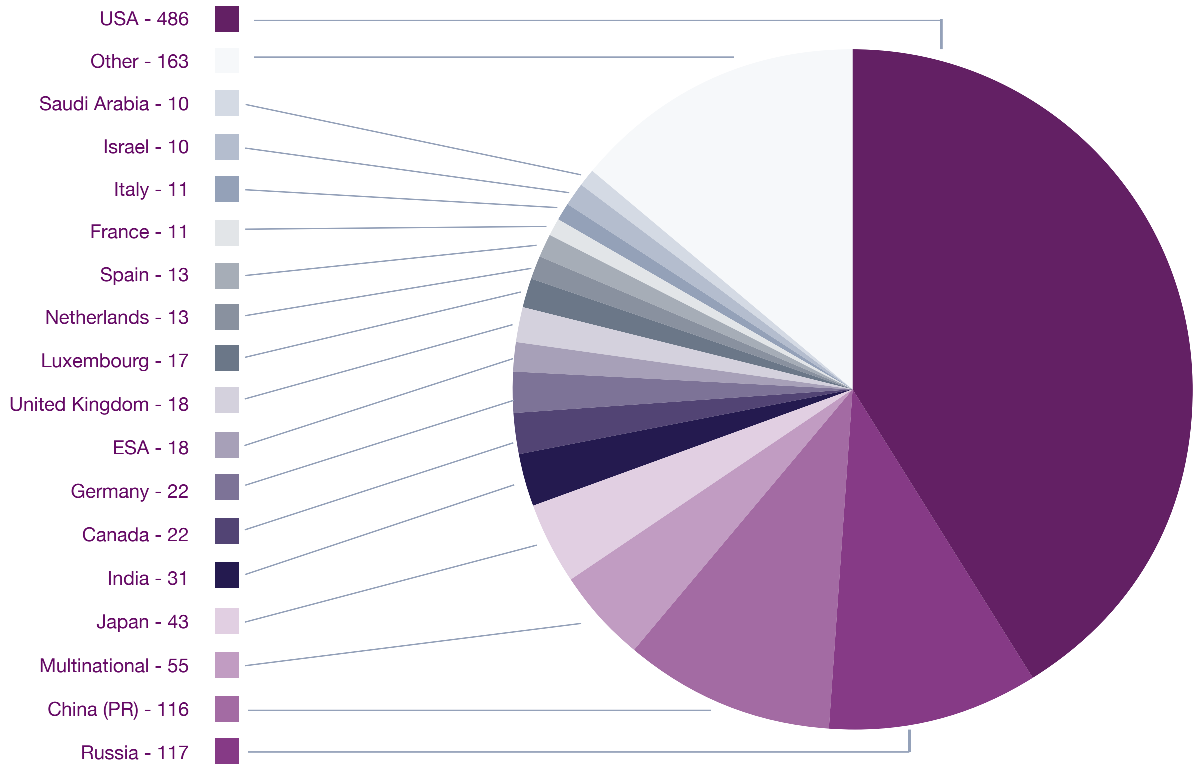
The Teal Group [9] estimates that 3,164 payloads are under consideration for launch between 2013 and 2032, with an estimated value of $235 billion. The decline in launches in the future is consistent with a forecast model as shown in Figure 2, as some planned launches are not yet publicly known:

FIGURE 2: FUTURE EXPECTED SPACE PAYLOAD LAUNCHES



According to data from the USA's Union of Concerned Scientists (UCS), there are currently 1176 active satellites in orbit as of 31 January 2014 [10]. Figure 3 shows satellite operators by country:

FIGURE 3: NUMBER OF SATELLITES BY COUNTRIES



Australia (listed under 'Other' in Figure 3) operates five communication satellites and one shared communication satellite with the US, listed in Table 2:

TABLE 2: AUSTRALIAN SATELLITES, ACCURATE AT 31 JANUARY, 2014

NORAD NUMBER	SATELLITE NAME	USERS	DATE OF LAUNCH	CONTRACTOR
27831	Optus and Defence C1	Military/Commercial	12/06/2003	Space Systems/Loral
23227	Optus B3	Commercial	28/08/1994	Hughes Space and Communications
29495	Optus D1	Commercial	13/10/2006	Orbital Sciences Corp.
32252	Optus D2	Commercial	5/10/2007	Orbital Sciences Corp.
35756	Optus D3	Commercial	21/08/2009	Orbital Sciences Corp.
20410	Leasat 5 (Syncom IV-5, Leased Satellite F5)	Military	9/01/1990	Hughes

Source: [10]

There are currently no Australian imaging or positioning satellites planned or in orbit.

According to UCS [10], there are 94 active satellites for Navigation/Global Positioning (see Appendix A) and 227 imaging satellites[1] (see Appendix B) as at 31 January 2014.

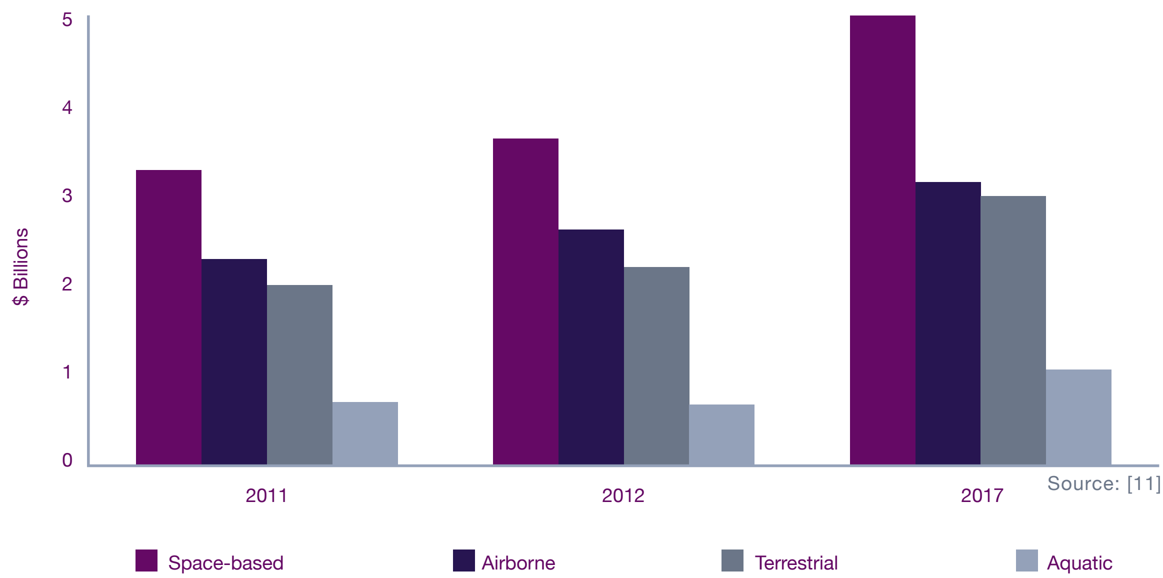
4.2.2.2 REMOTE SENSING MARKETS

The global remote sensing[2] market was estimated at $7.6 billion in 2013, with expected growth to $8.1 billion in 2014. BCC Research forecasts that the market will reach $12.1 billion in 2019 with a five-year CAGR of 8.2% [11].

World sales of satellite imagery are expected to grow at 12% compound over the next decade from $1.3 billion in 2010 to $4.0 billion by 2020. Synthetic Aperture Radar (SAR) imagery already accounts for 17% of sales [12]. The number of high-resolution satellites is set to double over the next three years. Over 40 countries will be launching Earth Observing (EO) satellites over the next seven years [12, 13].

The US Congress-mandated 'Open skies' policy for UAVs, together with increased capabilities of Geographic Information Systems, will stimulate production and reduce costs of remote sensing products. The ease of access to free and low-cost historic, recent and real-time imagery is increasing and complete unmanned aerial systems can now be purchased for what was previously the cost of one manned aircraft mission [11, 14]. The value of remote sensing products, categorised by platform, is summarised in Figure 4.

FIGURE 4: VALUE OF REMOTE SENSING PRODUCTS BY PLATFORM, 2011 TO 2017 ($BILLION)



Source: [11]

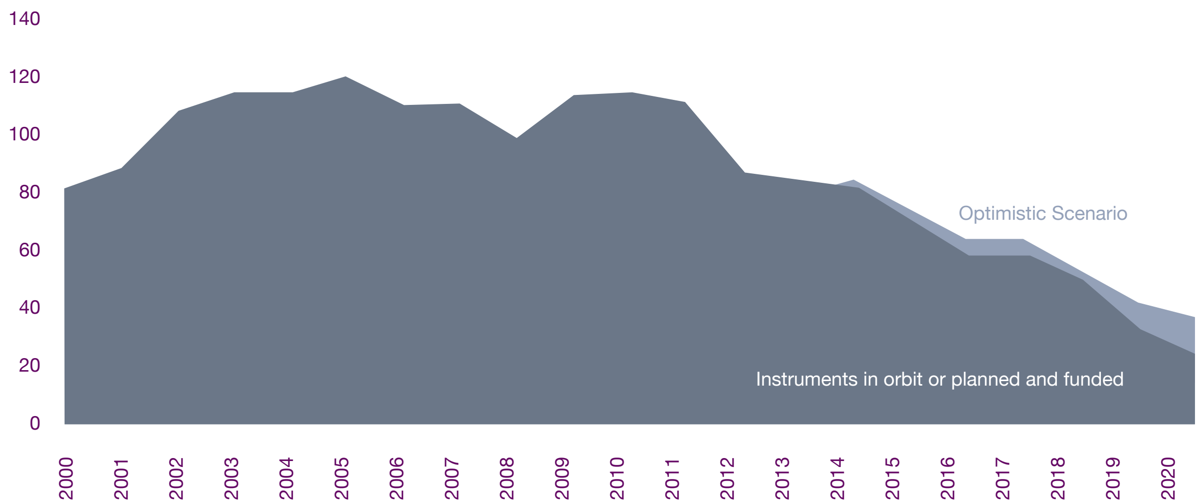
[1] Includes the following classes of satellites: Earth Observation, Earth Science, Meteorology, Reconnaissance, Remote Sensing, Surveillance
[2] Remote sensing comprises satellite earth observation and airborne (manned and unmanned) aerial imaging.

Commercial remote sensing is at a tipping point. Satellite imagery will become plentiful with planned constellations of lightweight and comparatively inexpensive satellites such as those from Skybox Imaging and Planet Lab. Skybox Imaging successfully launched its first small (60 x 60 x 90 centimetres) high-resolution satellite (Skysat 1) in November 2013 [15]. The constellation is planned to be extended with a further 23 satellites with a 1-metre pixel resolution (achieved by merging video stream data) to be launched by 2016; data are accessible in the cloud.

Planet Lab has secured funding for its constellation of 100 shoebox-sized 'Dove' satellites (3–5 metre resolution). Twenty-eight satellites were deployed in February 2014 ('Flock 1'), joining the four experimental Doves launched in 2013. The remainder will be launched in 2014 [16]. Russia's GazProm plans to launch its SMOTR constellation. UrtheCast flies two video cameras (1- and 6-metre resolution) on the International Space Station (ISS) [17]. A further upcoming endeavour on the ISS is Teledyne's MUSES system [17].

Planet IQ is launching the first commercial weather satellite constellation by 2017 to compensate for a decline in public weather data [18]. Dauria Aerospace (a German/Russian startup) plans four satellites between 2014 and 2017. Tyvak offers a complete nanosatellite solution; the founders invented the CubeSat standard [17]. NovaWurks builds modular multi-use space platforms [17]. GeoOptics will launch its CICERO constellation (12 satellites) between 2014 and 2017 [19]. Figure 5 shows the decline in the number of NASA/NOAA Earth-observing instruments.

FIGURE 5: NUMBER OF NASA/NOAA EARTH-OBSERVING INSTRUMENTS [20]



Source: [20]

4.2.3 POSITIONING AND LOCATION-BASED SERVICES (LBS)

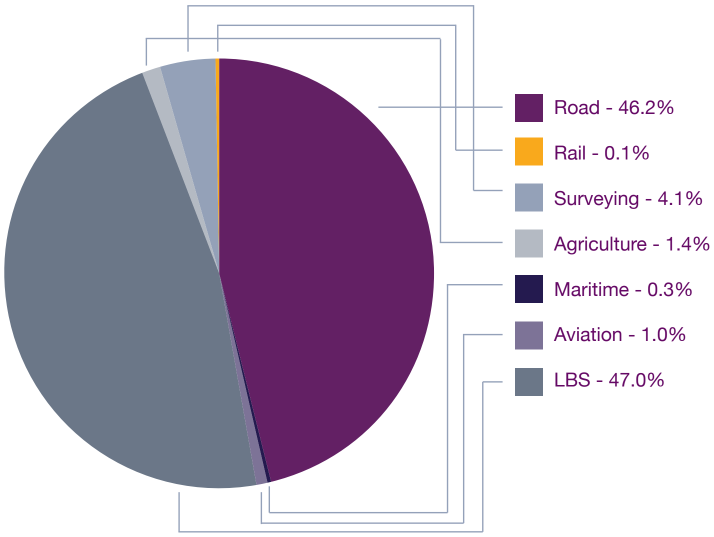
Improved technologies are starting to challenge the way vertical reference systems are defined [21]. There is significant growth in indoor positioning: for example, Apple launched the iBeacon service in December 2013. It works on Bluetooth Low Energy (BLE) and aims to simplify payment and enable on-site offers. It has a spatial accuracy of approximately 30 centimetres and a range of 10 to 15 metres, depending on where the receiver (iPhone) is stored. In December 2013, iBeacon was introduced to 254 retail stores in the US [22]. The device works at three distances: immediate (a few centimetres, like Near Field Communication (NFC)), near (a couple of metres) and far (more than 10 metres). It will transmit to and receive from mobile devices, using specialist Apps to provide micro-location awareness. The developer kit for iBeacon allows companies to develop their own applications. For example, the Australian company Tzukuri is developing sunglasses that notify the owner when they are left behind [23], sending alerts at 4 metres, 8 metres and 16 metres and including guidance as to where to find them. It is predicted that iBeacon will revolutionise the shopping experience in brick-and-mortar shops as well as how groups interact with each other in educational and corporate contexts [22].

Google has developed Google Maps Indoors for Android, which includes interior maps and measuring and mapping of the Wi-Fi signal strength throughout the building to within 2 to 3 metres' accuracy.

SkyHook has cell tower triangulation as well as a Wi-Fi network database to determine position indoors accurate to 3 to 4 metres. IndoorAtlas senses location within several metres using magnetic sensors in smartphones to detect signature magnetic anomalies within buildings and map the unique patterns of their interiors. Nokia uses Bluetooth technology to provide 0.3-metre position accuracy by measuring the Direction of Departure (DoD) of signals from installed positioning beacons. Broadcom offers a special chip that takes in data from the inertial sensors on the device, Wi-Fi access points, Bluetooth low energy beacons and multiple Global Navigation Satellite System (GNSS) signals to determine indoor position. Finally, Ubisense provides precise real-time location systems for tracking moving assets using ultra-wideband transmitters that signal a network of base stations, which then triangulate the position to within 15 to 30 centimetres [21, 24].

The European GNSS Agency [25] has summarised the markets for Location-Based Services (LBS), road, aviation, rail, maritime, agriculture and surveying in Figure 6:

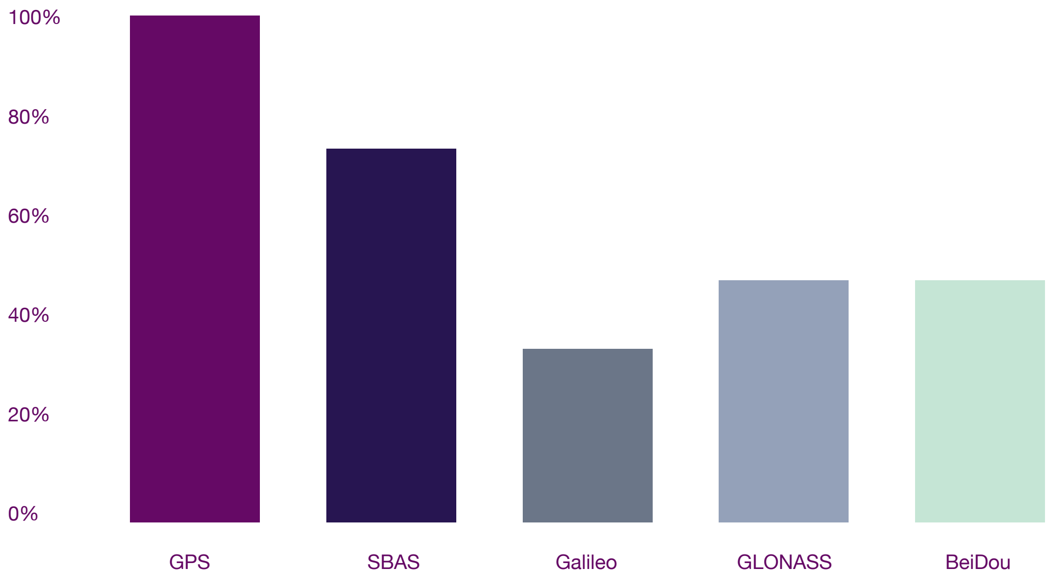
FIGURE 6: CUMULATIVE CORE REVENUE FOR VARIOUS SECTORS BETWEEN 2012 AND 2022



Location-based services delivered via smartphones will comprise almost half of the total global GNSS market in 2022, estimated at € 250 billion per annum [25]. GNSS-enabled smartphone ownership will greatly increase, especially in low-income countries, due to lower smartphone costs of around $25 per unit [26].

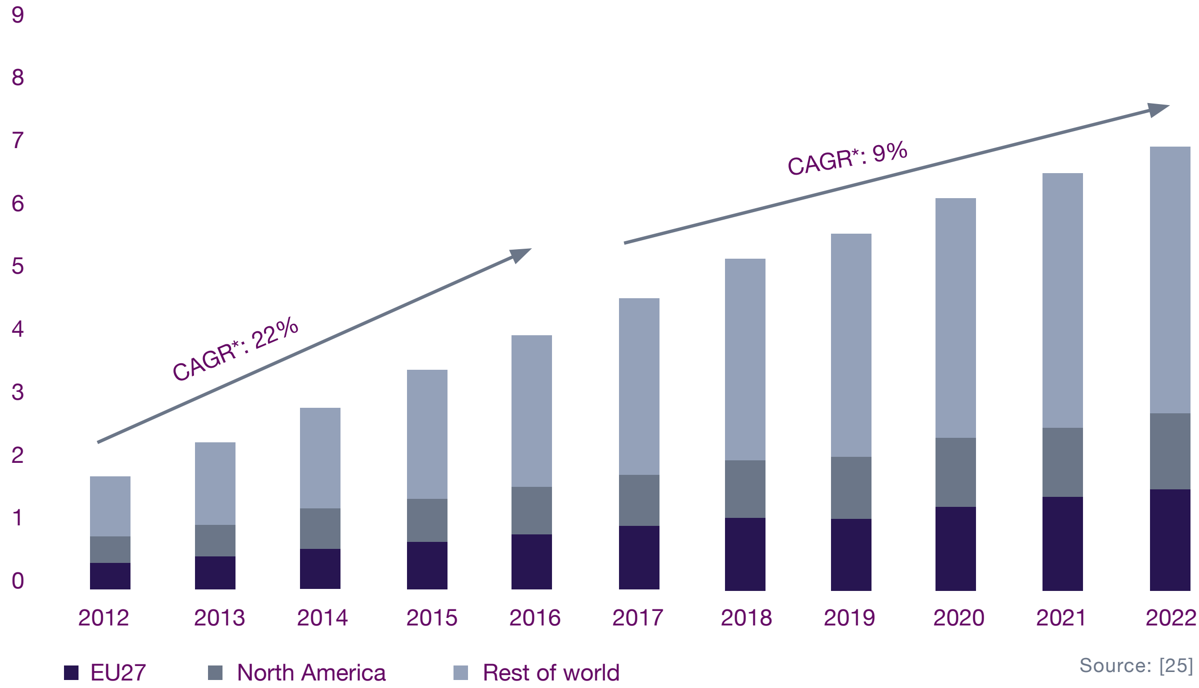
Multi-constellation devices are becoming more common in the market with more than 70% of models being Global Positioning System (GPS) and Satellite Based Augmentation System (SBAS) capable[3]. These trends are highlighted in Figure 7 and Figure 8.

FIGURE 7: GNSS CAPABILITY IN RECEIVERS [25]



Source: [25]

FIGURE 8: INSTALLED BASE OF GNSS DEVICES BY REGION



Source: [25]

[3] Satellite Based Augmentation System (SBAS) are systems that transmit additional information on clocks, ephemeris and ionospheric delays to improve the accuracy of Global and Regional Satellite Navigation Systems.

It is forecast that in 2022 there will be 7 billion GNSS devices (almost one for each person on the planet) and these are likely to contribute to global efficiency gains. Most of the devices serve the LBS and transport markets. Initial growth rates to 2016 are projected at 22% CAGR, tapering off to 9% CAGR after 2018 [25]. Table 3 gives an overview of GNSS systems:

TABLE 3: OVERVIEW OF GNSS SYSTEMS

SYSTEM	GPS	GLONASS	COMPASS	GALILEO	IRNSS
POLITICAL ENTITY	United States	Russian Federation	China	European Union	India
CODING	CDMA	FDMA/CDMA	CDMA	CDMA	CDMA
ORBITAL HEIGHT	20,180 km (12,540 mi)	19,130 km (11,890 mi)	21,250 km (13,140 mi)	23,220 km (14,430 mi)	36,000 km (22,000 mi)
PERIOD	11.97 hours (11h 58m)	11.26 hours (11 h 16 m)	12.63 hours (12h 38 m)	14.08 hours (14 h 5 m)	N/A
EVOLUTION PER SIDEREAL DAY	2	17/8	17/10	17/10	N/A (geostationary)
NUMBER OF SATELLITES	At least 24 1.57542 GHz	31, including 24 operational, 1 in preparation, 2 on maintenance, 3 reserve, 1 on tests	5 geostationary orbit (GEO) satellites, 30 medium Earth orbit (MEO) satellites	4 test bed satellites in orbit, 22 operational satellites budgeted	7 geostationary orbit (GEO) satellites
FREQUENCY	(L1 Signal) 1.2276 GHz (L2 Signal)	Around 1.602 GHz (SP) Around 1.246 GHz (SP)	1.561098 GHz (B1) 1.589742 GHz (B1-2) 1.20714 GHz (B2) 1.26852 GHz (B3)	1.164-1.215 GHz (E5a and E5b) 1.260-1.300 GHz (E6) 1.559-1.592 GHz (E2-L1-E11)	N/A
STATUS	Operational	Operational, CDMA in preparation	15 satellites operational, 20 additional satellites planned	In preparation	2 satellites launched, 5 additional satellites planned

Source: [27]

A 61% increase in satellite numbers within Global Navigation Satellite System (GNSS) and Regional Satellite System (RNSS) constellations is expected by 2020, as shown in Table 4:

TABLE 4: CURRENT AND PLANNED NUMBERS OF GNSS AND RNSS SATELLITE NUMBERS

NAME	CURRENT ACTIVE SATELLITES	TOTAL PLANNED TO CIRCA 2020	
GNSS			
• GPS (US)	30	24	
• Glonass (Russia)	28	24	
• Galileo (EU)	4	31	
• BeiDou (China)	14	35	
RNSS			
•QZSS (Japan)	1	3	
•IRNSS (India)	0	7	
TOTAL	77	124	Source: [28]

The Japanese are developing an RNSS known as the Quasi-Zenith Satellite System (QZSS) and South Korea have announced that they will develop a regional SBAS[4].

4.2.4 MOBILE SENSORS AND USAGE – INTERNET OF 'THINGS'

There are predictions of massive growth of interconnected sensors including estimates of over 50 billion 'things' in a hyper-connected environment by 2020 [21].

An estimated 485 million wearable computing devices will be shipped by 2018, of which 61% will be for wearable fitness or activity tracking [29].

The global market for health Information and Communications Technology (ICT) products is estimated to be $96 billion and growing. E-health is considered to be one of the six most promising lead markets of the European Union [1].

International and Australian Telephone, Mobile and Internet Usage, and ICT
In 2013 the Consumer Electronics Association estimated that shipment revenues for smartphones would be about $37 billion in 2013, with almost 126 million units shipped to dealers, a 16% increase on 2012. They also estimated that tablet computer unit sales would exceed 105 million and be worth $36 billion in shipment revenue, up 54% from 2012 [30].

Some other interesting statistics include [31]:

- In Australia, 81% of people use the Internet
- Smartphone usage increased by 272% in Australia in 2011
- Of online Australians, 61% have an active Facebook account
- Of online Australians, 86% purchased products and services online in 2011

[4] The following countries have SBAS: US – WAAS; Europe – EGNOS; Japan – MSAS; India – GAGAN; Russia – SDCM; China – COMPASS; South Korea – name yet to be published.

Mobile phone usage differs by demographics and market. For example, the majority of mobile consumers in developed markets such as South Korea (67%), Australia (65%) and the UK (61%) prefer smartphones. Pew data shows smartphone ownership has risen 20% just in one year [29]. Basic phones are more commonly used in India (80%), Turkey (61%) and Russia (51%). Mid-range multimedia phones, which have more capabilities than feature phones but less than smartphones, are least popular, with less than 10% usage in most countries [29]. The mobile phone usage (smartphones and other phones) for the following countries is; Brazil (84%), Australia (86%), China (89%), USA (94%), Italy (97%), UK (97%), Russia (98%), and South Korea (99%) [32].

In Europe, investment in ICT will accelerate over the next two years, though not as significantly as in Asia. Comparing data from three years ago to projections for two years from now, survey data shows that as a percentage of the total European ICT budget [33]:

- Investment in mobility will increase from 12% to 20% (66% growth);
- Investment in cloud-based services will almost double from 12% to 23% (96% growth); and
- Investment in collaboration tools will rise slightly from 16% to 17%.

In Asia-Pacific, firms are investing a much greater percentage of their information and communications technology budgets in new technology, and expecting to grow those investments more quickly, compared to all other regions. For example [33]:

- Investment in mobility will grow from 17% three years ago to 31% two years from now (82% growth)
- Investment in the cloud will more than double from 12% to 30% (150% growth); and
- Investment in collaboration tools will increase from 18% to 26% (44% growth).

By the end of this decade, it is estimated that the 50 billion ‘things’ that will connect to the mobile network, such as clothes, cars, trains, tractors, and body sensors, will consume 1000 times as much data as today’s mobile devices at rates 10 to 100 times faster than existing networks can support [34].

In early 2014 Google made the announcement that it had bought the smart thermostat maker Nest Labs for $3.2 billion. At present a connected nest smoke alarm costs about $130, while a stand-alone version costs just over $5. Mass production is likely to see these costs fall.

Cisco has estimated significant growth in both smartphones and tablets as well as machine-to-machine (M2M) connections, as shown in Figure 9 and Figure 10 respectively. In 2013, 4G accounted for 0.43% of global M2M connections, and this is expected to rise steadily to 1.5% in 2014, 3% in 2015 and 5.6% in 2016 [34].

FIGURE 9: GLOBAL NUMBERS OF IPV6-CAPABLE SMARTPHONES AND TABLETS, 2013 TO 2018

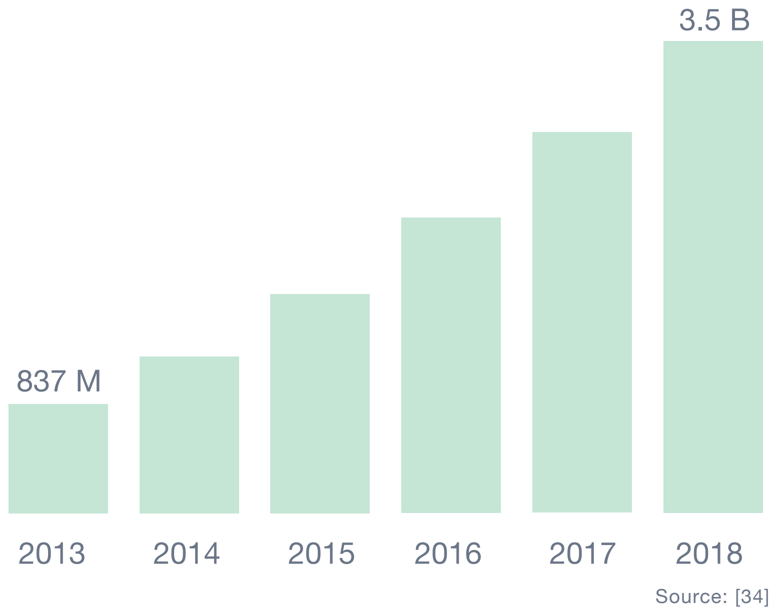
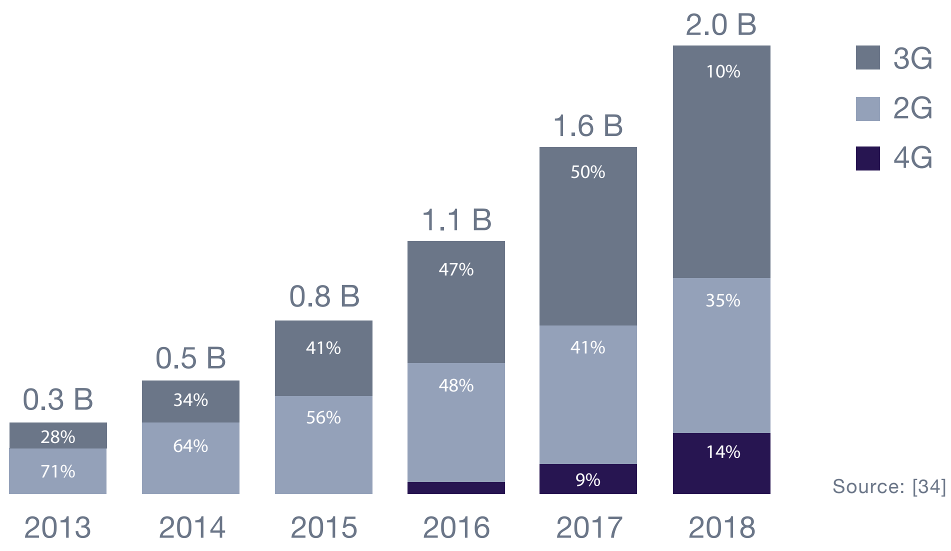


FIGURE 10: GLOBAL MACHINE-TO-MACHINE GROWTH AND MIGRATION, 2013 TO 2018



According to Mat Hatton, director of Machina Research, a connected home is a complex thing, plagued by a lack of standards and general difficulties for end users [35]. There is no guarantee that the different devices and hubs will interoperate, as all use different protocols. But smartphones can help. While individual smart appliances may not be able to communicate with each other, they can communicate with a smart mobile device. Smart phones act as remote controls for many devices. Google/Nest Duo are creating open platforms like Android, says Jeremy Warren, Vice President of Innovation at Vivint.

An open platform could effectively be like Wi-Fi, a technology all can use to allow us to connect more devices, more readily [35]. Vandrico has compiled a comprehensive database and analysis of 178 wearable devices for a range of uses including industrial, medical, gaming, fitness, lifestyle and entertainment. Vandrico expects to see particularly rapid growth in wearable medical devices for disease diagnosis through the continuous monitoring of a persons vital signs as influenced by their lifestyle choices. More than half the devices reviewed by Vandrico had an inertial measurement unit (accelerometers, gyroscopes, and or magnetometers) [36]. Mobile sensors are integrated in wearable devices, and can be controlled by the user (actively or passively) to augment knowledge, facilitate learning or enhance the user experience.

Sarah Rotman Epps, a former Forrester analyst who specialises in wearable computing, expects the Apple smartwatch (which may be announced in 2014) to change the way we engage with our wrist in the same way Apple changed the mobile phone industry in 2007. Expected sales are as high as $17.7 billion [37]. Already available is the Pebble smartwatch [38], which displays phone and email messages and calendar entries, and even connects to the Mercedes-Benz Smart Car App, which acts as a real-time data centre informing drivers about hazards such as accidents and road construction using vibrations [39].

Other examples of wearable technology are the Samsung Gear Smartwatch [40], FitBit [41], Jawbone Up [42], Nike FuelBand [43] and Sony Smartband Core [44]. A form of wearable technology that came to prominence in 2013 was Google Glass, a heads-up display with integrated camera and sound projection technology. Google Glass connects to the Android phone and encourages people to look up in the world again, rather than being buried in their smartphone screen (a commonly observed phenomenon, particularly among younger smartphone users) [45].

Oculus Rift, partially crowdfunded on Kickstarter, created immersive Virtual Reality[5] goggles, which can be used in applications such as gaming. In March 2014 the company announced their sale to Facebook for $2 billion [46].

It is expected that eight million wearable technology units will be shipped in 2014, rising to 23 million units in 2015 and 45 million units in 2017 [47].

4.2.5 NETWORKS

As shown in Table 5, Australia ranks 43rd globally in Internet connectivity with an average connection speed of 4.8 megabits per second (Mb/s). South Korea is the global leader with 13.3 Mb/s, followed by Japan with 12 Mb/s [48]. Currently, more than two thirds of Australian households have a broadband Internet subscription. With current technology, the fastest connection Australian telecommunication companies can guarantee is 50 Mb/s [48].

[5] Virtual reality is a computer-generated simulation of the real world. This should not be confused with augmented reality, which is a computer generated overlay superimposed on the view of the real world with both visible simultaneously.

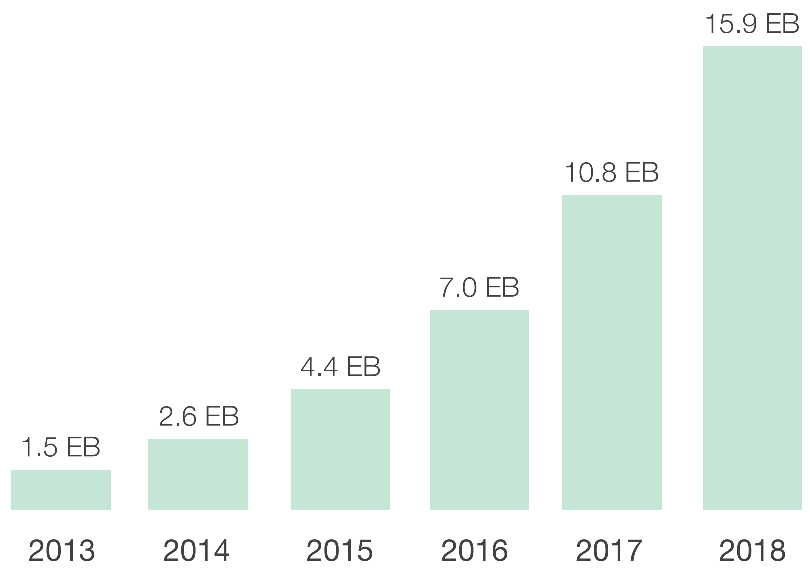
TABLE 5: AVERAGE INTERNET CONNECTION SPEEDS BY COUNTRY

GLOBAL RANKING	AVERAGE CONNECTION SPEED (Mb/s)
1 - South Korea	13.3
2 - Japan	12.0
3 - Switzerland	11.0
4 - Hong Kong	10.8
5 - Latvia	10.6
6 - Netherlands	10.1
7 - Czech Republic	9.8
8 - United States	8.7
9 - Sweden	8.4
10 - United Kingdom	8.4
43 - Australia	4.8
Global Average:	3.3 Mb/s

Source: [48]

The CISCO visual networking index predicts that global mobile data traffic will increase 18-fold between 2011 and 2016, as shown in Figure 11 [34].

FIGURE 11: GLOBAL MOBILE DATA TRAFFIC, 2013 TO 2018



Source: [34]

According to Kelly Ahuja, Senior Vice President and General Manager of Cisco's Mobility Business Group, the many new sensors associated with Internet of Things (IoT) will put pressure on the wireless spectrum. Strategic small cell development will help cities and service providers to combat congested cell towers and customer frustration. Small cells also offer new market opportunities for location-based services [50].

The WinterGreen Research team published a report on wireless sensor network markets [51]. The market for wireless sensor networks was $552.4 million in 2012 and is growing rapidly to an expected $14.6 billion in 2019.

According to Metcalfe's law, the value of a telecommunications network is proportional to the square of the number of connected users of the system (n2). At the edge of the Internet of Things are appliances and equipment in use every day. These 'things' are connected by an infrastructure backbone such as ZigBee, sub-GHz, Wi-Fi or Power Line communications (PLC), thus providing a robust bidirectional communication link with relatively long range, low latency for fast responsiveness, low power and a sufficient data rate to aggregate information from many connected devices. This infrastructure serves as a gateway to the Internet and enables remote monitoring and control of devices by end users, utility companies and other networks [52].

Most connected devices in the IoT are nodes located in the last centimetres of the network. It is essential that machines communicate among themselves. For example, users do not want to have to monitor fifty or more sensors throughout their house to see if the air conditioning has been left on with a window open. Smart sensor systems are able to recognise this independently [52].

The connected and smart home product market grew by almost 19% between 2010 and 2012. It is estimated to continue growing at an 8% CAGR to reach $930 million by 2015 [35].

The Sense-T network is a living laboratory in Tasmania where shared data drives new approaches to social, environmental and economic sustainability. The system uses sensor technology to aggregate data in the cloud and provides sophisticated modelling and data analysis in real time. New ideas are tested using Sense-T and scaled cost effectively elsewhere. Specific applications are in development, such as for the beef, dairy, viticulture, aquaculture and water industries. The 'Pathways to Market' project partners Sense-T with the Tasmanian government, the University of Tasmania, CSIRO, IBM and Grey Innovation among others. The World Bank's chief innovation officer, Chris Vein has identified this development as disruptive in nature and highly interesting, with potential for deployment in developing nations [53].

Another example of device connection via IoT is a wireless sensor system designed and tested by Taggle in cooperation with CSIRO in Queensland, whose applications include cattle tracking, water meters and irrigation systems [54].

4.2.6 CYBERSECURITY

In the early stages of development of the IoT, the design of physical security has had limitations. The security function usually resides within the web servers that sit in front of the object. Objects will initially focus on message integrity and secure communication, but as the technology develops, the security levels will move closer to the objects before eventually becoming embedded [55].

The first stages of IoT will exist on current infrastructure and protocols, using object gateways and consolidators. The true IoT, however, will need to be built on the foundation of Internet Protocol version 6 (IPv6), a protocol that offers almost limitless IP addresses but whose adoption will take time [55].

According to Caitlin Cosoi, Chief Security Strategist and Global Communication Director at Bitdefender, cybersecurity threats and vulnerabilities represent a serious concern when it comes to devices such as wearable technology, smart TVs, smart houses, smart cars, smart infrastructure appliances and smart medical devices. She predicts that in 2014 such security flaws may lead to human casualties [50].

A big Internet issue is authentication. Having to keep track of a multitude of passwords that need to be changed frequently is annoying for the user. Security flaws, such as Heartbleed [56], are a huge threat to user privacy and carry the risk of identify theft. Apple kicked off mobile biometrics in 2013 with the iPhone's 5S Touch ID. Motorola was first to develop a fingerprint-reading phone, but Apple's Touch ID is more user-friendly, allowing users to easily unlock the phone and authenticate iTunes purchases [50]. The Samsung Gallaxy S5 has a more complex fingerprint 'swipe', and can be used to authorise Paypal payments.

Recently, Google acquired the startup SlickLogin, which uses sound as an authentication tool. SlickLogin creates a sound that is inaudible to the human ear. Apps, websites and services that use SlickLogin technology can do away with passwords by simply allowing authentication of users by playing an inaudible sound from a nearby smartphone [57].

Biometrics are likely to play a bigger role in 2014 and beyond, particularly for secure logins and banking applications. Companies such as Bionym and EyeVerify have unique biometric technology that would be perfect for phones. [50].

The spatial enablement of the IoT, especially through the rapidly expanding use of location-based services, substantially increases the risk of breaches of security, privacy and confidentiality.

4.2.7 3D PRINTING

Sales of 3D printers are expected to grow by 75% in 2014, followed by a near doubling of units in 2015. While very expensive additive manufacturing devices have been around for 20 years, the market segment between $500 and $50,000 is rapidly growing. The advantges of 3D printing include its ability to reduce costs, improve design, streamline product prototyping and help with short run manufacturing [58].

New 3D printing tools and techniques are empowering anyone from do-it-yourself enthusiasts to global corporations to create new devices, such as car parts, batteries, prosthetics, computer chips, jewellery, clothing, firearms and even pizza, more quickly, cheaply and easily than ever before. In 2014 there will be more 3D tools and processes including crowdfunding sites [49].

Among 3D innovations is printing of biological materials, such as human tissue and bone. Organovo, a biotech company from San Diego, recently claimed that it would have a 3D printed liver available by the end of 2014 [59]. The University of Sheffield recently demonstrated their laser-sintered, entirely 3D printed UAV [60].

Spatial applications for 3D printing are not yet evident in practice but in theory the geo-referencing of points, lines and polygons inside tangible 3D printed objects such as human organs could quite feasibly lead to a form of modelling equivalent to a Building Information Model.

4.3 BIG DATA STORAGE AND ACCESS

4.3.1 BIG DATA AND THE CLOUD

Digitisation: The World Economic Forum (WEF) reports that in 2013 Australia was ranked 18th of 144 countries in terms of its digitisation index. This is one place lower than in the previous year. Very high costs of telephony by world standards work against Australia. New Zealand has dropped six places to 20th for the same reason. Finland, Singapore and Sweden make up the top three positions respectively [1].

The Cloud: The quantity of information that was generated from the dawn of time until 2005 (5 exabytes) is now being created every two days according to Eric Schmidt, executive chairman of Google [61]. According to Brock et al. [62], five major applications can be envisaged: generating new business insights; improving core operating processes; enabling faster, better decision-making; taking advantage of changing value chains; and creating new data-centric businesses. New technologies like Hadoop and MapReduce allow data to be processed in its native form.

TABLE 6: CLOUD COMPUTING SCORECARD MEASURING 'CLOUD-READINESS'

MEASURES	JAPAN	AUSTRALIA	GERMANY
Rank Worldwide	1	2	3
Data Privacy	8.8	7.9	6.6
Security	8.4	8	6.4
Cybercrime	10	9.4	10
Intellectual Property	17.2	17.8	16.8
Support for Industry-Led Standards	8.8	10	9.8
Promoting Free Trade	9.2	7	9.2
ICT Readiness, Broadband Deployment	20.9	21.3	20.2
TOTAL	83.3	79.2	79

Source: [63]

Use of the cloud will become the norm, enabling the desired information to be accessible to anyone, anywhere, anytime, on the device of their choice [21].

The Cloud Computing Scorecard (see Table 6) placed Australia 2nd in the evaluation of 24 countries for 'cloud-readiness'.

According to Gartner, big data are estimated to have influenced $34 billion in IT spending in 2013 [64]. Big data are perceived to be more difficult to manage due to their volume, velocity and variety. Skilled data analysts and new tools are needed to support the growing big data needs of industry, including insurance, financial, marketing, scientific research and healthcare sectors. The IEEE predicts that in 2014 simpler analytics tools will be created, resulting in new market leaders in the data management and analytics space [49].

Cloud computing is now used by 54% of businesses [65]. One of the drivers behind the move toward cloud computing is the increase in mobile computing. Mobile devices have limitations in memory, processing power and battery life but when combined with cloud services are the processing and storage can happen outside the mobile device improving their utility [66].

4.3.2 OPEN ACCESS AND STANDARDS

In 2011 McKinsey & Company published a report on big data that highlighted the rapid rate of growth of digital information: 40% growth in global data per annum, 30 billion pieces of information shared on Facebook per month, and the need for 1.5 million more analysts in the US alone to take advantage of big data. McKinsey & Co. estimate that the use of personal location data contributes $300 billion in annual value to the US health care system and $600 billion in annual consumer surplus globally [67].

Australian governments are working toward making geospatial data available within the data.gov.au initiative, which comprises 3,500 public datasets currently available on the website. Australian governments are moving to make more of their data open and accessible. For example Queensland has seen a 500% increase in usage since it started its Queensland Globe less than a year ago. It is now receiving 8 million hits per day and serviced its one billionth map request in June [68]. Table 7 gives a summary of some of the prominent government-run and public web-based spatial data services in Australia.

High user-friendliness

Low user-friendliness

TABLE 7: SUMMARY OF PROMINENT GOVERNMENT-RUN PUBLIC WEB-BASED SPATIAL DATA SERVICES IN AUSTRALIA

	QUEENSLAND GLOBE	SLIP FUTURE [LOCATE] (WESTERN AUSTRALIA)	DATA VIC (VICTORIA)	NEW SOUTH WALES GLOBE	DATA-GOV.AU AUSTRALIAN GOVERNMENT
ABOUT	A free plug-in developed by the Queensland Goverment. Includes addresses, localities and boundaries, roads and rail networks, land parcls and tenure and areas affected by flood topographical maps http://www.dnrm.qld.gov.au/mapping-date/queensland-globe	Viewable via a browser in either 2D or 3D using Google Earth. Contains many layers, including aerial photography, property, road, public transport routes, historical maps, census data, schools, health facilities and more to come. http://slipfuture.landgate.wa.gov.au/pages/locatehome.aspx	Provides public access to data generated or owned by the Victorian Government. The Victorian Government's DataVic Access Policy promotes open access to government data to drive innovation, create new business opportunities and enable new services. http://www.data.vic.gov.au	Encompasses Land and Property Information, for NSW land and property information. globe.six.nsw.gov.au	Provides an easy way to find, access and reuse public datasets from the Australian Government. See draft data.gov.au roadmap, the new data.gov.au launch page and Government Data Landscape mind map for more information about related policies and initiatives. http://data.gov.au
KML ENABLED	Yes	Yes	Not fully*. Selected KMLs here: http://www.vic.gov.au/search-results.html?q=kml	Yes	Selected datasets can be downloaded in KMZ/KML format
2D GOOGLE MAPS	No	Yes	Other system	Yes	Not found
MOBILE DEVICE VERSION	Yes	Yes	No	Yes	No**
MORE INFO	http://www.spatialsource.com.au/2013/04/09/queensland-releases-google-earth-plugin	http://www.spatialsource.com.au/2013/11/05/landgate-launches-locate	http://www.governmentnews.com.au/2013/09/victoria-broadens-geospatial-mapping-data-release	http://www.spatialsource.com.au/2013/11/12/lpi-launches-nsw-globe	http://www.finance.gov.au/blog/2013/10/26/government-data-landscape-australia

ADDITIONAL NOTES/LINKS TO TABLE 7

* http://www.depi.vic.gov.au/_data/assets/pdf_file/0013/126310/3.0-IWS-Connecting-Google-Earth.pdf
** http://australia.gov.au/services/apps-services [APPS using specific government data, not a general Mapserver]

See also data from Geoscience Australia: http://www.ga.gov.au/meta
https://data.qld.gov.au/maps-geospatial/qld-globe
http://www.dnrm.qld.gov.au/mapping-data/queensland-globe/install-mac-pc
http://slipfuture.landgate.wa.gov.au/Pages/LocateGettingStarted.aspx#3dtips
http://globe.six.nsw.gov.au
https://mapsengine.google.com/09372590152434720789-0091331548129055690-4/mapview
http://er-info.dpi.vic.gov.au/sd_weave/anonymous.html [Not Google Maps]
http://maps.six.nsw.gov.au
http:// www.dnrm.qld.gov.au/mapping-data/queensland-globe

Geospatial information, resources and applications are increasingly being built collaboratively with open and rapid deployment strategies and open standards [7]. Government custodians of the data and information are increasingly inclined to provide open access to the data and resources and to make it freely available in a comprehensive and efficient way. Calls are being made for it to be organised in a way that can be easily shared, integrated and analysed, ready for value-adding services, resulting in a more spatially enabled society [70].

Other observations from the United Nations Initiative on Global Geospatial Information Management on the question of open data include [21]:

- Open source will be the preferred approach where resources are scarce or where it provides the best expertise
- Open source improves the ability to modify and share easily, and build common user communities
- Future geospatial leaders are increasingly exposed at an early stage to the use of open source and so are already culturally attuned
- Collection and maintenance of data is costly and no-cost open source, open access may not provide the best business model
- With likely reductions in central government funding for geospatial data, the private sector will be under pressure to make greater investments
- Transnational frameworks will be needed to overcome the increasing trend in data piracy and hacking
- Increasing demand will exist for global frameworks relating to ethics, privacy, security and IP protection, to enable consistent, transborder legal protections for individuals
- Getting the best from volunteer geospatial community and government will be a major challenge for society over the next five years
- Interoperability and unification of geospatial information datasets across the globe will become increasingly important

A 2011 report for the Australian National Data Service by Professor John Houghton of Victoria University's Centre for Strategic Economic Studies concluded that the benefits of open data typically outweigh the costs of making it available, without including additional long-term benefits [71]. He found that the overall benefit associated with free online access to Australian Bureau of Statistics data under an unrestricted standard licensing was worth between $6 million and $25 million per annum, up to five times the revenue it received for its publications when it was charging [71].

The US open licence weather data have provided an estimated 39-fold return on the initial investment [72]. Open data access contributes €40 billion to the economy of the EU each year [72]. In the UK, Deloitte estimated that data.gov.uk, to which 8400 datasets have been uploaded since 2009, could be worth about £16 billion ($24.1 billion) to the economy [72].

Lateral Economics published a study in June 2014 that suggested that a global open data policy could add an extra 1 percent of growth to global economy over the next five years, worth $13 trillion, including $16 billion in cumulative GDP to the Australian economy over the same period [69].

4.3.3 BIM AND GIS TECHNOLOGY

Building Information Models (BIM) and Geographic Information Systems (GIS) technology are merging, allowing seamless transition from the outdoor virtual world to indoor virtual models. Seamless models[6] are particularly important for virtual and augmented reality visualisation [77], as demonstrated in the San Francisco Golden Gate development [78]. The UK will introduce a BIM Level 2 standard for all government buildings with a view to introducing BIM Level 3 in 2018 [79], positioning itself to becoming a world leader in BIM.

In 2012, BuildingSMART called on the Australian Government to mandate the adoption of BIM, GIS and related digital technologies and processes for planning in the Australian built environment sector. It estimated that this would result in a $7.6 billion benefit to the Australian economy over the next ten years [80].

While the local government sector is already Australia's largest user of GIS technology, 38% of councils surveyed planned to increase their GIS technology budget in the near future [81].

4.4 PREDICTIVE MODELS AND APPLICATIONS

4.4.1 ALGORITHMS

In a peer-reviewed paper published in Science magazine, Song et al. studied 50,000 mobile phone users over three months and measured the entropy of each individual's trajectory. Based on the results, they reported a 93% potential predictability in user mobility [82].

Contextual computing (also referred to as predictive computing by Tom Malik) collects large amounts of personal data about the user including their history, preferences and location, and suggests information that the user might need right now – even before the user realises that it might be wanted [83, 84].

Google NOW [85] uses data that Google collects about users to predict what information the user would like to have at any given time, and presents the information as a report. If a user always checks the weather or traffic report at the start of the day, Google NOW will automatically bring up these reports without the user searching for it. If Google NOW sees a flight in the calendar, it will automatically check for flight updates for that particular flight. Preferences can be selected to optimise

[6] For in-depth information related to 3D models and theories refer to the following books: 'Advances in 3D geoinformation systems', edited by Peter van Oosterom [73]; 'Spatial data modeling for 3D GIS' by Alias Abdul-Rahman and Morakot Pilouk [74]; 'Geomodelling' by Jean-Laurent Mallet [75]; and 'An introduction to solid modeling' by Martti Mäntylä [76].

customisation and user experience. Google NOW is available in Google Glass.

Consumers are signing up for constant location monitoring when they opt into Google's location services. Google is testing a program to use smartphone users' location information (regardless of whether they are using a Google application or not) to test the usefulness of their location-based search advertising. In this program, phone location data are used to determine whether a user visited a store after being shown an ad for that retailer during a search [65].

Gartner predicts that revenue from consumer location-based services will reach $13.5 billion in 2015. Advertising will be a dominant contributor, as location targeting more than doubles the performance of mobile ads [86].

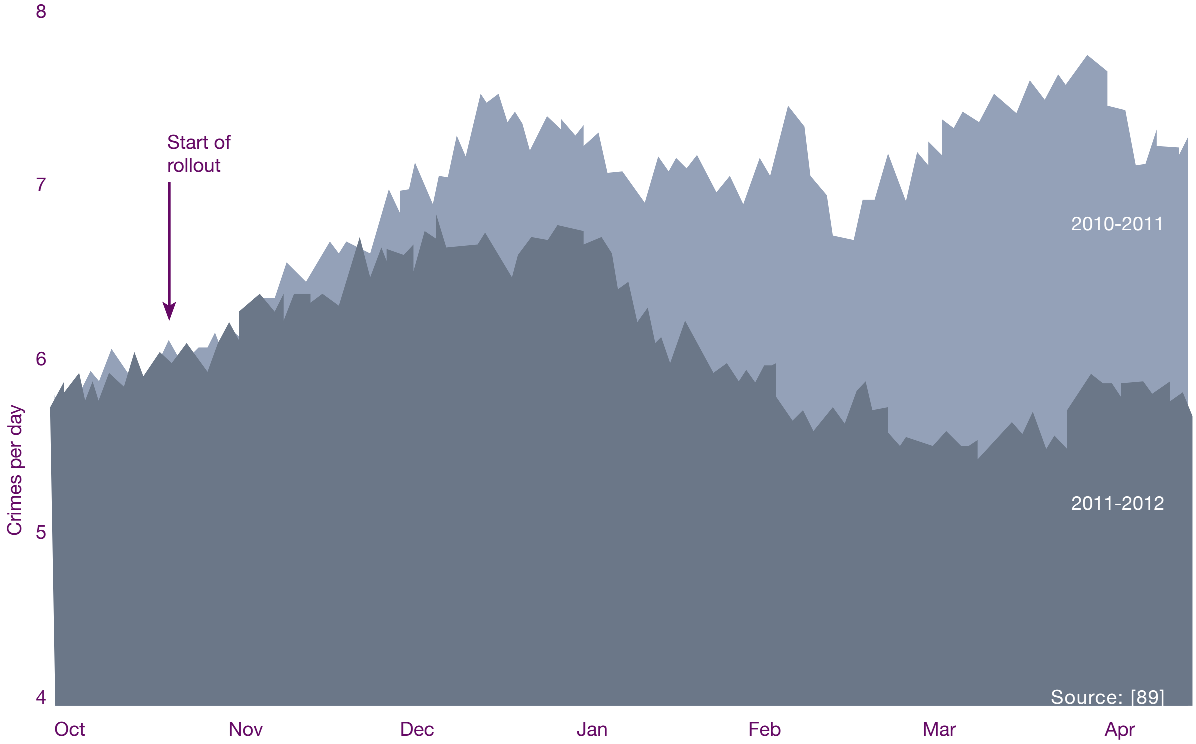
BIA/Kelsy estimate that spending on geo-targeted mobile ads reached $725 million in 2013 and will more than triple to $2.74 billion by 2017.
Alistair Goodman, CEO of Placecast, a location-based advertising provider, says that brands are realising that consumers are increasingly using mobile devices to navigate the physical world and that a unique opportunity exists to put a message into that experience [65].

Apple's iBeacon has substantial potential for location-based advertising [22]. Urban Airship's Push notification service is compatible with Apple's Bluetooth based iBeacon for more accurate location-based targeting of consumers. According to Ryan Caldbeck, 'Indoor GPS technology allows advertisers to target customers down to a particular aisle. This finally makes return on mobile advertising measurable and presents new opportunities for business services to market themselves with new efficiencies' [65].

Currently e-commerce accounts for less than 6% of total retail sales. IBM's Smarter Commerce initiative predicts that in five years advances in wearable technology, augmented reality and location-based technology such as Apple's iBeacon will transform traditional retailing. When a potential customer walks into a store, the smartphone will search the store's inventory and recommend options based on the user's purchasing history. This information can then be sent to the salesperson, who will use this information to assist further [87]. According to Damian Rollison, companies such as Goodzer and Retailigence may use inventory-tracking technologies to create local comparison-shopping or delivery services. [88].

Predpol has successfully reduced crime by merging big data with analytical algorithms. Operational Police staff are guided to target locations (a 500' x 500' prediction box). A 13% crime reduction was observed when Predpol was rolled out in the Los Angeles Foothill Division, compared to a 0.4% increase in other areas of Los Angeles at the same time (see Figure 12) [89]:

FIGURE 12: INCIDENCE OF CRIME PRE/POST APPLICATION OF PREDPOL



All these markets are powerfully aided by the fact that we are now almost always online, whether we know it or not.

4.4.2 SMART MACHINES

Smart machines will rapidly develop over the next decade, with the proliferation of contextually aware, intelligent personal assistance and smart advisers such as the IBM Watson. Further applications include global industrial systems and autonomous vehicles. Smart machines are predicted to be highly disruptive. New systems will do what was previously only thought possible by humans, and may well do it better. Gartner expects individuals to invest in, control and use their own smart machines to become more successful. Enterprises will also invest in smart machines to optimise their operation [58].

Jack Gold, information technology analyst at J.Gold Associates, speculates that in the next two or three years the personal computer model will morph into an ‘Everything Computing’ (EC) model. Smartphones and tablets are preliminary steps. Smart peripherals (such as wearables), embedded systems (cars, appliances) and personal assistants will change how individuals communicate, socialise and operate in a business setting. New methods of content delivery and accumulation and analysis of the immense streams of data created will be required to provide true universal connectivity. Most users will have three to six devices operating on a continuous basis. Evidence for this observation is mounting with M2M connections growing by 21.6% in 2013 [90].

FIGURE 13: M2M CONNECTIONS IN VARIOUS FIELDS

Banking	Mobile Payments
Healthcare	Remote Real-Time Patient Monitoring
Security	Remote Real-Time Surveillance
Oil and Gas	Oil and Gas Field Asset monitoring
Transport	Intelligent Transportation Networks
Retail	Location based promotions, Remote Vending Management
Automotive	Real- Time engine monitoring
Industrial	Remote Diagnostics and Updates

Source: Jeffries & Co. estimates

4.4.3 SIMPLE USER INTERFACES FOR BETTER USER EXPERIENCE

Foursquare, a location-based social network, is at the forefront of innovation when it comes to Apps using location. It works in the background to collect different pieces of information about the user such as location, time of day, where their friends have been and so on to suggest what that user might want to do. For example, if you are walking close by a coffee shop in the morning Foursquare might suggest, 'It looks like you're near "I Moccachino". Your friend Dennis has been there and recommends the cappuccino' [91].

Waze is another good example of a new company that is harnessing location-based information from mobile devices. Waze is a startup that provides community-based traffic reports, and was acquired by Google in 2013 for about $1 billion. CEO Noam Bardin suggests that 'maps are to mobile what search was to the web'. Location information of all types will drive an economy of activity based on location-enabled mobile and embedded devices [92].

Google Goggles allows image-based searches on the web and works well with books and DVDs, landmarks, barcodes, logos, artwork, businesses, products and text. It may be just a matter of time until Google Goggles is combined with Google NOW and becomes available on Google Glass, which in effect will make it an augmented reality solution [93].

Widespread augmented reality applications are closely linked to availability of wearable technology such as glasses with heads-up display. K-Glass, developed at the Korean Advanced Institute of Science and Technology (KAIST), uses the world's first augmented reality chip that works just like human vision. The processor works with a visual attention model (VAM) to simulate the way the human brain processes visual data, allowing it to recognise a target object.

For example, when a K-Glass wearer walks up to a restaurant and looks at its name, the menu and 3D images of food pop up. The display can even show the number of tables available in the restaurant. The processor uses 65-nanometre manufacturing processes and is able to deliver a 1.22 tera operations per second peak performance when running at 250 megahertz. The real-time operation camera runs at 30 frames per second.

Professor Yoo of the Department of Electrical Engineering at KAIST has said that the market is growing fast, and it is really only a matter of time before mobile users adopt the optical see-through heads-up display into their daily routine [94].

To enable rapid development of augmented reality applications, some software development kits (SDKs) have emerged. Some well-known augmented reality SDKs are offered by Metaio, Vuforia, Wikitude and Layar [95]. Augmented Reality Markup Language (ARML) is a data standard developed within the Open Geospatial Consortium [96].

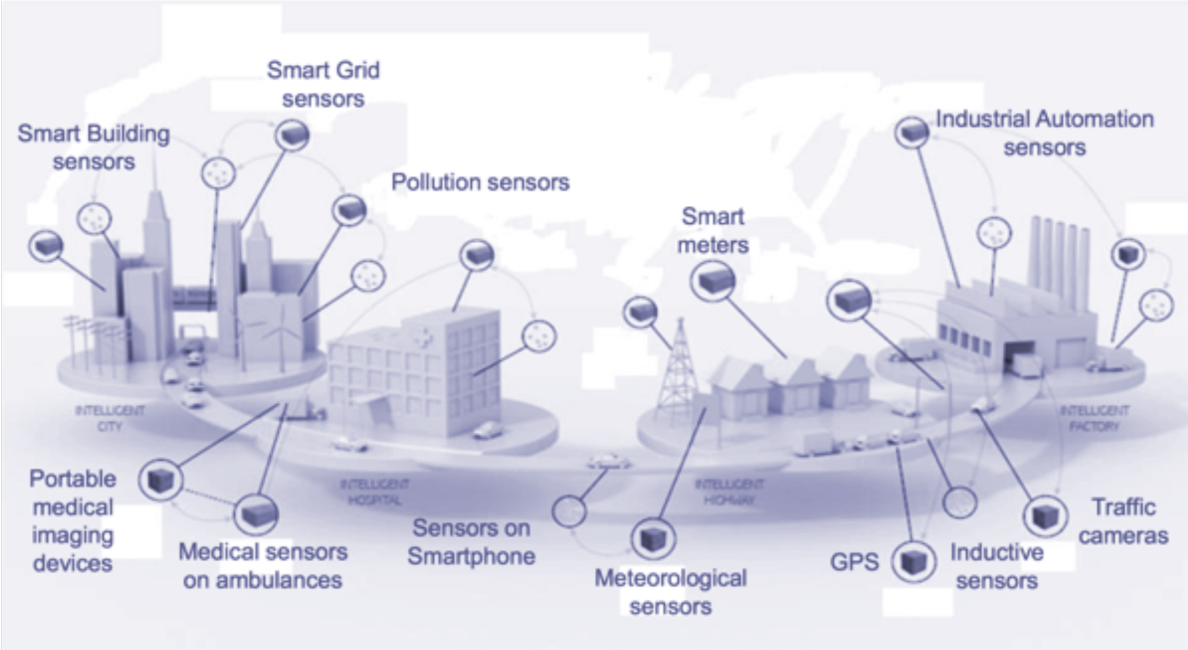
4.4.4 SMART SYSTEMS

The European Commission estimates economic losses due to traffic delays to be approximately $150 billion per year in Europe. The need to search for parking spaces is a significant contributor to congestion and a major cause of stress and delay for motorists. Over the years studies have shown that motorists searching for parking spaces accounted for 74% of traffic in Freiburg, Germany (1977); 30% in Cambridge, Massachusetts, USA (1985); 8% in New York, USA (1993); 28% in Soho, UK (2006); 45% in Brooklyn, USA (2007); and 60% in Berkeley, US (2013) [97, 98].

FIGURE 14: THE SPANISH CITY OF SANTANDER, WITH WIRELESS INTELLIGENT MOTES REPRESENTED BY YELLOW PINS

Source: [89]

FIGURE 15: TYPES OF SENSORS IN A WIRELESS SENSOR NETWORK



Source: [98]

The Spanish city of Santander [99] (see above) is a large-scale living lab for smart cities (see Figure 14). It aims to create a unique European experimental test facility for research and experimentation with different IT architectures, key enabling technologies and services and applications for the Internet of Things. A wireless sensor network using a distributed network of intelligent motes assists in efficient city management (see Figure 15). Parameters such as noise, temperature, carbon monoxide concentrations, ambient light levels and the locations of available parking spaces are monitored to benefit citizens. To realise the project, Libelium has deployed a large number of Waspmote wireless sensor nodes. The project aims to deploy 20,000 sensors in the European cities of Belgrade, Guildford, Luebeck and Santander [100].

IBM is working with local government agencies, farmers and ranchers in the Paraguay–Parana River basin to monitor and ensure the quality and availability of Sao Paulo's water system. A smart grid is being built in Malta to link power and water systems, detect leakages and allow more consumer control via variable pricing. New York, Syracuse, St Louis and Santa Barbara are using data analytics, wireless and video surveillance capabilities to strengthen crime fighting and coordinate emergency response services [101].

4.4.5 AUTONOMOUS TRANSPORT INCLUDING UAVS

Remote sensing and positioning are coming together in the form of intelligent transport, robotics and semi-autonomous UAVs. Washington DC is the first state to have published new guidelines for self-driving operators (not just testers) [102].

As of September 2014, California will issue Driver Licences to self-driving cars. However, the car still needs to bring along a licensed, sane, sober, attentive, insured human [103]. Legislation and guidelines for the operation of autonomous vehicles has been proposed or signed into law in California, Nevada, Arizona, Hawaii, Florida and Oklahoma [104]. Driverless vehicles use radar, lasers, light detecting and ranging (LiDAR), cameras, ultrasonic sensors and built-in navigation systems to pilot themselves and detect obstructions. Audi, Toyota, Nissan, Tesla, BMW, GM, Volvo, Volkswagen, Mercedes-Benz and Cadillac are all developing driverless cars [105, 106].

Google's Sergey Brin claims that in 2017 'Google's self-driving cars will be available for everyone' [107, 108]. Google is reported to have logged 500,000 kilometres in driverless vehicles without an accident [109]. A comprehensive study estimates that autonomous cars offer significant annual benefits to the US (see Table 8) [110]:

TABLE 8: ESTIMATES OF ANNUAL ECONOMIC BENEFITS FROM AVS IN THE UNITED STATES

CRASH COST SAVINGS FROM AVS	**10%**	**50%**	**90%**
Lives Saved (per year)	1,100	9,600	21,700
Fewer Crashes	211,000	1,880,000	4,220,000
Economic Cost Savings	$5.5 B	$48.8 B	$109.7 B
Comprehensive Cost Savings	$17.7 B	$158.1 B	$355.4 B
Economic Cost Savings per AV	$430	$770	$960
Comprehensive Cost Savings per AV	$1,390	$2,480	$3,100
CONGESTION BENEFITS			
Travel Time Savings (M Hours)	756	1680	2772
Fuel Savings (M Gallons)	102	224	724
Total Savings	$16.8 B	$37.4 B	$63.0 B
Savings per AV	$1,320	$590	$550
OTHER AV IMPACTS			
Parking Savings	$3.2	$15.9	$28.7
Savings per AV	$250	$250	$250
VMT Increase	2.0%	7.5%	9.0%
Change in Total # Vehicles	-4.7%	-23.7%	-42.6%
ANNUAL SAVINGS: ECONOMIC COSTS ONLY	$25.5 B	$102.2 B	$201.4 B
ANNUAL SAVINGS: COMPREHENSIVE COSTS	$37.7 B	$211.5 B	$447.1 B

Source: [110]

No legislation has yet been passed in Australia to endorse self-driving cars. Concerns include cost, technological challenges, privacy concerns and the possibility of hacker attacks of autonomous cars [111]. However, several organisations in Australia are working in the space, including the University of New South Wales with GoGet, CSIRO, BAE, Cohda Wireless and the Autonomous Ground Vehicle Challenge (AGVC). Sinclair Knight Merz (SKM) [112] outlines potential future developments in Table 9.

TABLE 9: POTENTIAL FUTURE DEVELOPMENTS IN AUTONOMOUS VEHICLES

	POTENTIAL IMPLEMENTATION
NOW-2025	▸ Increasing automation of driving functions, even on affordable cars ▸ Vehicles park themselves ▸ Vehicle to Vehicle communication ▸ Vehicles drive themselves in traffic jams or highways (adaptive cruise control) ▸ Early-adopter entrepreneurs start to hire out AVs ▸ Taxi industry disruption ▸ Standardisation of communication and technology protocols
2025-2035	▸ Car ownership declines — car sharing increases. Demand for parking starts to decline ▸ Bus service disruption — segregated or guided busways become fully driverless, bringing costs down ▸ Logistics industry disruption ▸ Vehicle to vehicle, and vehicle to infrastructure communication technology matures ▸ Accidents/collisions significantly reduce
2040-2045	▸ Vehicle size/weight/emissions reduce. New vehicle platforms ▸ Catalyst for alternative mass produced propulsion systems — electric ▸ Catalyst for fiscal incentives (road charging, pay as you go) ▸ Urban road-space optimisation — narrower lanes, tighter intersections, etc. ▸ Reduced need for urban parking — re-inventing/relocating car parks, on-street parking space reclaimed for other road uses (walking, cycling, market stalls) ▸ Vehicles on demand — no reduction in availability or quality of services
2045 ONWARDS	▸ Maturing technology, convergence and standardisation. Artificial intelligence on vehicles 'learns to read' the road ▸ Eradication of congestion on highways ▸ Elimination of accidents/collisions ▸ Significant reduction in urban congestion ▸ Ubiquitous autonomous door to door travel ▸ Increased urban sprawl

Source: [112]

Vehicles with drivers will also see major innovative improvements with automated vehicle-to-vehicle communication warning of accidents, excessive speeding and other problems in the general vicinity of vehicles [113, 114]. One commentator even suggests that it is possible to expect flying cars to be autonomous and common by 2045; see for example flying car developments of Terrafugia [115].

Rapid growth in UAV use is expected as costs fall and jurisdictions around the world open up the skies to more use. The Teal Group (2013) predicted that the worldwide UAV market would be worth $US89 billion over the next ten years [116]. The US Federal Aviation Administration will open the market for commercial UAVs in 2015. The Association for Unmanned Vehicle Systems International (AUVSI) report on the economic impact of UAVs in the US estimates the commercial benefits from UAV integration to include 70,000 new jobs and an economic gain of $13.6 billion within the first three years. By 2025, it estimates that this will increase to include 100,000 new jobs and $82 billion in economic gain [117]. Currently six states, including New York and Virginia (home to huge tech communities), are cleared to host drone test facilities.

Australia promulgated the first operational regulations for UAVs in the world in 2002 with Civil Aviation Safety Regulation part 101 (CASR101) [118], followed by a white paper in 2009 [119] and Project OS 11/20 [118].

Use of UAVs is most likely to grow in farming and mining and in places that are difficult to access or dangerous for human workers. Rooftop inspections, for example, could be done with high-resolution thermal imaging cameras attached to a UAV [91]. Use of UAVs is invaluable at nuclear disaster sites or where earthquakes have left structures unstable and too hazardous for emergency workers to enter without prior assessment. TEPCO have already realised this opportunity, using UAVs and other robots to survey the damage and aid in the cleanup of the nuclear power station accident at Fukushima [120].

The application of Smart Autonomous Transport Systems also extends to the sea. The MUNIN (Maritime Unmanned Navigation though Intelligence in Networks) project, co-funded by the European Union, is an automated maritime transport system for driverless ships [121]. Another relevant maritime initiative in the US was the Autonomous Maritime Navigation (AMN) system [122].

4.5 SOCIAL/HUMAN ASPECTS

4.5.1 EDUCATION, SKILLS AND CAPACITY BUILDING

Interest in massive open online courses (MOOCs) continues to grow rapidly. Well-known platforms include Coursera, with more than 3 million users and 107 partners, and edXa, a partnership between Massachusetts Institute of Technology and Harvard University with over 1.7 million users. The technology required to support MOOCs includes lecture delivery platforms, web forums, online meetups, keystroke loggers to check identities, and powerful servers to handle the volumes [49].

IBM is developing a large-scale integrated solution for educational institutions. The program combines predictive modelling and content analytics with traditional classroom learning. When fully implemented, every student will have an electronic persona that will follow them throughout their academic careers. If a student has trouble with a certain skill, for example fractions, that will be recorded and will allow the next teacher to design a personalised curriculum to strengthen that weakness from day one of the new year level [87].

A high priority for nations will be highly skilled workers capable of a range of data competencies with the ability to understand complex and time-based data [21]. Policy and decision makers, through to the very highest levels of governments and NGOs, will need to be educated in the value of geospatial information as a building block of base infrastructure for nations [21]. Students educated in the use of geo services can expect 3% higher wages five years after graduation [6].

The US Department of Labour (2012) estimated that in 2010 there were about 165,000 GIS-related jobs in the US (cartographers, photogrammers, surveyors, technicians and geographers) [123]. The jobs outlook for the period 2010 to 2020 was set for growth of between 16% and 35% [6, 123].

In 2012 Boston Consulting estimated that the US geospatial industry employs at least 500,000 'high wage' geo-related jobs (geo-date providers, location-enabled device manufacturers, geo-App developers, and others including educators) [8]. In 2010 the Allen Consulting Group estimated there were approximately 51,000 people in the spatial information workforce in Australia and approximately 13,400 in the New Zealand workforce [124]. A 2013 report for Australia by ACIL Tasman and Spatial Information Services estimated that there would be a national shortfall of graduate or licensed surveyors of approximately 1,300 in 2025, and a shortfall of geospatial specialists with university degrees of approximately 500 in 2017 and 300 in 2025. Moreover, by 2025 the Australia-wide shortfall is estimated to be approximately 360 for surveying technicians with diplomas and associate degrees and 250 for surveying technicians with a Certificate I to IV qualification [125].

A December 2012 report released by Engine Advocacy and the Bay Area Council Economic Institute stated that, between 2002 and 2011, job growth in science, technology, engineering and mathematics (STEM) fields has outpaced many other occupations by a ratio of up to 27 to one. This demand is expected to continue through to 2020. High-tech and STEM employees are paid between 17 and 27% more than workers in many other fields [126, 127].

The US National Academy of Science identified five emergent academic research areas that could improve geospatial intelligence by adding new types of information and analysis methods as well as new capabilities to help anticipate future workforce needs and future threats [128]:

- GEOINT fusion – the aggregation, integration and conflation of geospatial data across time and space with the goal of removing the effects of data measurement systems and facilitating spatial analysis and synthesis across information sources.

- Crowd-sourcing – a process in which individuals gather and analyse information and complete tasks over the Internet, often using mobile devices such as cellular phones. Individuals with these devices form interactive, scalable sensor networks that enable professionals and the public to gather, analyse, share, and visualise local knowledge and observations and to collaborate on the design, assessment and testing of devices and results.

- Human geography – the science of understanding, representing and forecasting activities of individuals, groups, organisations and the social networks to which they belong within a geotemporal context. It includes the creation of operational technologies based on societal, cultural, religious, tribal, historical and linguistic knowledge; local economy and infrastructure; and knowledge about evolving threats within that geotemporal window.

- Visual analytics – the science of analytic reasoning, facilitated by interactive visual interfaces. The techniques are used to synthesise information and derive insight from massive, dynamic, ambiguous and often conflicting data.

- Forecasting – an operational research technique used to anticipate outcomes, trends or expected future behaviour of a system using statistics and modelling. A forecast is used as a basis for planning and decision making and is stated in less certain terms than a prediction.

4.5.2 MACHINE/HUMAN INTERACTIONS

Brainwave detectors can use signals to gain insight into a person's level of engagement. Interaxon's headband, for example, can tell whether the wearer is bored with the conversation or having trouble concentrating [129]. When combined with other data, eye scanning provides insight into a person's mood and interests. By studying someone's gaze, eye-tracking software such as Tobii can make myriad inferences about a person, including whether they ignore banner ads, like certain colours, or naturally tend to look at a particular area of a webpage [129].

4.5.3 PRIVACY VERSUS IDENTITY

Although Internet-enabled social networks offer tremendous opportunities, they also entail new risks and growing concerns. For example, social network users can be bullied, their status posts can reach unwanted audiences, or their pictures can be stolen. Even when profiles do not list specific information, population graphs can be analysed and personal information can be inferred. Risks relate to identity management, as profiles do not exist purely in the virtual world but have impact on real, offline life [49].

Jeramie Scott, of the Washington-based Electronic Privacy Information Centre, says 'biometric information is personal, identifiable information and the question is how will it be stored and who has access to it' [129]. Consumer devices are being equipped with the ability to measure biometric information such as iris configuration and walking gait and this heightens the issues of privacy versus identity [129].

Public concern about privacy has been raised by revelations of the National Security Agency's broad and secret surveillance of the Internet and mobile devices. FBI, Customs and other agencies are known to collect biometric information such as fingerprints, facial and voice data.

Commercial web-based firms such as Instagram, Apple, Google and Yahoo collect similar data, and privacy advocates suggest consumers may not realise how much sensitive information they are disclosing [129]. Consumers question the assurances of companies that biometric information will not find its way onto the Internet where outsiders could access it.

A new phone recently entered the market for users concerned about their privacy. Retailing at $629, the Blackphone runs a custom version of the Android operating system, encrypts communication and blocks tracking of the owner's activities, such as the sites they browse. It also blocks Wi-Fi tracking that shows the location of the phone (and the user). The inventor, Zimmerman, says, 'We are not a phone company adding a privacy feature. We are a privacy company selling a phone'. Secure communication can only work when the receiver of the call or message also has encrypted services. For this reason, the Blackphone's subscription plan includes subscriptions for three other non-Blackphone users [130].

Researchers from the International Computer Science Institute have designed a mobile App ('Ready or Not?') that gathers location information shared through a user's social media accounts to create a blueprint of the user's movements over a month. The App is intended as an educational tool to demonstrate, particularly to younger users, how easily geo-tagging can be used to create a map of one individual's movements [65].

Several countries are implementing legislation to provide greater protection for individual privacy in the face of growing concerns over the implications of social media. Calls are being made for a code of ethics to guide the use of personal information with a location component [21, 131].

4.5.4 PUBLIC ENGAGEMENT

Increasingly, Volunteered Geographic Information (VGI) and crowdsourced information will be used in combination with quality-assured government-produced information, such as that covered by the Australia and New Zealand Foundation Spatial Data Framework, to make useful information available to the public [132].

From commercial custom applications to Government initiatives, crowdsourcing is growing at a very fast rate [133, 134, 135]. 3D user-defined operational picture (3D UDOP) applications provide crowd-sourced information that is used by emergency responders [136]. The Federal Emergency Management Agency (FEMA) recently added crowdsourcing capabilities to their Disaster Relief App [137].

Tomnod is a crowd-sourcing platform for information from satellite imagery operated by Digital Globe [138, 139, 140]. It is estimated that up to 7 million people may have searched images for clues on missing flight MH370 based on the 800,000 registrations and 800 million map views [141]. BlackBridge also opened its Rapideye image archive via Mapbox to enable the public to search for the missing flight [142]. Other successful spatial crowd-sourcing platforms include Ushahidi and Open Street Map.

Location-based technology offers the opportunity to crowd-source information on everything from real-time traffic flow to road conditions [143] and makes innovation accessible to everyone anywhere [144].

Hackers are now using increasingly inexpensive sensors and open source hardware such as Arduino and Netduino to add intelligence to ordinary objects. For the digitally literate, new devices such as Koubachi, NEST and Twine can be easily connected to the Internet and controlled by mobile phones. Client services such as Cosm, Evrything and IfThisThenThat allow devices to be meshed together in unexpected ways [145].

Startups in the geospatial world are burgeoning. Australia is currently trying to encourage a startup ecosystem with the launch of Startup Victoria. In its Tin Alley Program, Melbourne University is assigning tech startups to students studying ICT in paid internships. Swinburne University announced their partnership with startup education events such as Startup Grind Melbourne. These program launch announcements are part of a national trend that is also being witnessed at Flinders University, University of the Sunshine Coast, Curtin University, The University of Sydney and The University of New South Wales [146].

Co-working spaces are an upcoming trend. In the US in 2013, 4.5 new co-working spaces were opened up each workday. Globally, co-working spaces have grown at a rate of 83% [147]. The way people work together is being redefined by technology, eliminating the need to work in a set place at a set time [147].

In a recent study it was found that 71% of people felt more creative, 62% believed their work improved significantly, 90% felt more confident and 70% felt healthier when working in a co-working space as opposed to a traditional office setting [147].

4.5.5 HEALTH

A new concept in the field of human machine interfaces and body area networks is the use of sensors placed around the body to monitor a variety of physical parameters such as stress, heart rate, position and motion. With these sensors the body area networks can collect information about the individual's fitness and energy expenditure as well as health. The system can also be used in gaming, where sensors measure the player's motion and allow an immersive experience. For ill and disabled people it offers the potential to provide assistive robotics. Physiotherapists may be able to conduct rehabilitation exercises with the patient under remote surveillance using robotics [148].

Designers are working to directly integrate sensors into the fabric of smart textiles and components to transmit information wirelessly. Key challenges are development of antenna systems that can handle environmental stressors as well as wireless protocols [148].

John Rogers, a material scientist at the firm MC10, has developed a flexible electronic biostamp that sticks to the skin like a temporary tattoo. The electronic circuit mesh stretches with the skin and measures temperature, hydration and strain. These data give insights into the wearer's health [149].

IBM predicts that in five years medical practitioners will sequence the DNA of patients in only one day. They will then access cloud-based systems like IBM Watson that will provide recommendations based on the most up-to-date clinical and research information, considering the patient's body at DNA level [87].

Interesting work has been conducted in the last few years in the field of brain machine interfaces. A recent study connected two brains via a computer [150]. The first human brain (the sender) was connected to a computer via an electroencephalogram (EEG)-based brain–computer interface. The second human brain (the receiver) was connected to another computer via a transcranial magnetic stimulation (TMS) machine, usually used for treating depression. Several trials showed that when the sender, playing a game, thinks about firing a cannon to a target, the EEG picks it up and sends a signal via the Internet to the second computer where the TMS stimulates the region of the receiver's motor cortex that controls hand movement. This causes the receiver's index fingers to twitch, firing the cannon and blowing up the target. Advances like these raise important consideration on ethics and security to ensure people's minds are not involuntarily 'hacked' [151].

The Aircasting App is a platform for recording, mapping and sharing (online via CrowdMap) personal health (heart rate) and environmental (temperature, humidity, carbon monoxide, nitrogen oxide) data using a smartphone. This data is uploaded via a map and the user plots their location manually [152]. Other health-related services include Patients Like Me (a data-centric social networking site), Cure Together (a health-tracking site) and Asthmapolis (a system that allows patients to connect to a mobile App via a sensor-enabled inhaler) [107]. These simple, wearable devices are set to expand rapidly [107].

In addition to work that focuses on individuals there is a significant increase in the use of intelligent systems for large-scale analysis of biomedical data, socially relevant data and metadata, such as information about the spread of disease or certain health habits in populations [49].

4.6 SPECULATION ON FUTURE DEVELOPMENTS

4.6.1 THE MOMENT OF SINGULARITY

Futurist Ray Kurzweil predicts 'technological singularity' by the year 2029 [153]. Technological singularity is the moment in time when artificial intelligence surpasses human intelligence. In view of the opportunities and challenges of this event, Kurzweil, together with Peter Diamandes, founded the Singularity University in 2008 with funding from Google and NASA among others [154]. The intensive Graduate Studies Program, based in Mountain View, California, is a ten-week program, typically hosting around 80 students from 36 countries. It aims to equip and train students to become high impact innovators, changing the lives of 1 billion people within ten years. Typical subjects taught include future studies and forecasting, policy law and ethics, entrepreneurship, design, networks and computing systems, biotechnology and bioinformatics, nanotechnology, medicine and neuroscience, artificial intelligence, robotics and cognitive computing, energy and ecological systems, and space and physical sciences [155].

Spatial information will play a significant role in future developments, as almost all activities are attached to a location. Every activity, human or machine, may be configured at some time in the future to leave a time-stamped and geo-referenced digital trail (Geoweb) and it will be possible to use this information (in IPv6 format) for user verification, operations certification, and forward modelling.

4.6.2 ROBOTICS

The convergence of robotics, artificial intelligence (quantum computing) and cyborg developments with spatial information will be a game changer for the real world, and will open up new virtual worlds to humankind.

Progress has been made with the advent of robots, such as Asimo, Nao, Icube, HRP C4, Roboy and Atlas just to name a few [156]. Organisations share progress on the open robotic platform and make robotic hardware available to the robotic community. Hardware component design is modular to optimise user applications. The robotic operating system (ROS) is today the standard software platform for robotic research institutes, dramatically speeding up developments [157].

The recent winner of the US Defense Advanced Research Project Agency (DARPA) Robotics Challenge, Team SCHAFT from Japan, has been bought by Google in an effort to focus on robotics over the next ten years. Google plans to develop the SCHAFT concept further for robotic responders in emergency situations [158].

Tele-operated robots offer great potential. These step-by-step human-remote-controlled robots are not autonomous, but prove very useful in situations where it is too dangerous or complex for humans to be present, such as at a nuclear waste site, or in deep-space operations. Humans initiate remote operations, typically via a joystick, Wii sensing technology, motion capture suits, exoskeletons or brain–machine interfaces. Repetitive tasks can be initiated via recorded instructions, but the remote-controlled robot is not able to respond to unknown situations such as an obstruction, so detailed BIMs will prove essential for the areas within which these robots operate.

It is anticipated that such a remote 'master–slave' robotic system will come down in price over time and become widely available to the public for purchase or hire for remote 'employment'. This will bring tele-working, across nations and time zones, to a whole new level. A time-poor working couple could employ a tele-robot to cook dinner, operated by robotic control centres similar to today's call centres. Advanced versions of tele-robots will allow medical staff to treat patients in remote areas. In this way, employment opportunities will be redefined.

4.6.3 ARTIFICIAL INTELLIGENCE AND QUANTUM COMPUTING

Alan Turing proposed a test in his 1950 paper to assess a machine's ability to behave indistinguishably from a human during a five-minute natural conversation with another human in text format [159]. Since then remarkable advances in the hardware and software components of artificial intelligence (AI) are promising breakthroughs in applications of AI to solve real life problems for users [160], with the semantic web underpinning these advances in the near term.

Kurzweil thinks that a new technology such as quantum computing will replace current technology permitting both Moore's law to gain additional life and proving Alan Turing 'test' – where a machine behaves indistinguishably from a human during a five-minute natural conversation with another human in text format [159]. Advances in the hardware and software components of artificial intelligence (AI) are promising breakthroughs in applications of AI to solve real life problems for users [160, 162], with the semantic web underpinning these advances in the near term.

The D-Wave 512-qubit-quantum computer [163] is the most advanced quantum computer in the world to date. This system needs a near absolute zero temperature and a magnetically-shielded environment to operate with a new type of superconductor processor that uses the principles of quantum mechanics to massively accelerate computation. It is built by the Canadian company D-Wave systems and is most suited to solving quantum-annealing problems, commonly found in optimisation, machine learning, pattern recognition, anomaly detection and financial analysis [163]. In 2011 Lockheed Martin and the University of Southern California (USC) bought a D-Wave ONE adiabatic quantum computer for the UCS Marina Del Ray campus. In 2013 Google announced a quantum artificial intelligence lab with a D-Wave quantum computer, co-owned and hosted by NASA at the Ames Research Centre, aimed primarily at advanced machine learning [164]. D-Wave has announced its intention to bring quantum computing to the cloud [165]. Quantum computing offers the potential for massive improvements in processing speeds, which will be critically important to a world deluged by data and almost certainly a requirement for complex near real-time decision making.

4.6.4 CYBORGS

A cyborg (cybernetic organism) has both organic and bio-mechatronic parts. Two different types of cyborgs exist: restorative and enhanced. Restorative technologies help restore lost human functions. For example pacemakers are interactive sensors that repair heart functionality and represent an early form of what some may consider a cyborg-like capability. Other examples of restorative cyborg technology include insulin pumps, artificial limbs operated with neural wiring, and epilepsy control using brain-machine interfaces. Brain-machine interfaces can provide extended memory, artificial extra limbs can perform functions that human limbs cannot [166], and extra-human sensor capabilities may be wired into the brain, such as thermal infrared sensing or infrared vision [167].

In 2006, DARPA invited proposals to develop innovative insect cyborg technology [168]. The listed requirements included reliable electromechanical interfaces to insects, locomotion control using microelectromechanical system (MEMS) platforms, demonstration of technology to scavenge power from insects, ability to fly 100 metres guided by a computer interface and ability to have a controlled landing within five metres of a specific endpoint. Today a RoboRoach kit [169] is available on the Internet for students to learn about neuroscience by experimenting on live cockroaches. Use of this technology on humans raises a whole new chapter of concerns regarding ethics and cybersecurity, warranting a thorough public debate.

4.6.5 VIRTUAL WORLDS

Technological advances have forever changed the world we live in. Virtual worlds are being built for gaming, remote interactions, modelling what-if-scenarios and more [170]. Augmented reality allows us to combine the virtual world with the real world. Information flows both ways: we receive information in the real world from the virtual world and adjust our decision-making with the given information overlays. On the other hand, in our daily life we constantly feed information back into the virtual world via spatially-enabled wearable sensor technology. In combination with advanced visualisation techniques, such as virtual reality glasses [171] and contact lenses or bionic vision implants; large display screens with user-interactive and personalised content [172]; and tele-presence through holograms [173], will allow users to live in a much smarter world.

As the seamless integration and accuracy of indoor and outdoor navigation rapidly improves over the next few years, so will the virtual worlds that we can access.

For example, shopping is likely to change dramatically. If you want to buy a new light pendant for your house, augmented reality will allow it to be viewed virtually 'in-situ' before purchase. Once selected, the digital model of the lamp will be delivered together with the real lamp and the virtual world model of your house (BIM) will be upgraded accordingly. Residential building companies may be required to hand over a digital model of the house (BIM) together with the house key upon building completion. A certified master digital mirror world will be created in order to avoid conflicting models. This virtual world will need specific spatial access rights for each user. This concept is embodied in initiatives like VANZI [161].

4.7 THE OUTLOOK

Most future developments will be built with location as a key component and identifier, thereby making spatial innovation vital to advancement of these technologies.
Key developments in spatial technology are likely to share these common elements:

- High precision location accuracy
- The 'always on' phenomenon (ubiquitous streaming and continuous analysis)
- A sentient presence (making us, and the world around us, 'smart')
- Universal accessibility irrespective of skill level, language, location or socio-demographic circumstances.

There are unprecedented opportunities for the spatial information industry in the next decade and beyond.

5 THE WORLD ECONOMY

This section summarises world economic growth, global debt, productivity and collaboration for countries and regions of relevance to the spatial industry and the aspirations of the Australia and New Zealand Cooperative Research Centre for Spatial Information (CRCSI).

5.1 THE WORLD IN OVERVIEW

5.1.1 GROWTH

The global economy is expanding at a moderate pace, with acceleration anticipated in 2014 and 2015. Global growth fell to around 2.0% in 2013 but is expected to grow to 2.9% in 2014 and 2015 then decline to 2.8% in 2016 and 2017 [174]. Weaker prospects in many emerging market economies (EMEs) have resulted in a downward revision of global growth forecasts for 2014 [175].

Three major events that have unsettled confidence and market stability in early 2014 are [175]:

- The reaction to the tapering of asset purchases by the US Federal Reserve;
- Increased concerns about developments in some EMEs leading to capital outflows; and
- The US brinkmanship and near crisis associated with its legislative ceiling on federal government debt.

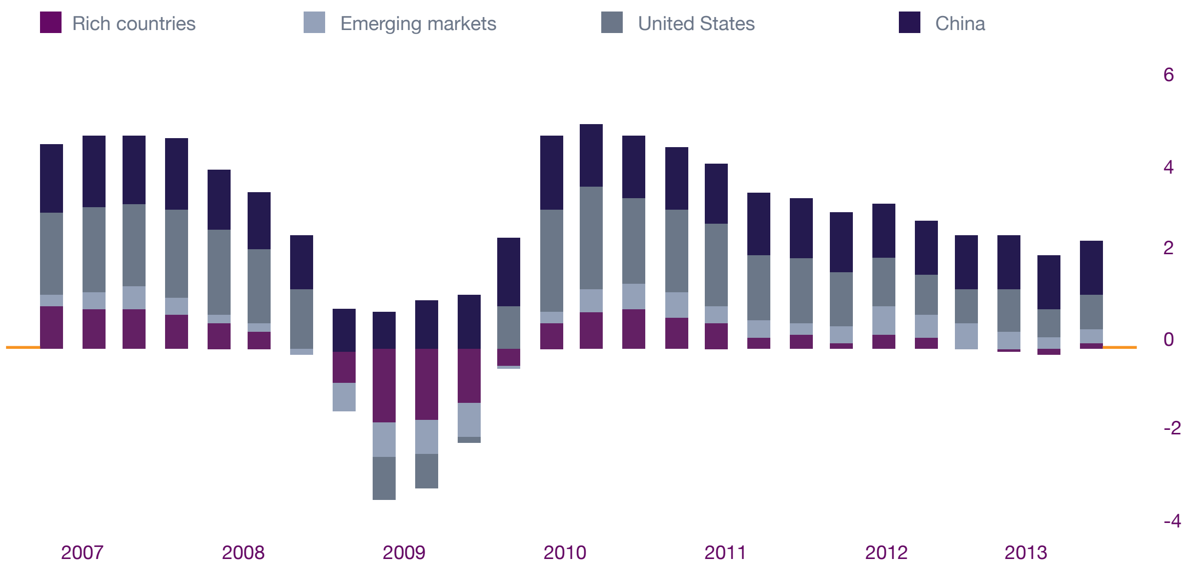
Political turmoil and social instability are also putting pressure on global growth. Russia's emerging economy has been threatened by its intervention in the Ukrainian crisis. Resulting sanctions from the West are, so far, modest in scope but significant in eroding investor and market confidence [174]. Ongoing political tensions in Turkey, Thailand and Venezuela, and to a lesser extent in India and Brazil, are also creating issues for regional economic expansion. The Economist Intelligence Unit (EIU) has reduced its outlook for real GDP growth in most of these countries in recent months, most notably in Russia in March 2014.

While growth in EMEs is weak, the EIU forecasts that in 2014 the economies of the US, euro zone and Japan, which have collectively accounted for about US$35 trillion in nominal output this year (just under half of the global total), will experience their first upturn since the 2010 recovery from the recession [174].

Coincident with these developments are concerns about China, whose growth is edging lower and whose manufacturing has been softer than expected [174]. World growth seems increasingly dependent on China. Since the beginning of 2010 China has contributed over one-third of global GDP growth, with another 40% coming from the rest of the emerging world. In 2013, China contributed 50% of global growth [176]. Since the financial crisis, the rich world has been weighed down by debt. As a result, its growth has been unpredictable and it has provided just 10% of global growth since 2010, with America contributing another 12.5% [176]. Allan Conway, Head of Emerging Markets Americas of Schroders, expects 'emerging markets to bounce back in 2015' [177].

The rate of change of global GDP and global GDP growth are shown in Figure 16 and Table 10 respectively [176].

FIGURE 16: RATE OF CHANGE OF GLOBAL GDP



Estimates based on 52 economies representing 90% of world GDP. Weighted by GDP at purchasing-power parity. Source: [176]

China is forecast to overtake the US to become the largest economy in the world around 2020, and India is likely to overtake Japan as the third-largest economy within a decade. The combined GDP of China and India is forecast to exceed that of the Organisation for Economic Cooperation and Development's (OECD) major seven (G7) economies by around 2025, and by 2050 it is estimated to be 50% larger. Contrast that with 2010, when the combined GDP of these two countries equated to less than one-half of that of the G7 countries [178].

TABLE 10: GLOBAL GDP GROWTH

WORLD ECONOMY: FORECAST SUMMARY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
World (Market Exchange rates)	-2.3	3.9	2.6	2.2	2.0	2.9	2.9	2.8	2.8	2.9
US	-2.8	2.6	1.9	2.7	1.9	2.9	2.6	2.5	2.4	2.6
Japan	-5.5	4.7	-0.4	1.4	1.6	1.5	1.5	1.2	1.2	1.3
EURO area	-4.4	1.9	1.6	-0.6	-0.4	1.1	1.4	1.4	1.4	1.5
China	9.2	10.4	9.3	7.7	7.7	7.3	6.9	6.8	6.3	6.0
Eastern Europe	-5.6	3.4	3.9	2.1	1.6	2.6	3.5	3.8	4.0	4.1
Asia and Australasia (exc Japan)	5.1	8.5	6.5	5.3	5.5	5.7	5.7	5.7	5.5	5.5
Latin America	-1.5	5.9	4.4	3.0	2.7	2.4	3.2	3.7	3.8	3.8
Middle East & Africa	1.9	5.3	2.8	3.8	2.2	3.4	4.0	4.4	4.4	5.0
Sub-Saharan Africa	1.3	4.6	4.7	4.0	3.7	4.0	4.5	5.3	5.6	5.2

Source: [174]

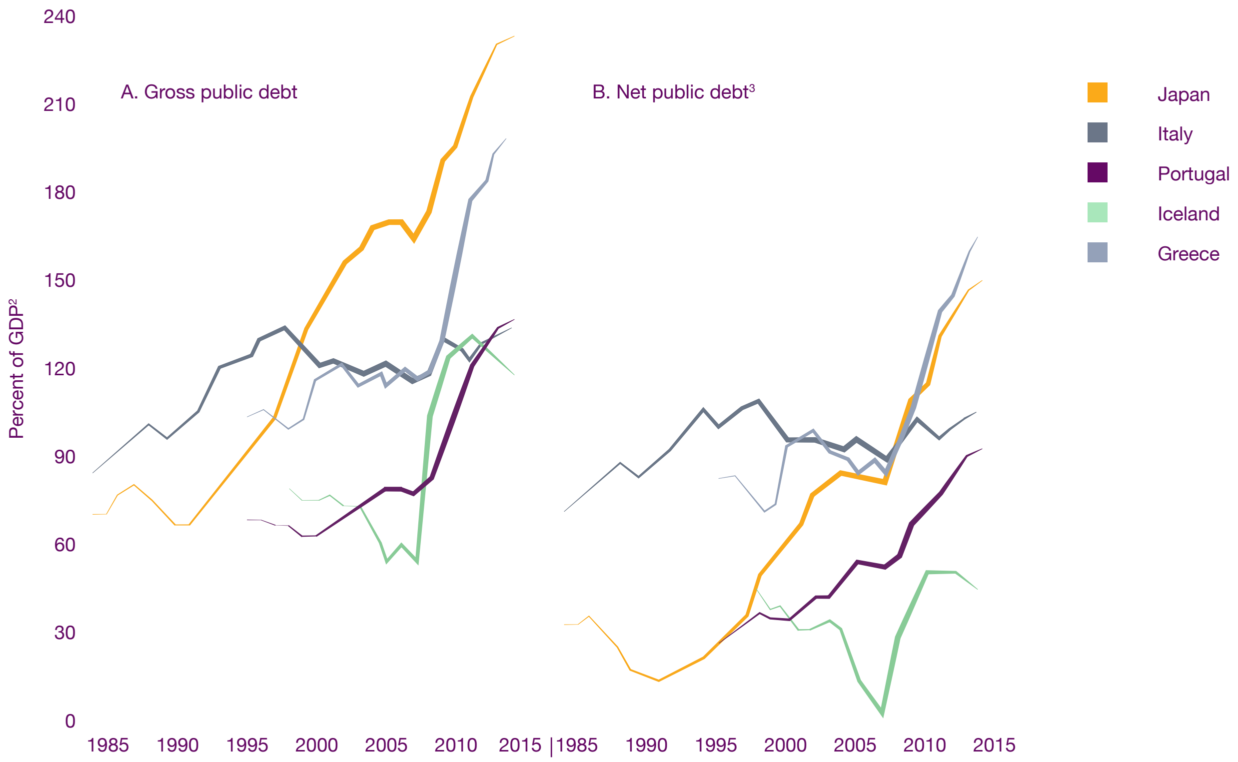
5.1.2 DEBT

Government debt ratios for the OECD are expected to grow or remain at high levels in the coming year. The global government debt-to-GDP ratio reached 111.4% in 2013. However, overall debt ratios are increasing more slowly than in the past, declining from an increase of 11.5% in 2008–2009 to a projected 1.1% increase in 2013–2014 [179].

Some forecasters predict that the scale of the current global account imbalances may increase to pre-crisis peaks by the late 2020s. In addition, in many OECD countries government debt will exceed thresholds beyond which interest rates, growth and economic stability will be adversely affected [180].

Management of public debt is a major issue for many countries (see Figure 17). For Japan, government debt is running at about 230% of GDP (see Figure 17) and steadying the debt-to-GDP ratio requires a fundamental improvement in the primary fiscal balance from a deficit of 9% of GDP in 2012 to a surplus as high as 4% by 2020. Controlling expenditures is essential, particularly in the social security sector, which faces the challenge of a rapidly ageing population. For the US, where government debt is about 102% of GDP, fiscal consolidation is currently 2.7% of GDP, whereas the total required to stabilise debt is about 6.5% [181, 182].

FIGURE 17: PUBLIC DEBT IN SELECTED OECD COUNTRIES OVER TIME



1. The five countries with the highest gross debt rations (gross liabilities divided by GDP) in the OECD area in 2010.
2. OECD estimates for 2012 and projections for 2013-14.
3. Net debt is gross debt less financial assets held by the government.

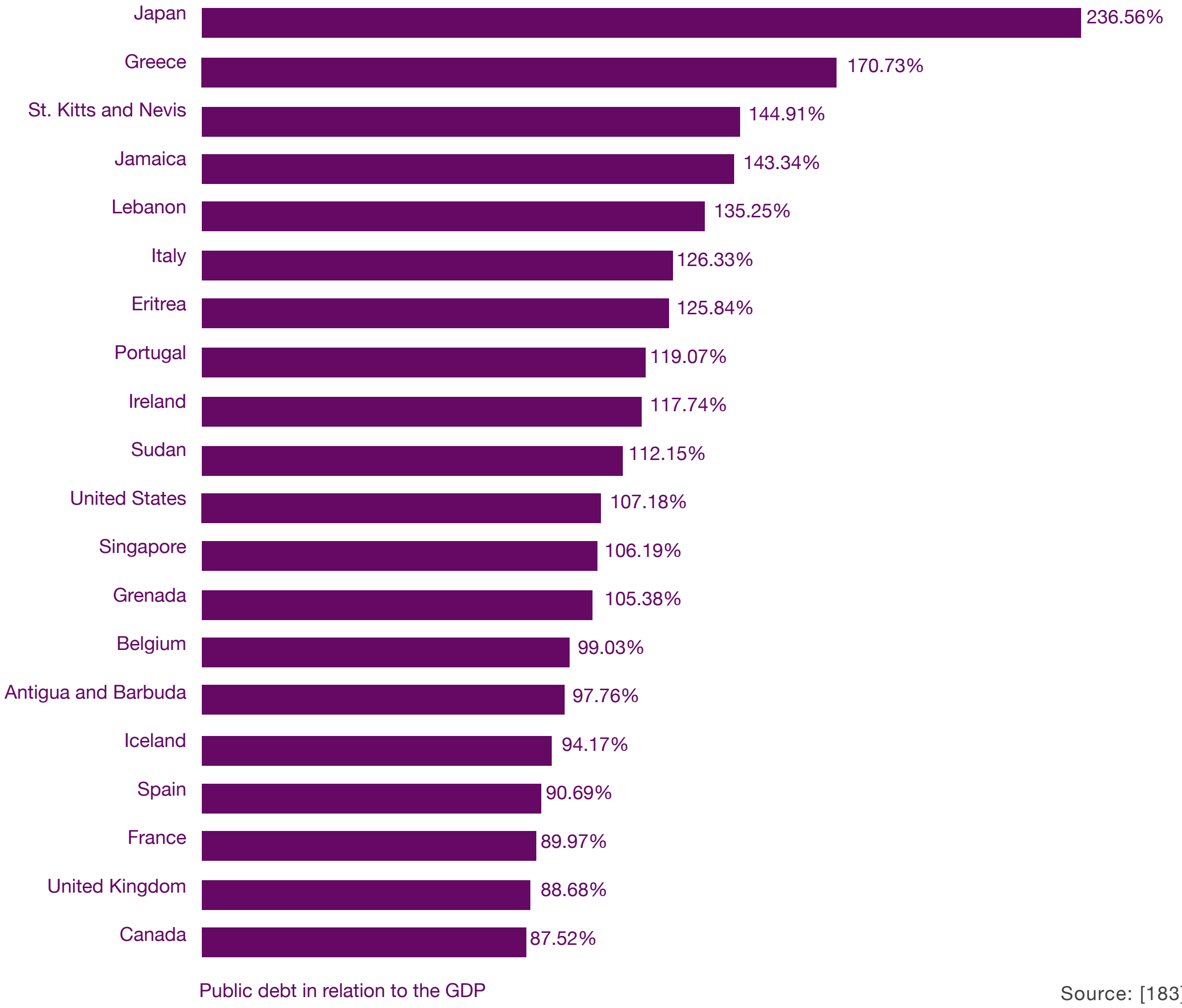
Source: *OECD Economic Outlook*, No 92, and revised OECD estimates and projections for Japan for 2012-14.

Source: [181]

Ireland, Italy, Iceland, Greece, Portugal and Spain among others also need to focus on debt management. To stabilise debt, most countries require a 4% to 7% GDP improvement in the underlying primary balance between 2011 and 2030, with the majority of the adjustment being planned for the next two years [179].

Other OECD countries requiring consolidation of more than 4% of GDP from 2011 include Poland, the Slovak Republic, Cyprus, Slovenia and the UK. In addition, for a typical OECD country, additional offsets of 3 to 4% of GDP will be required over the next 20 years to meet spending pressures due to increasing pension and health care costs [180]. Figure 18 shows government debt as a percentage of GDP for the twenty countries with the highest debt.

FIGURE 18: GOVERNMENT DEBT AS A PERCENTAGE OF GDP [183]



Source: [183]

5.1.3 PRODUCTIVITY

Global labour productivity growth is slow (see Table 11 and Table 12). Productivity growth as measured by GDP per employed person fell to 1.7% in 2013, compared to 1.8% in 2012 and 2.3% in 2011 [184]. The global financial crisis had a big impact. In China average productivity growth fell from 12% per annum between 2003 and 2007 to less than 9% between 2008 and 2013.

This declining productivity confirms that efficiency remains a problem for the global economy [184]. In 2014 a moderate improvement in global productivity growth to 2.3% is forecast, mainly as a result of improved growth performance in mature economies (1.5% in 2014 compared with 0.9% in 2013). Emerging and developing economies may see a moderate improvement in productivity growth. However, at 3.6% in 2014, these growth rates will stabilise at much lower levels than in the first decade of the century, when productivity growth rates ranged between 5% and 7% [185].

Christopher Vas notes that 'The productivity slowdown has been attributed to many things, predominantly weaker demand, a mismatch in resource allocation between labour and capital, and lesser than optimum innovation outcomes emerging despite technology advancements in mature economies' [184]. Emerging economies contributed 1.8% to global growth while mature economies contributed 0.4% [184].

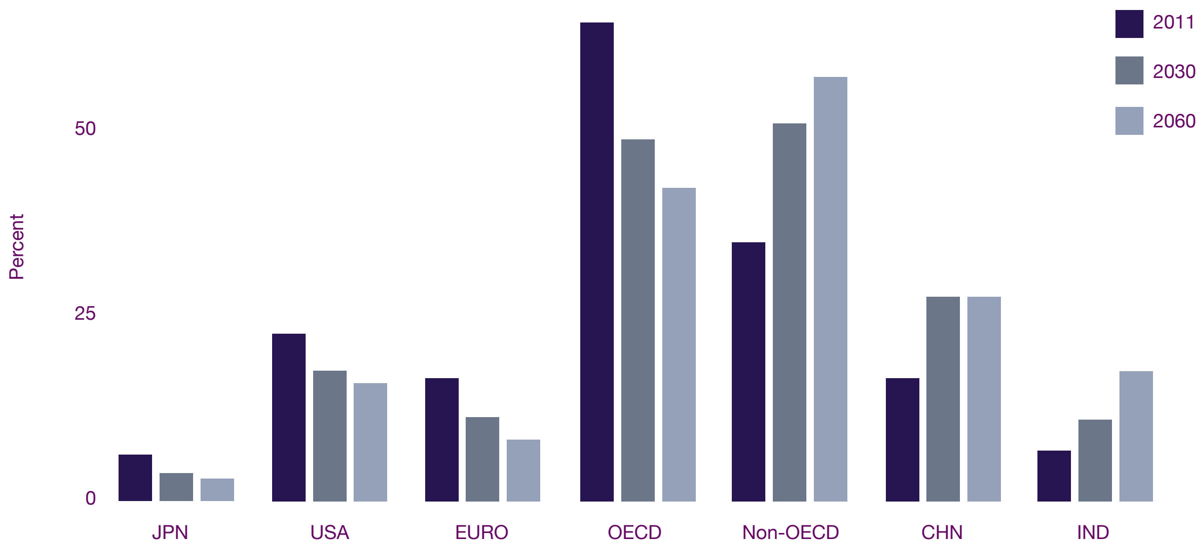
Some countries saw improvements in productivity last year. However, such gains may result from increased unemployment rather than increased GDP: a reflection of a faltering economy, in which fewer people are doing the work. In the euro area, for example, productivity growth has improved since 2012 from –0.1% to 0.4%, but both GDP and employment have fallen. Spain and Italy both showed positive productivity growth. The business cycle influences productivity because firms wary of another downturn tend to make employees work harder during an upturn instead of hiring new workers. Productivity increases until new workers are hired, and the cycle starts to repeat [184]. The next 50 years will see major changes in both productivity and GDP in many countries.

On the basis of purchasing power parities (PPPs), China is projected to surpass the US by 2020 with India overtaking Japan a few years later and then the euro area in about 20 years. China and India will experience a greater than seven-fold increase in their income per capita by 2060. By that time China will have a 25% greater income level than the US, while in India income per capita will be about half of the current US level [186].

Australia's productivity has steadily improved over the past 24 months by 2.7%; however, this is partly due to an increase in unemployment. Because they represent a ratio, productivity values should always be interpreted with caution [184].

The Gross Domestic Product normalised to Purchasing Power Parities (GDP (PPP)) per hour worked is a measure of the productivity of a country when not taking into account unemployment or hours worked per week: it normalises each country's GDP based upon its PPP (see Figure 19).

FIGURE 19: 2005 PPPS AS A PERCENTAGE OF GDP



Source: [186]

TABLE 11: GLOBAL LABOUR PRODUCTIVITY GROWTH

REGIONAL INDICATORS	2012	2013
NORTH AMERICA		
Labour productivity growth	0.9%	0.9%
GDP growth	2.8%	1.9%
Total Factor Productivity	0.7%	0.7%
EURO REGION		
Labour productivity growth	-0.1%	0.4%
GDP growth	-0.7%	-0.3%
Total Factor Productivity	0.8%	-0.6%
LABOUR PRODUCTIVITY GROWTH IN:		
Brazil	-0.4%	0.8%
China	7.3%	7.1%
India	3.1%	2.4%
Japan	1.2%	0.8%
Poland	5.6%	1.4%
Russia	3.1%	1.6%
Singapore	-2.5%	1.6%
Spain		1.4%
United Kingdom	-1/8%	0.5%
United States	0.7%	0.9%

Source: [184]

Australia’s productivity growth was 2% in 2012 and 0.6% in 2013 [184, 187]. In 2013, mining investment in Australia began a contraction that is set to continue beyond 2014, while mining output will keep growing as new mines and gas projects come on stream. All else being equal, this should result in an improvement in Australia's productivity growth [187].

TABLE 12: GLOBAL GROWTH INDICATORS, LABOUR PRODUCTIVITY AND REAL GDP 2012–2013

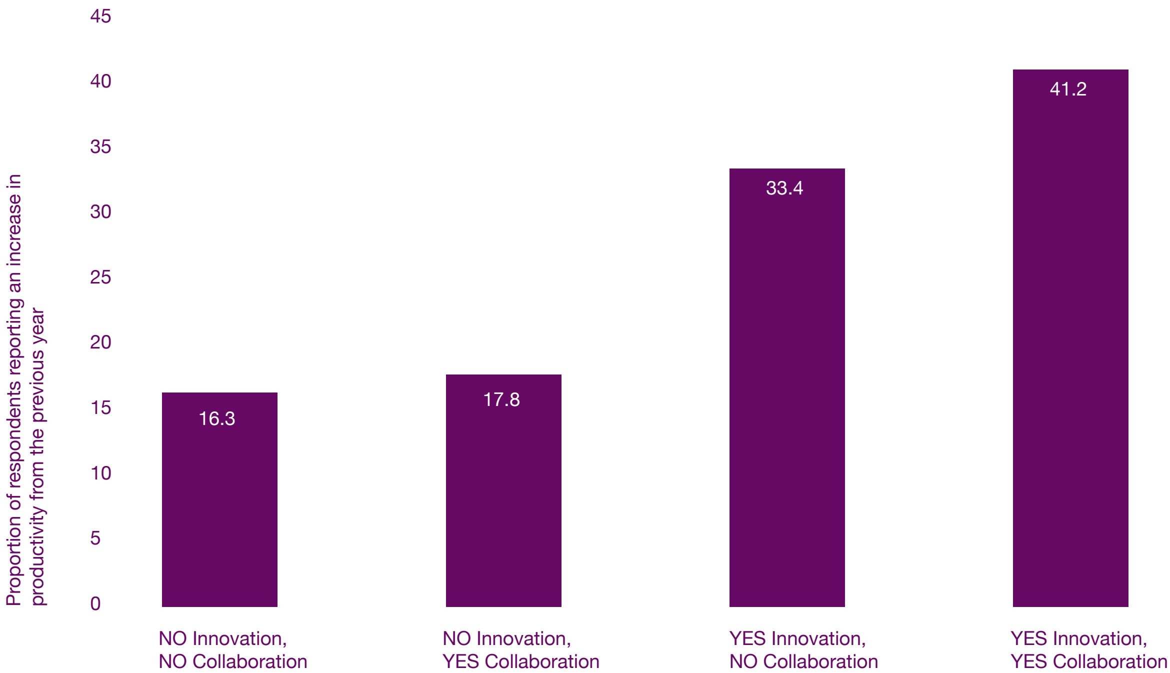
	2012	2013
GLOBAL GROWTH INDICATORS		
Employment growth	1.3%	1.2%
LABOUR PRODUCTIVITY (GLOBAL)	1.8%	1.7%
Emerging economies	3.7%	3.3%
Mature economies	0.9%	0.9%
REAL GDP (GLOBAL)	3.1%	2.9%
Emerging economies	5.2%	4.7%
Mature economies	1.4%	1.3%

Source: [184]

5.1.4 COLLABORATION

Effective global collaboration for the purpose of innovation relies on planned, interactive cross-border arrangements, international trade and competition. It also reflects the reality of the greater fragmentation of production processes along global value chains. Collaboration within firms, both domestically and internationally, increases the likelihood of improvements in productivity, as shown in Figure 20 [188]:

FIGURE 20: THE BENEFITS OF COLLABORATION TO ORGANISATION PRODUCTIVITY



Source: [188]

Australian businesses that collaborate are 55% more likely to report increased productivity. Innovation-active businesses are more than three times more likely to collaborate than their non-innovative counterparts [188].

In Cleveland, USA, non-traditional partners such as rival universities and hospitals now collaborate, pooling billions of dollars to improve efficiency. In Atlanta, ten counties and business groups joined together to raise regional taxes and issue a US$8 billion bond to promote economic growth. This approach of 'collaborative competition' helps organisations move up the value chain to highly productive activities [184].

International collaboration on innovation in many OECD countries exceeds national collaboration, except in a small number of countries including Australia, Korea, China and Chile. Australia ranks a poor 25th out of 26 OECD countries in international collaboration on innovation, with New Zealand outranking Australia at 17th [188].

Effective global collaboration on innovation is fuelled by cooperative research and development (R&D) among businesses. For example, businesses that make well-informed and targeted investments in global R&D, based on choice of sites and personnel and with good insights into customer demands, are more likely to secure a better return on their R&D investments than those that invest exclusively in home-grown R&D activities [188].

Global scientific and technological collaboration also provides access to a larger pool of expertise that enables international research partners to produce joint scientific publications and/or inventions with greater impact. Australia's contribution to the world's top 1% of highly cited publications is made up primarily of research publications involving international collaboration. Its overall contribution has grown over the last six years, from 2.14% in 2006 to 3.14% in 2011 [188].

5.2 COUNTRY BY COUNTRY ECONOMIC OUTLOOK

5.2.1 USA

In 2014 the American economic data continues to be distorted by unusually bad weather conditions, but the US economy is generally considered to be recovering without inflationary pressure. The debt ceiling has been suspended until 2015, removing an issue that created uncertainty in 2013. This has had a stabilising effect on markets.

GDP grew 2.4% in 2013, in line with expectations [189, 190]. The EIU is forecasting real GDP growth of 3% in 2014, the fastest rate since 2005 [174]. Labour market recovery, debt deleveraging and gains in asset prices will help to underpin consumption and residential investment growth [191].

In December 2013 consumer spending in the US rose at its fastest pace in three years, while its export performance has picked up firmly as the US shale energy revolution boosts domestic production [174].

The unemployment rate fell to 6.6% in January 2014, its lowest level since October 2008 [191]; however, this rate is still considered high. The US economy may be negatively impacted by the combination of high unemployment rates, persistently high debt levels, the expectation of gradually increasing market interest rates and a slowing housing market [174]. The OECD forecasts that the unemployment rate will rise to 6.9% in December 2014 and fall back to 6.3% in 2015 [191].

Europe's debt crisis has impacted on the US economy. US companies typically generate around 25% of their profits from foreign sales, and Europe has been an important source of income [192].

US government debt was 99% of GDP in in 2013, down slightly from 102% in 2012. It is forecast to increase to 106% by 2015 [193].

Productivity growth could more than double from 0.8% in 2013 to 1.8% in 2014. Productivity performance in 2014 will be important, as the US is likely to be among the first economies to show positive effects from a recovery in demand, because its markets show good ability to reallocate resources to the most productive industries and sectors [194].

5.2.2 CHINA

The Chinese economy grew by 7.7% in 2013 (lower than the forecast 8.4%). The EIU expects growth of 7.3% in 2014, supported by improving conditions in its two biggest export markets, the US and the Euro zone [174].

Economic growth continues to slow in China. Industrial production grew by 8.6% year-over-year in January and February 2014, the lowest growth rate in four years. Investment and exports have also been lower than expected. The government is now restricting credit availability with the aim of reducing investment-led growth, which has created overcapacity in China's economy and led to rising levels of debt and signs of stress among its banks [195].

China's unparalleled growth since 1979 has been created by two key factors: the influx of tens of millions of new workers from the countryside to power its industrial economy, and huge investments in factories, urban infrastructure and heavy machinery. However, China's population is rapidly ageing, and the size of the labour force is likely to plateau by 2016. Not only that, but the pace of capital investment growth is expected to slow as Beijing seeks to rebalance the economy in favor of more internal consumption and less reliance on exports [195].

The Chinese government recently undertook a major audit of debt and concluded that the economy was robust enough to forge ahead with interest rate liberalisation. China is comfortable with its economy's ability to withstand the rise in defaults associated with this approach [186]. Meanwhile, China's reform of state-owned enterprises (SOEs) continued when the China International Trust and Investment Group announced that it is listing all its operating assets outside of China. This has improved the perception of corporate governance in China and allowed more disclosure about the financials and strategic planning of a major China-run investor. SOE reforms will continue, providing comfort for investors [183].

Trust financing, part of China's $7.5 trillion shadow banking system, has been key to fuelling the nation's 10% annual growth rate in the past decade by providing easy credit to companies that banks considered too risky. Since trust loans to various industries, including property, solar and coal, tripled in the past three years to 10.9 trillion yuan ($1.8 trillion), bondholders have become increasingly alarmed as the government reins in lending, cooling housing demand and slowing the economy [196].

China's government debt is progressively taking up a greater portion of the national GDP but is not yet a problem, according to the International Monetary Fund (IMF). China's government debt in 2013 was 50% of GDP, up from 40% in 2012 and 37.8% in 2011 [183].

Some commentators consider that China does not have to accept slower growth as inevitable. But to avoid this, it must generate greater productivity from its people and more benefit from its yuan. Both are achievable if policymakers and company leaders start to make changes now [194].

In China average productivity growth fell from 12% a year between 2003 and 2007 to less than 9% between 2008 and 2012. Labour force participation rates remain above OECD averages and the difference in income per head essentially reflects lower capital per worker [194]. However, productivity growth in China has been and remains ahead of most other countries. Between 1990 and 2010, China's average annual productivity growth rate was 2.8%, far greater than that of the US and Japan (0.5% and 0.2% respectively). China's rate was greater than South Korea (2.1%), which has the best record for productivity performance among developed countries, and exceeded Brazil (0%), Russia (1.7%) and India (1.9%) [194].

5.2.3 JAPAN

Japan's recovery from the 2012 recession is driven by strong export growth; consumer spending amid rising confidence and employment; and a rebound in business investment. Its expansion, supported by strong monetary stimulus and a fiscal package, is expected to continue. However, fiscal consolidation, including the consumption tax increases in 2014 and 2015, is projected to slow output growth to around 1.5% in 2014 and 1% in 2015. The sustained recovery will help push inflation toward the 2% target [197].

GDP growth in Japan stagnated to 0.7% in 2013. Japan's industrialised free-market economy is the third biggest in the world, having been overtaken by China in 2011. Japan has the largest electronics industry and the third-largest automobile industry in the world. Japan's economy is well-known for efficiency and competitiveness in exports-oriented sectors, but its productivity is lower in areas such as agriculture, distribution and services [198].

The initial impact of new monetary, fiscal and structural policies has produced strong export growth, rising consumer spending and a rebound in business investment. The consumption tax rate is now 8% and is planned to increase to 10% by 2015. However, public debt is high. The tax increase leaves Japan's economic outlook in 2014 uncertain, as it will affect data for both GDP growth and inflation [174, 175].

Industrial production improved in January 2014, and retail sales increased by 4.4%. Unemployment remains at 3.7%. The Japanese Government's aggressive program to stimulate the economy and end the deflation era has been making progress, but the Bank of Japan has indicated that it will continue to provide liquidity to the economy until it has achieved its objective of 2% inflation [189].

The government's medium-term fiscal objectives, announced in June 2010, are aimed at halving the primary deficit of the central and local governments by fiscal year 2014/15, and eliminating it by 2020. As of 2013 Japan has one of the highest gross public debt levels in the world at around 230% of GDP, and reducing it is a priority [197].

Despite the large monetary and fiscal stimulus in Japan, productivity growth dropped from 1.2% in 2012 to 0.8% in 2013. Average labour productivity remains nearly a quarter below the leading OECD economies. Japan's total factor productivity growth grew modestly in 2013, at a rate somewhat higher than that in the US. However, Japan's productivity level remains lower than Europe's, reflecting the weak performance of Japan's services sector relative to other major mature economies [185].

Japan is forecast to experience only a moderate productivity improvement in 2014 to 1.2%. Efficiency gains in Japan are difficult as long as structural rigidities in Japan's labour market and in several services industries remain unresolved [185].

5.2.4 INDIA

India is expected to continue its economic recovery following a couple of difficult years. The EIU is forecasting GDP growth of 6% in fiscal year 2014/15, following GDP growth of 4.7% in 2013 [174, 199].

India's GDP growth slowed from 6.7% in 2012 to 5% in the year ending 31 March 2013, the slowest pace in a decade, as high inflation, borrowing costs and delayed project approvals forced companies to put investments on hold. Between July 2013 and December 2013, growth averaged 4.6% as consumer spending slowed [200].

Productivity growth in India fell to 2.4% in 2013, the slowest rate since 2002. In 2012 productivity had already slowed dramatically to 3.1% (from 5.8% in 2011). The slowdown in productivity occurred despite only a marginal decline in employment growth (from 1.8% in 2012 to 1.7% in 2013), as output declined much faster (from 5% in 2012 to 4.2% in 2013). The economy is going through a difficult time, as it suffers major macroeconomic challenges including high inflation, slowing exports, increasing current account and fiscal deficits, a falling exchange rate and a slowdown in structural reforms [185].

Persistent inflation has forced up interest rates. Inflation based on the wholesale price index has been around 7% and is above the central bank's preferred rate of 5% [200].

India recorded a government debt-to-GDP ratio of 67.7% of the country's GDP in 2013 [201]. Moody's Financial Services warns that the Indian financial system's ability to absorb rising government debt could diminish significantly if the combination of low economic growth and high inflation continues beyond June 2014, potentially weakening the country's sovereign credit profile [200]. India's government debt-to-GDP ratio was still the highest among major developing countries at 67.7% in 2013, compared with 60.3% for Brazil, 42.9% for the Philippines, 34.4% for Turkey and 24.5% for Indonesia [200].

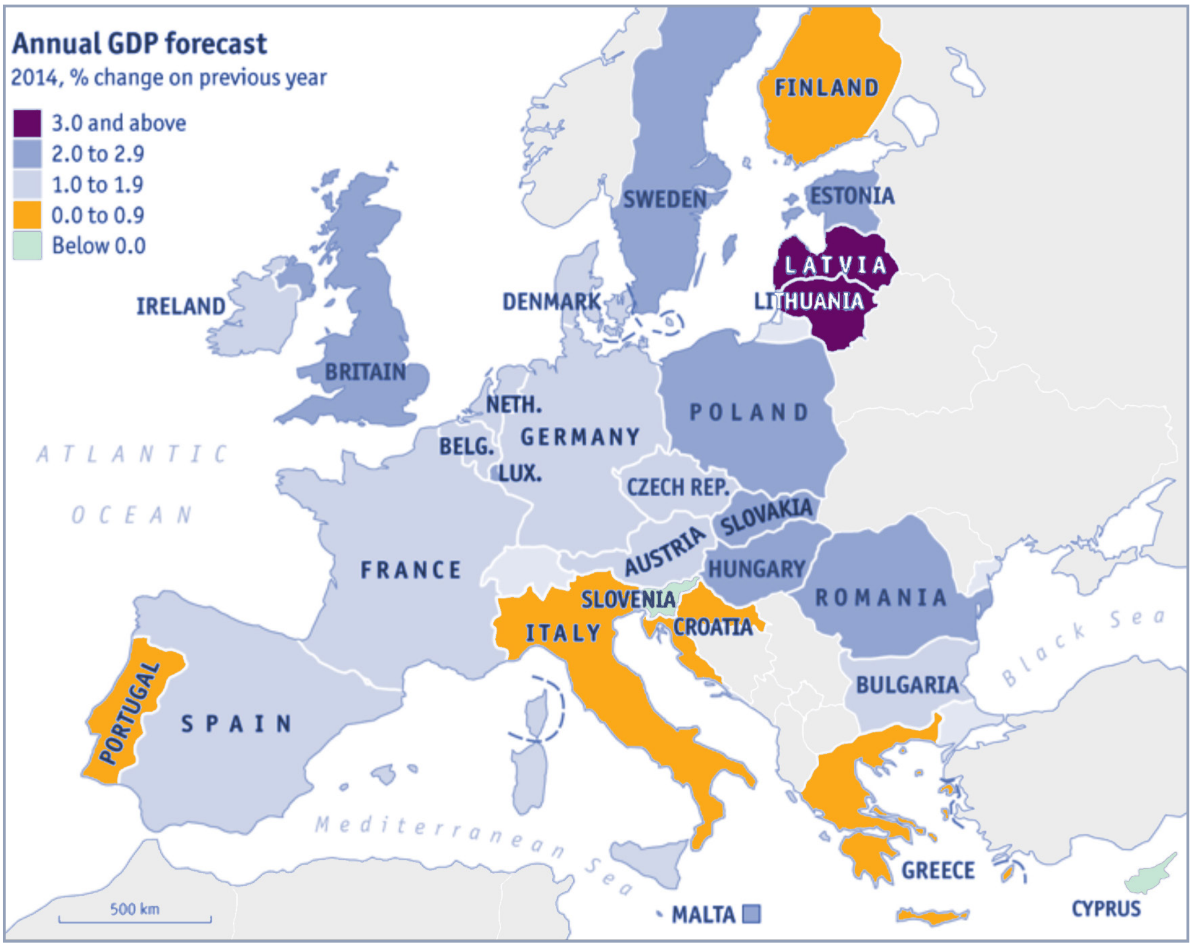
5.2.5 EUROPE

Growth in Europe was 0% for 2013, significantly lower than the previous OECD prediction for the euro area of 1.3% for 2013 [202, 175]. The expected growth in Europe is forecast to increase to 1% in 2014 and 1.6% in 2015 [175]. The GDP forecasts and government debt levels vary between European countries, as shown in Figure 21 and Figure 22.

As the political situation in Ukraine has become increasingly unstable, the financial markets have been negatively impacted. The direct economic impact of the turmoil in the Ukraine is likely to be relatively low, as Europe does not have major trade links with the country. However, geopolitical tension negatively impacts financial market sentiment [189].

Problems continue in Cyprus, where ongoing decreases in output will be associated with a 4.8% fall in GDP. The only other country forecast to go backward will be Slovenia, whose GDP will marginally contract by 0.1% [203]. In contrast, the best performing country is forecast to be Latvia, which will grow by over 4% per annum in both 2014 and 2015. Lithuania, which is expected to join the euro area next year, will grow by 3.5% in 2014 and 3.9% in 2015.

FIGURE 21: ANNUAL GDP FORECAST BY COUNTRY



Source: [203]

The euro has staged a good recovery and increased steadily during the past year and in recent months. After trading at around US$1.28:€1 in March 2013, the exchange rate rose to around US$1.39:€1 by mid-March 2014. As a result, the EIU has changed its 2014 exchange-rate forecast from US$1.29:€1 to US$1.34:€1, implying an appreciation of the dollar in the remaining nine months of this year. This change contradicted predictions [174].

Britain is at last experiencing a recovery, and the Bank of England has revised its forecasts of UK economic growth in 2014 from 2.8% to 3.4% [189]. GDP is also forecast to expand by around 2.5% in 2015 [203].

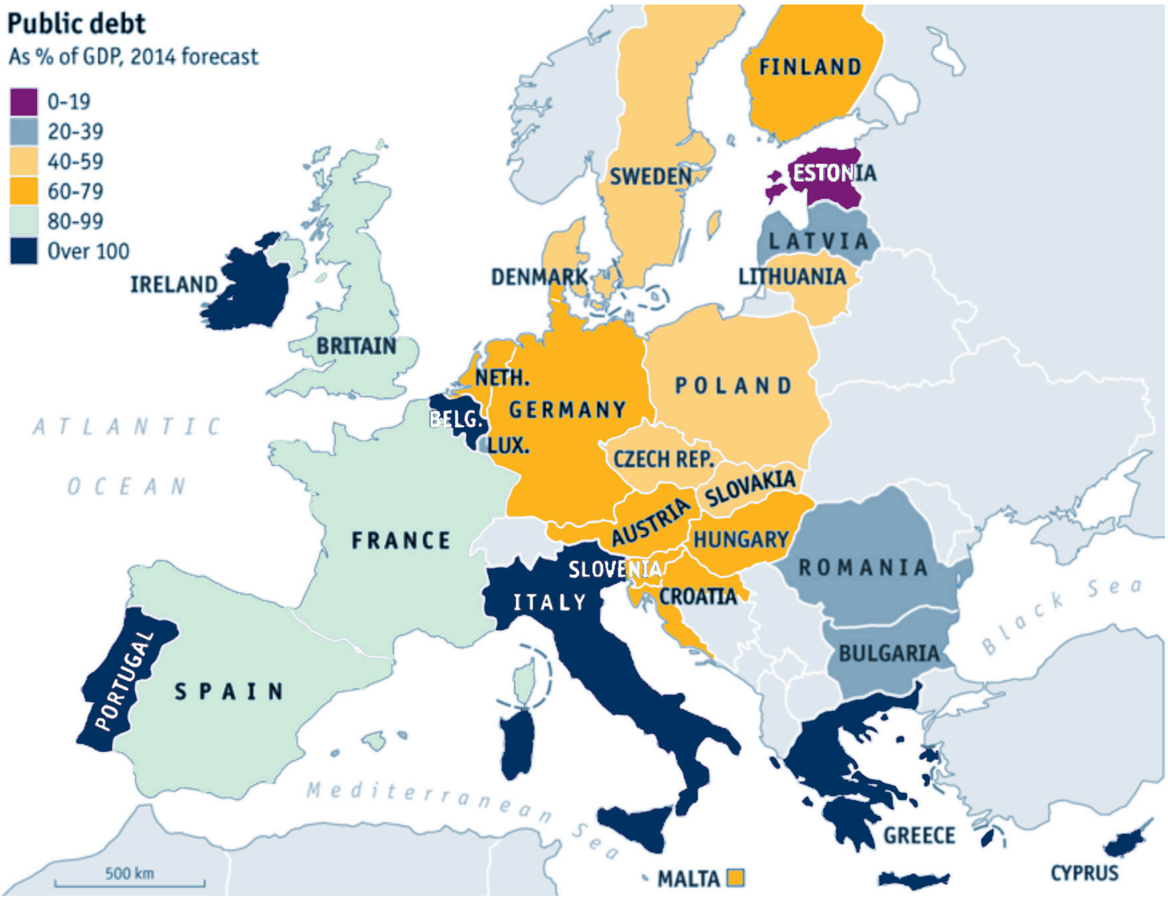
Italy is to introduce some long-needed reforms to the Italian economy. If successful, this will be of significant benefit not only to Italy but to the European economy as a whole [189].

The French economy faces significant adjustments in 2014 that will likely impact growth negatively [189].

The transition economies of Eastern Europe experienced another difficult year in 2013. The EIU estimates that GDP growth dropped to 1.6%, as a marked slowdown in Russia compounded ongoing weak conditions in eastern and central Europe. An improvement across the region is expected in 2014, although negative sentiment toward emerging markets, geopolitical tensions in Ukraine and sanctions against the Russian economy by the West all pose risks [174].

In Europe, recovery is lagging and uneven; unemployment, especially among the young, remains very high; and inflationary pressures are very subdued [175]. The unemployment rate was 12% in 2013, and is expected to rise to 12.1% in 2014, then drop to 11.8% in 2015 [175]. Inflation was at 1.4% in 2013, anticipated to fall to 1.2% by 2015 [175].

FIGURE 22: GOVERNMENT DEBT IN EUROPE AS A PERCENTAGE OF GDP



Source: [203]

Substantial debt consolidation is planned in Europe, especially in Greece, Ireland and Portugal, which have endured the greatest pressure from financial markets and requested assistance from the European Union and the IMF. The extent of the planned debt/GDP consolidation beyond 2013 should reduce the debt-to-GDP ratio [180]. Structural reforms in labour and product markets are considered necessary to boost growth and jobs, with emphasis upon completing the EU Single Market Program [180].

Europe is projected to come out of recession slowly in 2014, but as the labour market recovery typically lags, the growth in output per hour is expected to remain at 0.6% in 2014. More sustainable productivity improvement in Europe will need to come from acceleration in investment and a more efficient allocation and use of resources. Many of those potential gains will arise from the finalisation of a single market in Europe, where labour, capital, products and services can float freely through trade; banking rules are harmonised; and migration and cross-border investments abound. Such sustainable productivity gains will likely take longer to achieve in the wake of the recession [185].

The UK showed an improvement of 0.5% in labour productivity growth in 2013, after a substantial contraction in 2012 (-1.8%). However, its output per hour remains 76% below the USA and well below that of its main continental counterparts, France and Germany [185].

In 2014, Germany is expected to achieve GDP growth of 1.7%, with productivity growth of 1.2%. France is forecast to have a GDP growth of 0.9% and productivity growth of 0.4%. Productivity growth in Spain is expected to drop significantly to only 0.1% (compared to 1.4% in 2013), as the GDP will grow only marginally and hours are expected to grow at almost the same rate as GDP [185].

In Russia, productivity growth declined from 3.1% in 2012 to 1.6% in 2013. There exists much room for improvement, as it remains at only 34% of the US productivity growth [185].

In Spain the unemployment rate is expected to peak in 2014 before gradually declining as growth picks up [204]. Productivity has improved since 2007 but both GDP and employment have fallen, by 4.2% and 13.7% respectively [205]. Productivity in Spain increased in the third quarter of 2013 [206].

In 2013, productivity growth also contracted in Turkey with a decline of -0.6%, compared to -0.8% in 2012. Turkey seems to have suffered severely from the European crisis, but it is forging a difficult transition from a low-cost producing economy to a higher position in the value chain and raising its efficiency through productivity-enhancing investments in labour skills, technology and innovation [185].

5.2.6 SWEDEN

The Swedish economy lost momentum in 2013 with GDP growth slipping to 0.7%, but is set to recover gradually as world trade picks up, and stronger exports and improving business confidence spark a revival in business investment. The unemployment rate is expected to continue to fall, but inflation will remain at modest levels. The OECD forecasts that GDP growth will increase by 2.3% in 2014 and 3% in 2015 [207].

Sweden's growth in 2013 was held back by a weak international economy due to financial and debt crisis. Despite this, the labour market has developed more strongly than expected. In the face of ongoing world economic weakness, exports are only gradually recovering, while households are continuing to increase their consumption. The growth rate will strengthen and unemployment will decline slightly from 8% in 2013 to 7.8% in 2014 and 7.5% in 2015 [207]. However, weak growth remains a risk and the economic outlook remains uncertain [208].

5.2.7 ASIA (OTHER THAN CHINA, JAPAN AND INDIA)

The export-oriented economies of East Asia saw a sharp slowdown in growth through most of 2012 but conditions started to improve toward the end of 2012 and into early 2013, driven by an upturn in industrial output and exports [178].

Singapore continues to suffer from very low growth. In the first quarter of 2013, the economy contracted 0.6% year-over-year and 1.4% quarter-over-quarter, as exports and industrial production remained flat [209].

South Korea, the world's 15th largest economy [210], has maintained low budget deficits and government debt, which is running at 33% of GDP. GDP growth is estimated to be about 1.5% based on first quarter growth. South Korea is rapidly ageing, which will put pressure on government budgets. It is also dominated by a few large conglomerates including Samsung. Some of these have high debt levels and must continue to innovate to remain globally competitive [211].

Malaysia and Vietnam showed an improvement in productivity growth in 2013 while the Philippines and Thailand both suffered a decline. Indonesia's productivity growth slowed significantly, from 5.1% in 2012 to 3.6% in 2013. While the economies of the Association of Southeast Asian Nations (ASEAN) are all affected by the slowdown in global exports, the strengthening of the domestic sectors of most Southeast Asian economies has had strongly positive effects on productivity. Productivity growth in Singapore improved from -2.5% in 2012 to 1.6% in 2013 [185].

5.2.8 LATIN AMERICA

Forecast GDP growth in Latin America will accelerate to 3.2% in 2014, lifted by stronger global growth [174]. Latin America struggled in 2013 with regional growth dampened by less favourable conditions on global capital markets and weak demand in Europe and China. Capital flight prompted by the US Federal Reserve's tapering of its bond-buying program has intensified pressure on regional currencies, notably the Argentinian peso, although economic mismanagement also made this currency especially vulnerable [174].

Labour productivity growth in Latin America decelerated marginally to 0.7% in 2013 from 0.8% in 2012. Brazil and Mexico, the major economies in the region, have shown opposite trends. Brazil has recovered from a negative productivity growth of –0.4% in

2012 to 0.8% in 2013, whereas Mexico lost 0.1% of its productivity growth in 2013, down to 0.3%. The efficiency of resource use, as measured by total factor productivity, declined for both Brazil and Mexico. The main reasons for the brake on productivity include inadequate infrastructure, too little investment in new machinery and equipment, high payroll taxes, and slow improvements in worker skills and management practices [185].

Productivity growth in Latin America is considered the key to unlocking sustainable growth, as the terms of trade become less favourable and expansion of employment and credit dwindles. The importance of improved productivity is also highlighted by the latest annual macroeconomic report of the Inter-American Development Bank (IADB), released on 30 March 2014 [212].

Since 1960 Latin America has gone from being better off on average than the rest of the world to being worse off. The gap between the typical Latin American country and the US has also widened. It has expanded its labour force and its capital stock faster than the US. However, the region's total factor productivity (TFP), the efficiency with which the economy uses its capital and labour, has declined. Latin America's productivity problem looks even worse when compared with Asia. To improve productivity the region must focus on better infrastructure, a reduction in the size of the informal economy, and more efficient adoption of new technologies [212].

In Brazil, GDP grew by 2.5% in 2013, in line with the expectations of Standards & Poor's. This is an improvement on the 1% GDP growth in 2012. This growth is attributed to a recovery in investment and manufacturing (industrial production). GDP growth is forecast to be 2.2% in 2014 and 2.5% in 2015. Inflationary pressures are likely to remain until the effects of tighter monetary policy are felt. Unemployment remains at record low levels. Structural factors underlying weak manufacturing performance need to be addressed to improve growth further, notably by improving infrastructure and by reducing the tax burden and tax complexity [213].

5.2.9 AFRICA AND THE MIDDLE EAST

The EIU is forecasting real GDP growth of 4% for Sub-Saharan Africa in 2014, rising to 5.6% by 2017 [176]. However, the performance of sub-regions and individual states will vary substantially. Countries affected by political unrest or potentially contentious elections could register expansion of less than 2.5%, or even contraction. On the other hand, the strong investment of recent years in the extractive industries will see commodity production continue to rise strongly. More broadly, over the next few years expansion of the lower middle class will stimulate infrastructure spending, which will in turn positively influence regional GDP growth [174].

Political instability in several major economies in the Middle East and North Africa (MENA) are considered by some commentators to be likely to hold back economic performance across the region. The transition to civil authority has created real risks in several countries that experienced political upheavals in the Arab Spring in 2011. The ongoing civil war in

Syria is showing no signs of stopping and is leading to regional sectarian violence [174].

With international attention focused elsewhere (mainly on the crisis sparked by the Russian invasion of Ukraine), the government of the president, Bashar al Assad, may grow in confidence about its longevity and will maintain its military operations against rebel groups. Economic performance in the MENA region may improve in 2014–15 as Iran, among the largest regional economies, returns to growth after two years of contraction caused by international sanctions and a decline in oil production. Heavy capital expenditure among Gulf countries will also continue to move regional growth rates upward [174].

Productivity growth in the MENA region slowed as output growth declined in 2013, due to a combination of weakening oil prices and social and political unrest in the region, while employment growth remained stable [185].

Labour productivity growth in Sub-Saharan Africa has remained at 2.1% in 2013 due to stable output and increasing employment rates. Some African countries have very low levels of productivity (as low as 5% of the US level), but South Africa, the largest economy in the region, reaches 28% of the US productivity level. Estimates for South Africa suggest relatively stable labour productivity growth of over 3%, but there is still scope for more efficient use of resources since TFP growth is declining. There are also large variations in productivity growth between African economies, ranging from more than 4% expansions in large economies such as Ghana and Côte d'Ivoire to contractions in economies such as Zimbabwe and Madagascar [185].

Western aid agencies, Chinese mining companies and UN peacekeepers have helped the economy, but the main contributor to growth is the African population, which has embraced modern technology [214].

Links between Africa and China continue to deepen [215].

Africa's citizens are already striving to become more productive as the Internet changes the way the continent does business. For example, some farmers have been using hand-held devices to get weather reports. Even slum dwellers are using technology. In Kenya, a third of GDP flows through a mobile money-transfer system set up by a private telecommunications company [214].

According to Goldman Sachs' projections, Africa is one of the fast-growing parts of the world, where GDP growth is most likely to accelerate. Education of the young and adoption of technology appear to be transforming Africa [216].

5.2.10 AUSTRALIA

Australia is the world's 12th largest economy by real GDP [217]. The Commonwealth Bank is forecasting real GDP growth of 3% for 2014 and 3% for 2015 [218]. Overall, the economy is lifting and heading back to a 'normal' 3% trend pace. Recent data on consumer spending and dwelling approvals show improvement. Economic momentum is likely to lift over 2014. GDP growth of 2.4% was achieved in 2013 [219].

Australia's economy has experienced 22 years of uninterrupted annual growth, low inflation and low unemployment largely due to structural reforms made in the early 1980s and strong demand from Asia, particularly China, for the country's mineral and energy resources. The export-led mining boom has helped to strengthen the Australian dollar. So too have relatively high interest rates and a triple-A credit rating [219]. However, a potential slowdown in China could damage Australia's export economy, and large consumer and financial institution debt means neither the average citizen nor the country's large banks are well prepared for another global economic downturn [211].

Within Australia the economy is generally considered patchy and the Reserve Bank considers that a key challenge facing the economy is managing the rebalancing away from mining investment. The housing sector continues to lift and will help to fill part of the void left by the reduction in mining activity [219].

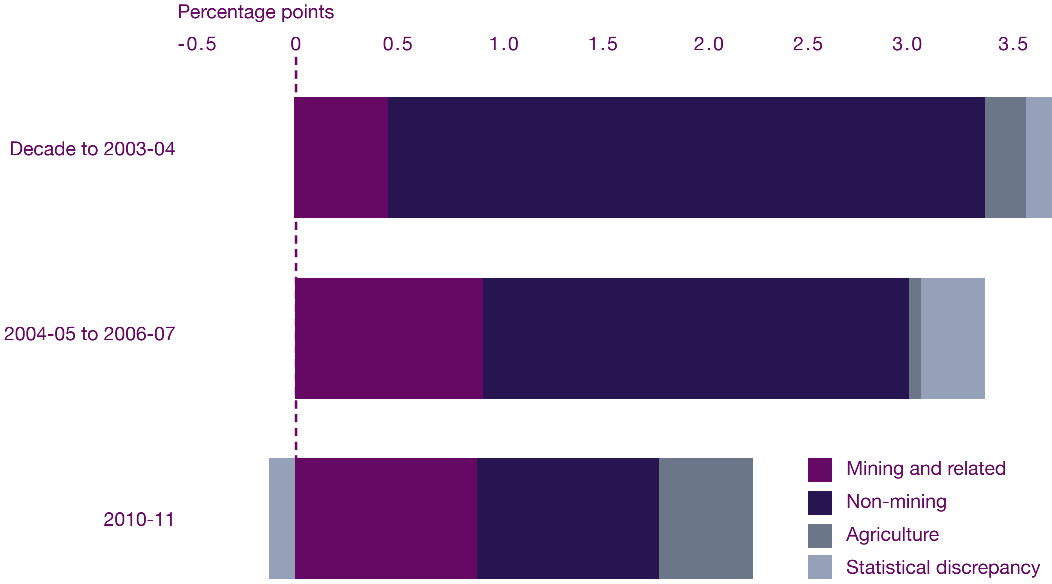
Since early 2009 the dollar has risen by two-thirds against the American dollar, to above $0.90; however, last year the USD was around $1.05 [219]. The Australian dollar is firmer due to positive local economic growth figures and renewed global risk appetite [220].

GDP growth through time is shown in Figure 23 and Figure 24:

FIGURE 23: GDP GROWTH OVER TIME

Source: [205]

FIGURE 24: CONTRIBUTIONS TO GDP GROWTH IN AUSTRALIA



Source: [205]

The Australian government's debt-to-GDP ratio was 17.5% in 2013 and 20.7% in 2012. By 2015 this is forecast to fall to 16.6% [221]. The IMF is not overly concerned about Australia's weaker fiscal position because of its relatively low level of debt [211].

Australia's productivity has steadily improved over the past 24 months by 2.7% but has also shown an increase in unemployment.

The unemployment rate rose to 6% in January 2014, the highest level since July 2003. Toyota, Ford and GMH-Holden have all announced they will be shutting down local manufacturing by 2017. Qantas have announced plans to cut 5,000 jobs. These job cuts will impact Australian households and highlight the pressures faced by large companies in Australia. The Reserve Bank left the cash rate unchanged at 2.5% at its board meeting on 4 March 2014. The Bank commented that economic conditions remained mixed and that unemployment will probably rise further before it improves [222]. The OECD predicts that unemployment will rise to 6.1% in December 2014 and 6.3% in December 2015, matching the USA [223].

In 2013, exports to China hit a record $96.7 billion and the trade surplus hit a record $49.1 billion. China accounts for a record 36.3% of exports. The trade surplus is now the highest it has been in over two years [219].

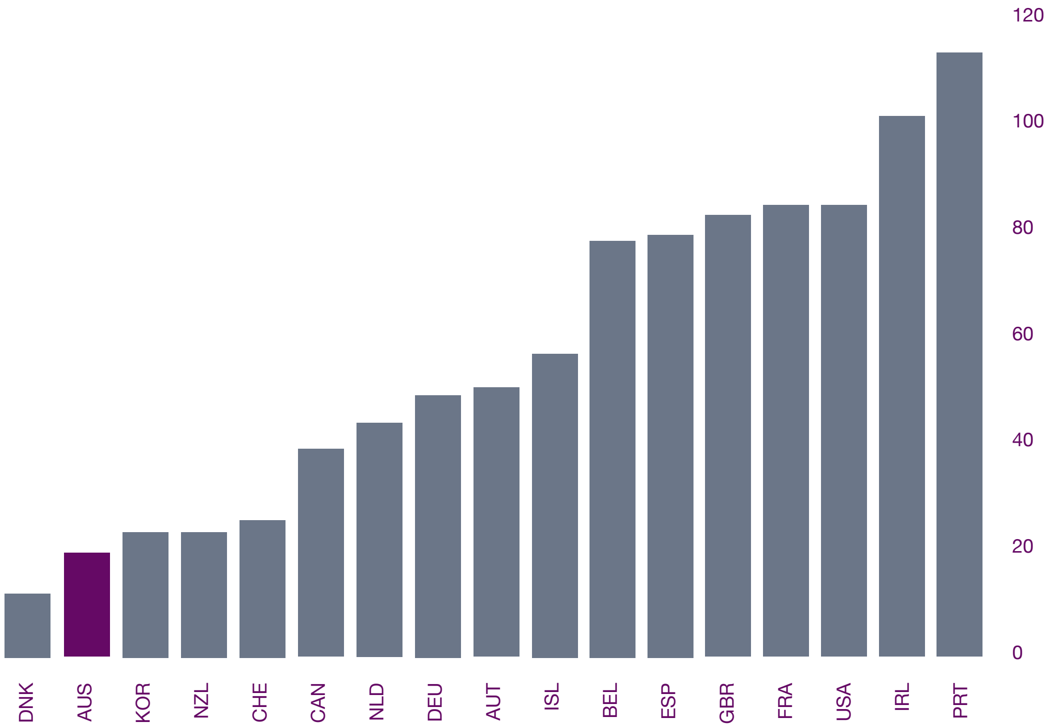
The Productivity Commission has explained much of Australia's slowdown by looking at trends in particular industries. The resource sector has led the fall in productivity, partly because high commodity prices have encouraged miners to chase lower grade or less accessible ore bodies. As mining projects come on stream, productivity should rise. Other resource-rich advanced countries, including Norway and Canada, have experienced similar productivity changes [224].

Business R&D expenditure accounts for about 60% of all Australian R&D activity. On average, public companies in Australia spend over 3% of their turnover on R&D. Small and medium enterprises with up to 200 employees spend an average of 1.5% and those with fewer than 20 employees spend less than 1% [225].

Australia has progressively had its World Economic Forum global competiveness ranking reduced from 15th in 2010/11 to 20th in 2011/12 and finally to 21st in 2012/13. New Zealand, at 18th, has now overtaken Australia. The main areas of concern are the rigidity of the labour market, where Australia is ranked 54th; hiring and firing practices (137th); wage setting (135th); and the burden of government regulations (128th). The business community considers the labour market and bureaucratic red tape as the most problematic aspects of doing business in Australia [225].

Australia currently has a relatively low debt-to-GDP ratio compared to most other developed countries (see Figure 25). In May 2014 the Australian government announced an austerity budget designed to reduce government debt and restore sustainable surpluses over time. The key areas of the budget included funding a National Disability Insurance Scheme and paid parental leave; ending carbon taxation and the mineral resource rent tax; cutting company tax; tightening eligibility for welfare; privatising and merging government agencies; increasing provision for new infrastructure spending; resuming petrol excise indexation; tightening eligibility for welfare; reducing subsidisation of health and education; reducing indexation for age and disability pensioners; reducing public sector employment; and reducing industry assistance [195].

FIGURE 25: GENERAL GOVERNMENT NET DEBT, 2013 (AS A PERCENTAGE OF GDP)

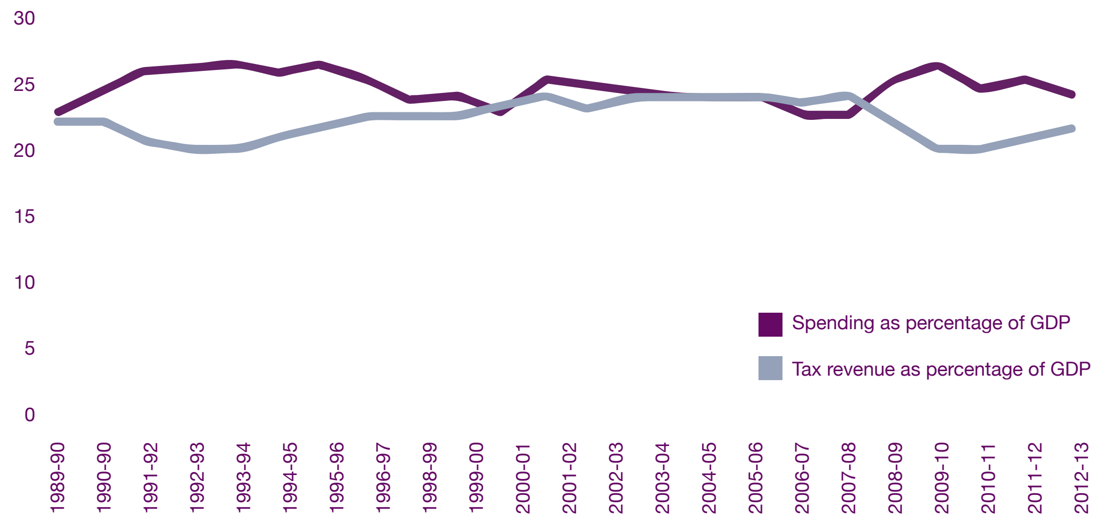


Source: [187]

The budget reduced commercialisation subsidies and R&D tax incentives. A $20 billion sovereign Medical Research Future Fund was established. Agribusiness will have access to a farm finance package of $320 million for debt and drought pressures as well as funds for research in partnership with rural research and development corporations. Higher education fees will be deregulated, potentially leading to increased tuition fees [195]. The Cooperative Research Centre's Program budget was reduced by 12% over the four-year forward estimates period and cuts were also made to CSIRO and the ARC program.

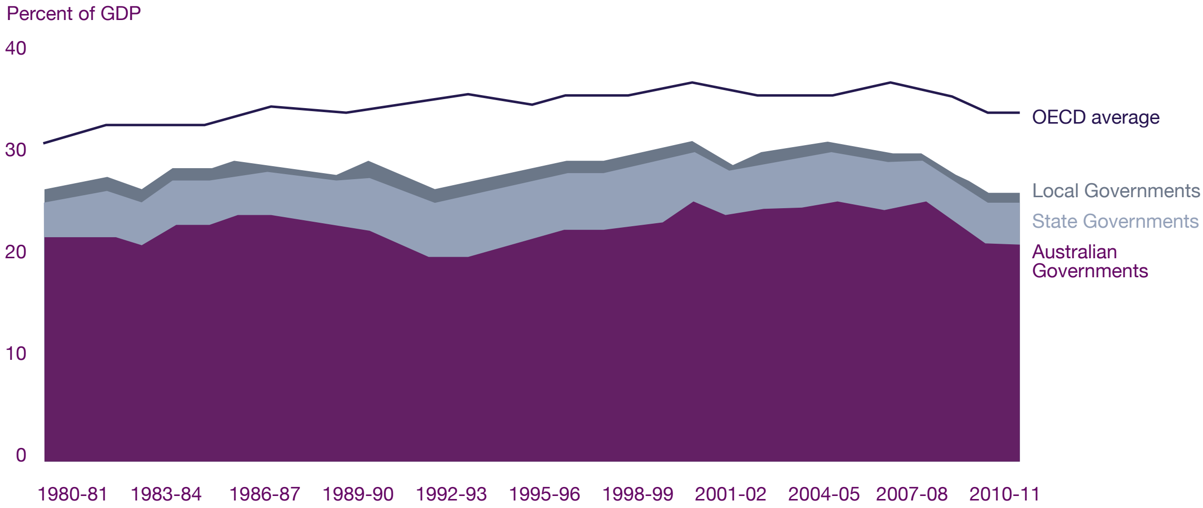
The IMF is of the view that 'gross debt in Australia is expected to peak at around 32% of GDP in 2015 and is among the lowest in advanced nations' [226]. Saul Eslake, chief economist at Bank of America Merrill Lynch, noted that Australia will continue to enjoy relatively low government debt-to-GDP ratio among developed countries up until 2018 [226]. The National Australia Bank predicts that the impact of the federal budget will be to reduce growth in Australia by 0.5% over the next three years [226].

FIGURE 26: AUSTRALIAN FEDERAL GOVERNMENT SPENDING AND TAX REVENUE



Source: [225]

FIGURE 27: AUSTRALIA'S TAX-TO-GDP RATIO BY LEVEL OF GOVERNMENT



Source: [225]

Figure 26 and Figure 27 show that Australians are paying less tax to the Federal Government as a proportion of GDP than they were a decade ago. This is attributable to a series of tax cuts and the global financial crisis. The Federal Government collects around 80% of tax paid in Australia [225].

The 2013–14 budget papers noted that the average tax-to-GDP ratio in the last five years was lower than in any other period since the mid-1990s (see Figure 27) [225].

5.2.11 NEW ZEALAND

The New Zealand economy is beginning to improve, with post earthquake reconstruction, business investment and household spending all increasing. Risks to growth include high private debt levels, weak foreign demand, large external imbalances, volatile terms of trade, a recent drought and an exchange rate that appears overvalued. The main structural challenge will be to create conditions that encourage resources to move toward more sustainable sources of prosperity. Average income per head is well below the OECD average, and productivity growth has been sluggish for a long time. Lifting living standards sustainably and equitably will require structural reforms to improve productivity performance and the quality of human capital [227, 228]. New Zealand's government debt-to-GDP ratio was 37.5% in 2013 and is expected to drop to 35.9% in 2014 [229].

New Zealand became the first developed nation to raise its interest rates in March 2014. It plans to remove stimulus faster than previously forecast to contain inflation [231]. GDP growth in 2013 was 3.2%, higher than the 2.5% in 2012. It is forecast that the GDP growth will increase to 3.3% in 2014 and 2.9% in 2015 [230].

However, GDP per capita is still lower than the top half of OECD nations, primarily as a result of lower than desired labour productivity [231].

The New Zealand Government has identified a number of areas for priority action including health care reforms, improving support for education and R&D and more efficient public spending. An emissions trading scheme has been introduced and personal and corporate income tax rates are being reduced [231].

New Zealand's business confidence dipped slightly in March 2014 but remains at the second-highest rate in 20 years according to the ANZ Bank's business outlook survey [232].

6 CONCLUDING REMARKS

Accelerating developments in spatial and related technologies are occurring. These are driving substantial growth with estimates of up to 30% per annum for the geoservices industries. On the other hand global GDP growth is forecast to average around 2.9% in 2014. These big picture trends suggest that there is ample opportunity for the spatial sciences and the spatial industry to expand its contribution to the economies of the world.

GLOSSARY OF TERMS

BIM	Building Information Models
CAGR	Compound annual growth rate
CRCSI	The Australia New Zealand Cooperative Research Centre for Spatial Information. CRCSI is an international R&D centre set up in 2003 under the Australian Government's CRC Program. CRCSI conducts user-driven research in emerging areas of spatial information that address issues of national importance. The CRCSI also undertakes commissioned research for key clients. Around 100 partnering organisations, drawn from Australian federal and state government agencies, the New Zealand Government, universities and over 50 companies, cumulatively provide $160 million (cash and in kind) over 2010–18 to the activities of the CRCSI.
G7	The G7 is a group consisting of the finance ministers of seven industrialised nations: the US, the UK, France, Germany, Italy, Canada and Japan. They are seven of the eight wealthiest nations on Earth, not by GDP but by global net wealth (China is the eighth). The G7 represents more than the 66% of net global wealth ($223 trillion) according to the September 2012 Credit Suisse Global Wealth Report.
CSIRO	Commonwealth Scientific and Industrial Research Organisation. Australia's national science agency and one of the largest and most diverse research agencies in the world.
GDP	Gross Domestic Product, the market value of all officially recognised final goods and services produced within a country in a given period of time. GDP per capita is often considered an indicator of a country's standard of living.
GNSS	Global Navigation Satellite System, a satellite navigation system with global coverage. As of April 2014, only the US NAVSTAR Global Positioning System and the Russian GLONASS are globally operational GNSSs. China is in the process of expanding its regional BeiDou navigation system into the global Compass navigation system by 2020. The European Union's Galileo positioning system is a GNSS in its initial deployment phase, scheduled to be fully operational by 2020 at the earliest. India and Japan are in the process of developing regional navigation systems.
GPS	Global Positioning System, the US space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the US government and is freely accessible to anyone with a GPS receiver.

IMF	International Monetary Fund, which describes itself as ‘an organisation of 188 countries, working to foster global monetary cooperation, secure financial stability, facilitate international trade, promote high employment and sustainable economic growth, and reduce poverty around the world’. The organisation’s stated objectives are to promote international economic cooperation, international trade, employment, and exchange rate stability, including by making financial resources available to member countries to meet balance of payments needs.
IoT	Internet of Things
LBS	Location-based services
NASA	National Aeronautics and Space Administration, an agency of the US government that is responsible for the nation’s civilian space program and for aeronautics and aerospace research.
OECD	The Organisation for Economic Cooperation and Development, promotes policies that will improve the economic and social wellbeing of people around the world. The OECD provides a forum in which governments can work together to share experiences and seek solutions to common problems; understand what drives economic, social and environmental change; measure productivity and global flows of trade and investment; analyse and compare data to predict future trends; and set international standards on a wide range of issues, from agriculture and tax to the safety of chemicals.
Productivity	A measurement of economic growth of a country. Labour productivity measures the amount of goods and services, or more specifically the amount of real GDP, produced by one hour of labour. Growing labour productivity depends on three main factors: investment and saving in physical capital, new technology and human capital.
PPP	Purchasing Power Parity, an economic theory that estimates the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to each currency's purchasing power. In other words, the exchange rate adjusts so that an identical good in two different countries has the same price when expressed in the same currency.
Real GDP	An inflation-adjusted measure that reflects the value of all goods and services produced in a given year, expressed in base-year prices. Often referred to as ‘constant-price’, ‘inflation-corrected’ or ‘constant dollar’ GDP.

Total Factor Productivity (Multi-Factor Productivity)	Total factor productivity (TFP), also called multi-factor productivity, is a variable that accounts for effects in total output not caused by traditionally measured inputs of labour and capital. If all inputs are accounted for, then total factor productivity (TFP) can be taken as a measure of an economy's long-term technological change or technological dynamism.
UAVs	Unmanned Aerial Vehicles, colloquially known as drones, are aircraft without a human pilot on board. Their flight is controlled either autonomously by computers in the vehicle or under the remote control of a pilot on the ground or in another vehicle. A wide variety of UAV shapes, sizes, configurations, and characteristics exists. Historically, UAVs were simple remotely piloted aircraft, but autonomous control is being employed more frequently.
WEF	The World Economic Forum is an independent international organisation committed to improving the state of the world by engaging business, political, academic and other leaders of society to shape global, regional and industry agendas.

REFERENCES

[1] World Economic Forum, 'Global Information Technology Report', accessed May 8, 2013, http://www.weforum.org/reports/global-information-technology-report-2013

[2] Strategy&, 'Digitization', accessed April 15, 2013, http://www.booz.com/global/home/what-we-think/digitization

[3] Elliot M, 'Megatrends and what's on the horizon', accessed February 19, 2014, http://www.ey.com/Publication/vwLUAssets/EY_-_Megatrends_and_what's_on_the_horizon/$FILE/EY-com_gl_state_of_mining_and_metals.pdf

[4] PriceWaterhouseCoopers, 'Five global megatrends', accessed February 19, 2014, http://www.pwc.com/gx/en/annual-review/megatrends/index.jhtml

[5] McKee L, 'OGC Identifies Geospatial Megatrend and Some Ripe Issues', Directions Magazine, published December 19, 2013, http://www.directionsmag.com/articles/ogc-identifies-geospatial-megatrend-and-some-ripe-issues/373566

[6] Oxera, 'What is the economic impact of Geo services? A report prepared for Google', accessed May 8, 2013, http://www.oxera.com/Oxera/media/Oxera/downloads/reports/What-is-the-economic-impact-of-Geo-services_1.pdf

[7] Federal Geographic Data Committee, 'National Spatial Data Infrastructure Strategic Plan 2014–2016', accessed February 19, 2014, http://www.fgdc.gov/nsdi-plan/nsdi-strategic-plan-2014-2016-FINAL.pdf

[8] Boston Consulting Group, 'Geospatial Services: A $1.6 Trillion Growth Engine for the US Economy', accessed May 8, 2013, http://www.bcg.com/documents/file109372.pdf

[9] Teal Group Corporation, 'Teal Group Analysts Identify 3,164 Space Payloads Proposed For Launch To 2032 With An Estimated Value Of More Than $235 Billion', accessed April 9, 2014, http://tealgroup.com/index.php/about-teal-group-corporation/press-releases/104-teal-group-analysts-identify-3-164-space-payloads-proposed-for-launch-to-2032-with-an-estimated-value-of-more-than-235-billion

[10] Union of Concerned Scientists, 'UCS Satellite Database', accessed April 9, 2014, http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html

[11] BCC Research, 'Remote Sensing Technologies and Global Markets', last modified September 2013, accessed April 16, 2014, http://www.bccresearch.com/market-research/instrumentation-and-sensors/remote-sensing-technologies-ias022d.html

[12] Euroconsult, 'Earth Observation Industry Remains Buoyant Despite Challenging Economic Environment', accessed April 16, 2014, http://www.euroconsult-ec.com/news/press-release-33-7/52.html

[13] Euroconsult, 'Satellite-Based Earth Observation', accessed April 30, 2014, http://www.euroconsult-ec.com/research-reports/space-industry-reports/satellite-based-earth-observation-38-42.html

[14] BBC Research LLC, 'BCC Research Publishes a New Report on Global Markets for Remote Sensing Products, Directions Magazine, accessed April 16, 2014, http://www.directionsmag.com/pressreleases/bcc-research-publishes-a-new-report-on-global-markets-for-remote-sensi/356450

[15] Berkenstock D, 'The World is One Big Data Set', accessed April 30, 2014, http://www.ted.com/talks/dan_berkenstock_the_world_is_one_big_dataset_now_how_to_photograph_it

[16] Selding PB, 'Planet Lab Secures Funding to Launch Another 72 Satellites', accessed April 30, 2014, http://www.spacenews.com/article/financial-report/39883planet-labs-secures-funding-to-launch-another-72-satellites

[17] Kumagai J, '9 Earth Imaging Startups to Watch' (published in IEEE Spectrum), accessed June 4, 2014, http://spectrum.ieee.org/aerospace/satellites/9-earthimaging-startups-to-watch

[18] PlanetiQ, 'Why PlanetiQ?', accessed April 30, 2014, http://www.planetiq.com/why-planet-iq/

[19] GeoOptics, 'Overview', accessed April 30, 2014, http://geooptics.com

[20] National Research Council, 'Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey', National Academies Press, Washington DC, 2012

[21] UN Initiative on Global Geospatial Information Management, 'Future trends in geospatial information management: the five to ten year vision', accessed April 30, 2014, http://ggim.un.org/docs/Future-trends.pdf

[22] Barker G, 'Apple iBeacon: signs of new direction' (published in the Sydney Morning Herald), accessed April 30, 2014, http://www.smh.com.au/digital-life/digital-life-news/apple-ibeacon-signs-of-new-direction-20140402-35x1j.html

[23] Kahn J, 'MFi Sunglasses w/ embedded iBeacon notify you when lost, act as beacons in retail' (published in 9to5mac), accessed April 30, 2014, http://9to5mac.com/2014/04/28/mfi-sunglasses-w-embedded-ibeacon-notify-you-when-lost-act-as-beacons-in-retail/

[24] Ball M, 'Interior Location and Mapping: Prompted by Innovations that Improve Position and Navigation' (published in Informed Infrastructure), accessed January 30, 2013, 'http://informedinfrastructure.com/2668/interior-location-and-mapping-prompted-by-innovations-that-improve-position-and-navigation/

[25] European Global Navigation Satellite Systems Agency, 'Market Report', accessed April 16, 2014, http://www.gsa.europa.eu/market/market-report

[26] Shankland S, 'With Firefox OS, Mozilla begins the $25 smartphone push' (published in CNET), accessed April 16, 2014, http://www.cnet.com/news/with-firefox-os-mozilla-begins-the-25-smartphone-push/

[27] Wikipedia, 'Satellite Navigation', accessed April 30, 2014, http://en.wikipedia.org/wiki/Satellite_navigation

[28] Dr Phil Collier, Research Director CRCSI, personal communication, April 2014

[29] Ramirez E and Wolf G, 'The State of Self-Tracking' (published in The Health Care Blog based on a report by the ABI Marketing Group), accessed March 31, 2013, http://thehealthcareblog.com/blog/2013/03/17/the-state-of-self-tracking/

[30] Leavitt N, '2013 Mobile Marketing/Technology Trends' (published in iMedia Connection), accessed April 6, 2013, http://blogs.imediaconnection.com/blog/2012/12/26/2013-mobile-marketingtechnology-trends/

[31] Victorian Information and Communications Technology Advisory Committee, 'Victorian Government ICT Strategy', accessed May 8, 2013, http://digital.vic.gov.au/wp-content/uploads/2013/02/Victorian-Government-ICT-Strategy-web.pdf

[32] Nielsen, 'The Mobile Consumer Report', accessed May 8, 2014, http://www.nielsen.com/us/en/reports/2013/mobile-consumer-report-february-2013.html

[33] Insead, 'Press Releases – 2013', accessed May 2, 2013, http://www.insead.edu/media_relations/press_release/2013_ATT-INSEAD-productivity-report.cfm

[34] Cisco, 'Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013–2018', accessed April 2, 2014, http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html

[35] Open Mobile Media, 'Smart Homes Connect to Europe's power grid, part I', accessed April 16, 2014, ihttp://analysis.openmobilemedia.com/apps-mobile-tech/smart-homes-connect-europe's-power-grid-part-i

[36] Vandrico Inc, 'Wearable Tech Market', accessed April 30, 2014, http://vandrico.com/database

[37] Whitney L, 'Apple iWatch could trigger sales as high as $17.5B – analyst' (published in CNET), accessed February 5, 2014, http://news.cnet.com/8301-13579_3-57618292-37/apple-iwatch-could-trigger-sales-as-high-as-$17.5b-analyst/

[38] Pebble, Home Page, accessed February 5, 2014, https://getpebble.com/

[39] Brooks R, 'Mercedes Teams Up With Pebble Smartwatch To Create A Fleet Of Connected Cars' (published in PSFK), accessed February 19, 2014, http://www.psfk.com/2014/01/mercedes-pebble-watch-smart-cars.html#!vn8tn

[40] Wikipedia, 'Samsung Galaxy Gear', accessed February 5, 2014, http://en.wikipedia.org/wiki/Samsung_Galaxy_Gear

[41] Fitbit, Home Page, accessed February 5, 2014, http://www.fitbit.com/au

[42] Jawbone, 'Up', accessed May 8, 2014, https://jawbone.com/up#up24

[43] Nike, 'Nike+ FuelBand', accessed February 5, 2014, http://www.nike.com/us/en_us/c/nikeplus-fuelband

[44] Sony, 'SmartBand SWR10', accessed February 5, 2014, http://www.sonymobile.com/au/products/smartwear/smartband-swr10/

[45] Wikipedia, 'Google Glass', accessed February 5, 2014, http://en.wikipedia.org/wiki/Google_Glass

[46] Panzarino M, 'Facebook To Buy Oculus VR, Maker Of The Rift Headset, For Around $2B In Cash And Stock' (published in Tech Crunch), accessed April 16, 2014, http://techcrunch.com/2014/03/25/facebook-to-buy-oculus-vr-maker-of-the-rift-headset-for-around-2b-in-cash-and-stock/

[47] Lomas N, 'Wearables Market Heating Up, With More Than 17M Bands Forecast To Ship This Year, Says Canalys' (published in Tech Crunch), accessed April 29, 2014, 'http://techcrunch.com/2014/02/12/wearables-market-heating-up/

[48] Tucker RS, 'The Rise and Fall of Australia's $44 Billion Broadband Project' (published in IEEE Spectrum), accessed April 2, 2014, http://spectrum.ieee.org/telecom/internet/the-rise-and-fall-of-australias-44-billion-broadband-project

[49] IEEE Computer Society, ‘Top Technology Trends for 2010’, accessed February 19, 2014, http://www.computer.org/portal/web/membership/Top-10-Tech-Trends-in-2014

[50] Murray M, ‘2014 Tech Predictions’ (published in PC Mag), accessed April 16, 2014, http://www.pcmag.com/article/print/319291

[51] PR Newswire, ‘Wireless Sensor Networks: Market Shares Strategies, and Forecasts, Worldwide, 2013 to 2019’, accessed March 31, 2014, http://www.prnewswire.com/news-releases/wireless-sensor-networks-market-shares-strategies-and-forecasts-worldwide-2013-to-2019-233305991.html

[52] Silicon Labs, ‘Overcoming Challenges of Connecting Intelligent Nodes to the Internet of Things’, published 2012, accessed February 19, 2014, http://www.silabs.com/Support%20Documents/TechnicalDocs/bringing-the-internet-of-things-to-life.pdf

[53] Sense-T, ‘Public Lecture: The World Bank eye on Tasmanian technology disrupters’, accessed April 16, 2014, http://www.sense-t.org.au/latest-news/news-items/public-lecture-with-chris-vein-of-the-world-bank

[54] Taggle, ‘Revolutionising Low Cost Monitoring for Australian Water Utilities’, accessed March 31, 2014, http://www.taggle.com.au

[55] Rose A, ‘The internet of things is set to change security priorities’ (published in Computer Weekly), accessed February 19, 2014, http://www.computerweekly.com/feature/The-internet-of-things-is-set-to-change-security-priorities

[56] Wikipedia, ‘Heartbleed’, accessed May 8, 2014, http://en.wikipedia.org/wiki/Heartbleed

[57] Cervantes E, ‘Google acquires SlickLogin – the quest to improve the annoying password issue’ (published in Chrome Spot), accessed February 19, 2014, http://chromespot.com/2014/02/17/google-acquires-slicklogin-password-authentication/

[58] Gartner, ‘Gartner Identifies the Top 10 Strategic Technology Trends for 2014’, accessed February 5, 2014, http://www.gartner.com/newsroom/id/2603623

[59] Basulto D, ’10 bold predictions for 2014’ (published by the Washington Post), accessed February 19, 2014, http://www.washingtonpost.com/blogs/innovations/wp/2014/01/07/10-bold-predictions-for-2014/

[60] University of Sheffield Institution of Mechanical Engineers, ‘Sheffield University produces 3D printed UAV’, accessed May 8, 2014, http://www.imeche.org/news/engineering/sheffield-university-produces-3d-printed-uav-280314-1

[61] PR Newswire, '"The Human Face of Big Data" Large Format Illustrated Book is Being Delivered Today by FedEx to 100,000 of the World's Most Influential People, Including World Leaders, Fortune 500 CEOs, and Nobel Laureates', accessed May 7, 2014, http://www.prnewswire.com/news-releases/the-human-face-of-big-data-large-format-illustrated-book-is-being-delivered-today-by-fedex-to-10000-of-the-worlds-most-influential-people-including-world-leaders-fortune-500-ceos-and-nobel-laureates-181982991.html

[62] Brock J, Souza R, Platt J and Dreishmeier R, 'Big Data's Five Routes to Value', accessed May 7, 2014, (published in BCG perspectives), https://www.bcgperspectives.com/content/articles/information_technology_strategy_digital_economy_opportunity_unlocked_big_data_five_routes_value/

[63] Sourabh, 'Business Software Alliance (BSA) Global Cloud Computing Scorecard' (published by Source Digit), accessed April 2, 2014, http://sourcedigit.com/493-business-software-alliance-bsa-global-cloud-computing-scorecard/

[64] Computerworld India staff, 'Gartner: Big data to drive $34 billion of IT spending in 2013' (published in IT World), accessed April 16, 2014, http://www.itworld.com/it-managementstrategy/304206/gartner-big-data-drive-34-billion-it-spending-2013

[65] LBx Journal, 'Location SmartBrief', accessed April 16, 2014, http://www2.smartbrief.com/servlet/ArchiveServlet?issueid=DD2E9EAC-75C4-4AF1-A667-1115F4FB0F2D&lmid=archives

[66] IEEE Computer Society, 'IEEE Computer Society Announces 13 Technology Trends for 2013', accessed April 16, 2014, http://www.computer.org/portal/web/pressroom/IEEE-Computer-Society-Announces-13-Technology-Trends-for-2013

[67] McKinsey Global Institute, 'Big Data: The next frontier for innovation, competition and productivity', published May 2011

[68] Steve Jacoby (Queensland Government), personal communication June 23, 2014

[69] Lateral Economics, 'Open for Business: How Open Data Can Help Achieve the G20 Growth Target', June 2014 http://www.omidyar.com/sites/default/files/file_archive/insights/ON%20Report_061114_FNL.pdf

[70] Steudler D and Rajabifard A (Eds.), 'Spatially Enabled Society' (published in FIG publication no. 58), accessed May 8, 2014, http://www.fig.net/pub/figpub/pub58/figpub58.pdf

[71] Houghton J, 'Costs and Benefits of Data Provision', accessed May 8, 2014, http://ands.org.au/resource/houghton-cost-benefit-study.pdf

[72] Clarke T, ‘Just do it: Nike opens access to customer data’, accessed January 22, 2013, http://www.theage.com.au/it-pro/business-it/just-do-it-nike-opens-access-to-customer-data-20130122-2d3tt.html#ixzz2IlX3zt2m

[73] Van Oosterom P, Zlatanova P, Penninga F and Fendel E (Eds.), ‘Advances in 3D geoinformation systems’, Springer Verlag, 2008

[74] Abdul-Rahman A and Pilouk M, ‘Spatial data modeling for 3D GIS’, Springer Verlag, 2008

[75] Mallet JL, ‘Geomodelling’, Oxford University Press, New York, USA, 2002, p 599

[76] Mäntylä M, ‘An introduction to solid modeling’, Computer Science Press , New York, USA, 1988

[77] Cheney LM, ‘Geographical and Building Information Systems Integration’, accessed May 8, 2014, http://ufdcimages.uflib.ufl.edu/UF/E0/04/16/58/00001/cheney_l.pdf

[78] Pitney Bowes Software, ‘A Golden Opportunity: Truly Integrated 3D GIS’, accessed April 29, 2014, http://www.mapinfo.com/wp-content/uploads/2014/01/CDLI_GLBL_3DGIS_WhitePaper.pdf

[79] Zeiss G, ‘Mobile scanning interiors of buildings with automatic feature extraction for energy performance modeling’ (In: Between the Poles), accessed April 29, 2014, http://geospatial.blogs.com/geospatial/bim/page/2/

[80] BuildingSMART Australasia, ‘National Building Information Modelling Initiative Volume 1: Strategy’, accessed April 6, 2013, http://buildingsmart.org.au/nbi-folder/NationalBIMIniativeReport_6June2012.pdf updated August 2012

[81] Surveying and Spatial Sciences Institute, ‘2013 GIS in local government benchmark study’, August 2013, https://esriaustralia.com.au/u/lib/cms/2013-gis-in-local-government-benchmark-study.pdf

[82] Song C, Qu Z, Blumm N and Barabasi A, ‘Limits of predictability in human mobility’, Science 327 (2010): 1018–21

[83] Scoble R and Israel S, ‘Age of Context: Mobile, Sensors, Data and the Future of Privacy’, Creative Space Independent Publishing Platform, September 2013

[84] Hiner J, ‘CES 2014: Four mega-trends for the professionals’ (published in ZDNet), accessed February 19, 2014, http://www.zdnet.com/ces-2014-four-mega-trends-for-the-professionals-7000024727/

[85] Google, ‘Google now’, accessed April 30, 2014, http://www.google.com.au/landing/now/#

[86] Percivall G, ‘The Power of Location’ (published in OGC), accessed February 19, 2014, http://www.opengeospatial.org/blog/1817

[87] IBM, ‘IBM Reveals Five Innovations That Will Change Our Lives within Five Years’, accessed April 16, 2014, http://www-03.ibm.com/press/us/en/pressrelease/42674.wss

[88] LBx Journal, ‘Location SmartBrief’, accessed April 16, 2014, http://www2.smartbrief.com/servlet/ArchiveServlet?issueid=99038395-D494-4EF9-B3C8-D90FE1A295D1&lmid=archives

[89] PredPol, ‘Scientifically Proven Field Results’, accessed February 5, 2014, http://www.predpol.com/results/

[90] Cett H, ‘Berg launches insight into retail M2M market’, accessed May 7, 2014, http://www.gomonews.com/berg-launches-insight-into-retail-m2m-market/

[91] Bilton N, ‘Disruptions: Coming in 2014: Extremely Smart Watches and Wearable TVs’, accessed February 5, 2014, http://bits.blogs.nytimes.com/2013/12/29/disruptions-coming-in-2014-extremely-smart-watches-and-wearable-tvs/?_php=true&_type=blogs&_r=0

[92] Percivall G, ‘Mobile Development’, accessed February 19, 2014, http://www.opengeospatial.org/blog/1826

[93] Google, ‘Google Goggles’, accessed April 16, 2014, https://play.google.com/store/apps/details?id=com.google.android.apps.unveil

[94] Red Orbit, ‘Researchers Create New Augmented Reality Chip for Head-Mounted Display’, accessed February 19, 2014, http://www.redorbit.com/news/technology/1113073697/k-glass-developed-by-kaist-021814/

[95] Wikipedia, ‘Augmented reality’, accessed February 19, 2014, http://en.wikipedia.org/wiki/Augmented_reality

[96] Open Geographical Consortium, ‘ARML 2.0 SWG’, accessed April 16, 2014, http://www.opengeospatial.org/projects/groups/arml2.0swg

[97] Barter P, ‘Is 30% of traffic actually searching for parking?’, accessed March 31, 2014, http://www.reinventingparking.org/2013/10/is-30-of-traffic-actually-searching-for.html

[98] Harper SF, ‘Introduction to “Big Data” (and Friends)’, accessed April 2, 2014, http://www.eli.org/sites/default/files/docs/big_data/harper_presentation.pdf

[99] SmartSantander Project, ‘Smart Santander Testbeds’, accessed April 2, 2014, http://smartsantander.eu/wiki/index.php/Experimentation/Testbeds

[100] Bielsa A, ‘Wireless Applications: The Smart City Project in Santander’, accessed March 31, 2014, http://www.sensorsmag.com/wireless-applications/smart-city-project-santander-11152

[101] IBM, ‘Smarter Cities’, accessed April 16, 2014, https://www.ibm.com/smarter planet/au/en/smarter_cities/ideas/index.html?re=sph

[102] Mitchell B, ‘DC Autonomous Car Proposal’, accessed April 16, 2014, http://www.scribd.com/doc/216865192/DC-Autonomous-Car-Proposal

[103] Ross PE, ‘California to Issue Driving Licences to Robots’, IEEE Spectrum, accessed June 4, 2014, http://spectrum.ieee.org/cars-that-think/transportation/advanced-cars/california-driving-licenses-autonomous-cars

[104] Senate Majority Caucus, ‘Legislation Introduced on Autonomous Vehicles’, accessed April 12, 2012, http://democrats.senate.ca.gov/news/2012-03-02-legislation-introduced-autonomous-vehicles

[105] Reynolds E, ‘Motoring bosses weigh up new laws to steer use of driverless cars’, accessed April 30, 2014, http://www.theaustralian.com.au/executive-living/motoring-bosses-weigh-up-new-laws-to-steer-use-of-driverless-cars/story-e6frg9zo-1226852390434

[106] Mack E, ‘Elon Musk: Tesla Will Be First With Autonomous Driving; Admits To Apple Meeting’, accessed April 30, 2014, http://www.forbes.com/sites/ericmack/2014/02/19/elon-musk-tesla-will-be-first-with-autonomous-driving-admits-to-apple-meeting/

[107] Frog, Co.Design, ’20 Tech Trends That Will Define 2013, Selected By Frog’, accessed April 7, 2013, http://www.fastcodesign.com/1671397/20-tech-trends-that-will-define-2013-selected-by-frog#7

[108] Driverless car market watch, ‘Key Players’, accessed April 16, 2014, http://www.driverless-future.com/?page_id=155

[109] ‘Driverless car legalized in California’ (published in The Australian), accessed April 30, 2014, http://www.theaustralian.com.au/technology/driverless-car-legalised-in-california/story-e6frgakx-1226481740630

[110] Eno Transportation Foundation, Inc., ‘Preparing a Nation for Autonomous Vehicles’, published October 2013, accessed April 30, 2014, https://www.eno trans.org/wp-content/uploads/wpsc/downloadables/AV-paper.pdf

[111] Clark Estes A, ‘What’s Keeping Self-Driving Cars Off the Road?’, accessed 30 April, 2014, http://www.gizmodo.com.au/2013/10/whats-keeping-self-driving-cars-off-the-road/

[112] 'Autonomous vehicles – the next revolution', accessed April 30, 2013, http://www.globalskm.com/Insights/Achieve-Articles/Items/2013/Autonomous-vehicles-the-next-revolution-the-road-ahead.aspx

[113] ITS Australia, 'Cooperative Intelligent Transport Systems close to reality: ITS Australia', accessed May 8, 2014, http://www.its-australia.com.au/wp-content/uploads/ITS-ARelease02EC7Mar13-2.pdf

[114] Research and Innovative Technology Administration, 'Vehicle-to-Vehicle (V2V) Communications for Safety', accessed May 5, 2014, http://www.its.dot.gov/factsheets/v2v_factsheet.htm

[115] Terrafugia, Home Page, accessed April 30, 2014, http://www.terrafugia.com

[116] Teal Group Corporation, 'Teal Group Predicts Worldwide UAV Market Will Total $89 Billion in Its 2013 UAV Market Profile and Forecast', accessed May 8, 2014, http://tealgroup.com/index.php/about-teal-group-corporation/press-releases/94-2013-uav-press-release

[117] Association for Unmanned Vehicle Systems International, 'Economic Report', accessed June 4, 2014, http://www.auvsi.org/econreport

[118] Civil Aviation Safety Authority, 'Review of Regulations and Guidance Material relating to Unmanned Aircraft Systems (UAS)', accessed April 30, 2014, http://www.casa.gov.au/scripts/nc.dll?WCMS:PWA::pc=PC_100532

[119] Australian Government, National Aviation Policy: White Paper', published December 2009, accessed May 9, 2014 http://www.infrastructure.gov.au/aviation/publications/pdf/Aviation_White_Paper_final.pdf

[120] Strickland E, 'Meet the Robots of Fukushima Daiichi' (In: IEEE Spectrum), accessed May 4, 2014, http://spectrum.ieee.org/slideshow/robotics/industrial-robots/meet-the-robots-of-fukushima-daiichi

[121] Maritime Unmanned Navigation through Intelligence in Networks', Home Page, accessed March 31, 2014, http://www.unmanned-ship.org/munin/

[122] Jet Propulsion Laboratory, California Institute of Technology, 'Intelligent Autonomy for Maritime Navigation on Unmanned Surface Vehicles', accessed April 30, 2014, http://www-robotics.jpl.nasa.gov/tasks/showTask.cfm?FuseAction=showTask&TaskID=164&tdaID=103765

[123] US Department of Labour, 'Occupational Outlook Handbook 2012–13', accessed May 13, 2013, http://www.bls.gov/ooh/

[124] The Allen Consulting Group (2010) ‘Spatial Market Infrastructure’, briefing note to the Department of Sustainability and Environment, accessed May 5, 2013, http://crcsi.com.au.stage.gs/getattachment/e686d67f-a9b0-438f-b32f-eae495165d6e/Briefing-Note--Spatial-Market-Infrastructure.aspx

[125] ACIL Tasman and Spatial Information Services, ‘Surveying and geospatial workforce modelling: Potential skills gap analysis for Queensland in particular with estimates extrapolated up for Australia’, published 2013, accessed May 9, 2014 http://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CBwQFjAA&url=http%3A%2F%2Fwww.crcsi.com.au%2Fgetattachment%2F5680d69c-dcd2-4c87-a821-051161e2d501%2FQueensland-surveying-and-geospatial-skills-gap-fin.aspx&ei=I5bYU-iXCsGm8AWdyIHYDw&usg=AFQjCNHfwRBQGw4_1M0m8afeLxjF54bywA&sig2=IBsrdcDx1EgwK3ymPSpOeg

[126] Bay Area Council, ‘New Study: For Every New, High-Tech Job, Four More Created’, accessed April 7, 2013, http://www.bayareacouncil.org/news/2012/12/10/new-study-for-every-new-high-tech-job-four-more-created/

[127] Patel P, ‘Early Signs Show Tech Jobs Doing Well’, accessed January 24, 2013, http://spectrum.ieee.org/tech-talk/at-work/tech-careers/early-signs-show-tech-jobs-doing-well

[128] US National Academy of Science, ‘Future U.S. Workforce for Geospatial Intelligence’, published 2013, accessed May 8, 2014, http://www.nap.edu/catalog.php?record_id=18265

[129] Kang C, ‘Consumer Electronics Show will highlight new ways to collect biometric data’ (In: The Washington Post), accessed February 19, 2014, http://www.washingtonpost.com/business/technology/consumer-electronics-show-will-highlight-new-ways-to-collect-biometric-data/2014/01/05/e8eac584-74c4-11e3-8def-a33011492df2_story.html

[130] Rozenfeld M, ‘The First Phone Designed With Privacy in Mind’, accessed April 16, 2014, http://theinstitute.ieee.org/ieee-roundup/opinions/ieee-roundup/the-first-phone-designed-with-privacy-in-mind

[131] The Location Forum, ‘Location Data Privacy Guidelines’, accessed June 17, 2014, http://www.thelocationforum.org/location-data-privacy-guidelines/

[132] Australian Government Department of Resources, Energy and Tourism, ‘ANZ Foundation Spatial Data Framework’, published November 2012

[133] Lynch A, ‘5 New Stars of Australian Crowdsourcing’, accessed March 31, 2014, http://e27.co/5-new-stars-of-australian-crowdsourcing/

[134] Burns R and Shanley LA, Wilson Center, ‘Connecting Grassroots to Government for Disaster Management: Workshop Summary’, accessed March 31, 2014, http://www.wilsoncenter.org/sites/default/files/STIP_Connecting-Grassroots-Workshop-Summary_Final2.pdf

[135] Wikipedia, ‘List of crowdsourcing projects’, accessed March 31, 2014, http://en.wikipedia.org/wiki/List_of_crowdsourcing_projects

[136] Thermopylae Sciences + Technology, ‘3D UDOP’, accessed April 16, 2014, http://www.gsdi.org/gsdiconf/gsdi12/slides/4.3d.pdf

[137] Kuriakose D, ‘FEMA App Adds Crowdsourcing for Disaster Relief’, accessed March 31, 2014, http://mashable.com/2013/07/29/fema-app-disaster-relief/

[138] Ralston N, ‘Search for Malaysia Airways plane turns to crowdsourcing for clues’, accessed March 31, 2014, http://www.smh.com.au/technology/technology-news/search-for-malaysia-airlines-plane-turns-to-crowdsourcing-for-clues-20140311-34ja9.html

[139] Zielinski C, ‘Malaysia Airways plane is in Malacca Strait, says crowd of 3 million’ (In: The Age), accessed March 31, 2014, http://www.theage.com.au/technology/technology-news/malaysia-airlines-plane-is-in-malacca-strait-says-crowd-of-3-million-20140319-hvkcp.html

[140] Tomnod, Home Page, accessed March 31, 2014, http://www.tomnod.com/nod/

[141] Ellery D, ‘Tomnod, Google Earth and MH370 change the world’, accessed April 9, 2014, http://www.smh.com.au/technology/technology-news/tomnod-google-earth-and-mh370-change-the-world-20140407-369cg.html

[142] BlackBridge, ‘Malaysia Airways – Flight 370’, accessed April 16, 2014, http://www.blackbridge.com/rapideye/news/action/malaysiaair.html

[143] ‘Victorian Government ICT Strategy Consultation’, accessed April 20, 2014, http://www.digital.vic.gov.au/2014/01/victorian-government-ict-strategy-consultation-2014/

[144] Vu T, ‘The Internet of Things: Why Does it Matter?’, accessed Feburary 19, 2014, http://makezine.com/2014/02/06/the-internet-of-things-why-does-it-matter/

[145] Percivall G, ‘Internet of Things’, accessed February 19, 2014, http://www.opengeospatial.org/blog/1818

[146] Powell R, ‘Melbourne universities launch programs to tap into evolving start-up scene', accessed February 19, 2014, http://www.startupsmart.com.au/growth/business-advice-and-education/melbourne-university-and-swinburne-university-programs-tap-into-start-up-scene/2013100910895.html

[147] Global Trends, '10 Key Trends to Watch For in 2014 (Trends 1 to 5)', accessed March 31, 2014, http://www.globaltrends.com/monthly-briefings/60-monthly-briefings/198-10-key-trends-to-watch-for-2014-trends-1-to-5

[148] Peiris V, 'Highly integrated wireless sensing for body area network applications', accessed March 31, 2014, http://spie.org/x105127.xml

[149] MC10 Inc., Home Page, accessed April 30, 2014, http://www.mc10inc.com

[150] Rao RPN and Stocco A, 'Direct Brain-to-Brain Communication in Humans: A Pilot Study', accessed February 19, 2014, http://homes.cs.washington.edu/~rao/brain2brain/experiment.html

[151] Science Channel, 'Can Our Minds Be Hacked?', accessed April 30, 2014, http://www.sciencechannel.com/tv-shows/through-the-wormhole/videos/can-our-minds-be-hacked.htm

[152] AirCasting, Home Page, accessed April 6, 2014, http://aircasting.org/

[153] Khomani N, '2029: the year when robots will have the power to outsmart their makers' The Observer, accessed June 4, 2014, http://www.theguardian.com/technology/2014/feb/22/computers-cleverer-than-humans-15-years

[154] Singularity University, Home Page, accessed June 4, 2014, http://singularityu.org

[155] Wikipedia, 'Singularity University', accessed June 4, 2014, http://en.wikipedia.org/wiki/Singularity_University

[156] YouTube, '10 Amazing Robots That Will Change the World', accessed June 4, 2014, http://www.youtube.com/watch?v=6feEE716UEk robots-10

[157] Robotic Open Platform, Home Page, accessed June 4, 2014, http://www.roboticopenplatform.org

[158] Ackerman E and Guizzo E, 'SCHAFT staying in DARPA Robotics Challenge, More Team Joining DRC Finals', accessed June 4, 2014, http://spectrum.ieee.org/automaton/robotics/military-robots/schaft-darpa-robotics-challenge-finals-more-teams

[159] Wikipedia, 'Turing test', accessed June 4, 2014, http://en.wikipedia.org/wiki/Turing_test

[160] Basulto D, 'Artificial intelligence is the next big tech trend. Here's why.', The Washington Post, accessed June 4, 2014, http://www.washingtonpost.com/blogs/innovations/wp/2014/03/25/artificial-intelligence-is-the-next-big-tech-trend-heres-why/

[161] VANZI: http://www.vanzi.com.au/ accessed August 28, 2014

[162] Kurzweil R, 'The Law of Accelerating Returns', accessed June 4, 2001, http://www.kurzweilai.net/the-law-of-accelerating-returns

[163] D-Wave, 'Quantum Computing', accessed June 4, 2014, http://www.dwavesys.com/quantum-computing

[164] Wikipedia, 'Quantum computer', accessed June 4, 2014, http://en.wikipedia.org/wiki/Quantum_computer

[165] Courtland R, 'D-Wave Aims to Bring Quantum Computing to the Cloud', accessed June 4, 2014, http://spectrum.ieee.org/podcast/computing/hardware/dwave-aims-to-bring-quantum-computing-to-the-cloud

[166] Ackerman E, 'Cyborg Drumming Arm Makes Amputee Into Superhuman Musician', accessed June 4, 2014, http://spectrum.ieee.org/automaton/robotics/robotics-hardware/cyborg-drumming-arm-makes-amputee-into-superhuman-musician

[167] Burks R, 'Brain implant could turn you into one of the X-Men', accessed July 16, 2014, http://www.dvice.com/2013-8-13/brain-implant-could-turn-you-one-x-men

[168] Anthes E, 'The race to create "insect cyborgs"', The Observer, accessed June 4, 2014 http://www.theguardian.com/science/2013/feb/17/race-to-create-insect-cyborgs

[169] Backyard Brains, 'Experiment: Neural Interface Surgery', accessed June 4, 2014, https://backyardbrains.com/experiments/roboRoachSurgery

[170] Rainie L and Anderson J, 'Scenario 5: The Evolution of Augmented Reality and Virtual Reality', accessed June 4, 2014, http://www.pewinternet.org/2008/12/14/scenario-5-the-evolution-of-augmented-reality-and-virtual-reality/

[171] Eveleth R, 'Augmented Reality System Goes From Military to Market', The Daily Beast, accessed June 4, 2014, http://www.thedailybeast.com/articles/2014/05/27/augmented-reality-system-goes-from-military-to-market.html

[172] Enplug, Home Page, accessed June 4, 2014, https://www.enplug.com/displays/

[173] Musion, Home Page, accessed June 4, 2014, http://musion.co.uk

[174] The Economist, 'Economic Intelligence Unit', accessed 19 March 2014, http://www.eiu.com/home.aspx

[175] Gurria A and Padoan PC, OECD Economic Outlook Press Conference, accessed June 4, 2014, http://www.oecd.org/economy/outlook/Handout_English.pdf

[176] The Economist, 'World GDP', accessed March 6, 2014, http://www.economist.com/news/economic-and-financial-indicators/21586611-world-gdp

[177] Rapoza K, 'Why China Is Not Dead Yet', Forbes, accessed April 1, 2014, http://www.forbes.com/sites/kenrapoza/2014/03/31/why-china-is-not-dead-yet

[178] National Australia Bank, 'Global and Australian Forecasts', accessed March 24, 2014, http://business.nab.com.au/wp-content/uploads/2013/03/global-australian-forecasts-march-2013.pdf

[179] OECD, 'OECD government borrowing set to rise slightly in 2013', accessed March 25, 2014, http://www.oecd.org/daf/fin/public-debt/oecdgovernmentborrowingsettoriseslightlyin2013.htm

[180] OECD, 'Medium and Long-Term Scenarios for Global Growth and Imbalances', OECD Economic Outlook 2012/1, accessed March 25, 2014, http://www.oecd.org/eco/outlook/50381011.pdf

[181] OECD, 'OECD Economic Surveys Japan April 2013', accessed March 25, 2014, http://www.oecd.org/eco/surveys/Overview%20Japan%202013%20English.pdf

[182] Trading Economics, 'United States Government Debt to GDP', accessed March 25, 2014, http://www.tradingeconomics.com/united-states/government-debt-to-gdp

[183] Rapoza K, 'IMF Warns China On Rising Government Debt', accessed April 1, 2014, http://www.forbes.com/sites/kenrapoza/2013/05/29/imf-warns-china-on-rising-government-debt/

[184] Vas C, 'Demystifying the global productivity puzzle', accessed March 27, 2014, http://theconversation.com/demystifying-the-global-productivity-puzzle-22041

[185] The Conference Board, 'Global Productivity Slowdown Moderated in 2013–2014 May See Better Performance', 2014 Productivity Brief—Key Findings, accessed March 27, 2014, http://static.tijd.be/upload/global_productivity-269819.pdf

[186] OECD, 'Productivity and long-term growth: Policy challenges for the next 50 years', accessed March 28, 2014, http://www.oecd.org/eco/growth/lookingto2060.htm

[187] ABC News, 'Global competitiveness, government regulation and productivity growth: Where does Australia rank?' accessed May 7, 2014, http://www.abc.net.au/news/2014-04-09/competitiveness-regulation-productivity-where-australia-ranks/5359694

[188] Australian Government Department of Industry Innovation, Science, Research and Tertiary Education, Australian Innovation System Report 2012, accessed March 27, 2014, http://www.industry.gov.au/Science/Policy/AustralianInnovationSystemReport/AISReport2012.pdf

[189] FMD Group Pty Ltd, 'FMD Economic Snapshot', published February 2014, accessed March 24, 2014, http://www.fmd.com.au

[190] Trading Economics, 'United States GDP Growth Rate', accessed March 25, 2014, http://www.tradingeconomics.com/united-states/gdp-growth

[191] OECD, 'United States – Economic forecast summary (May 2014)', accessed March 28, 2014, http://www.oecd.org/eco/outlook/united-states-economic-forecast-summary.htm

[192] Economic Intelligence Unit, 'US growth outlook is continuing to improve', accessed March 28, 2014, http://gfs.eiu.com/Article.aspx?articleType=gef&articleId=200297204&secID=10, accessed 28/3/14.

[193] Trading Economics, 'Forecast Government Debt to GDP', accessed March 31, 2014, http://www.tradingeconomics.com/forecast/government-debt-to-gdp

[194] Purdy M, Li G and Light D, 'The view from China's productivity frontier', Accenture, accessed April 1, 2014, http://www.accenture.com/us-en/outlook/Pages/outlook-journal-2014-beyond-capital-and-labor-china-productivity-frontier.aspx

[195] Brooker R, NAB Federal Budget Presentation, May 14, 2014

[196] Bloomberg News, 'China Defaults Sow Property Cash Crunch Concern: Distressed Debt', accessed April 1, 2014, http://www.bloomberg.com/news/2014-03-30/china-defaults-sow-property-cash-crunch-concern-distressed-debt.html

[197] OECD, 'Japan – Economic forecast summary (May 2014), accessed March 27, 2014, http://www.oecd.org/eco/outlook/japan-economic-forecast-summary.htm

[198] Trading Economics, 'Japan GDP Growth Rate', accessed March 24, 2014, http://www.tradingeconomics.com/japan/gdp-growth

[199] Trading Economics, 'India GDP Growth Rate', accessed March 24, 2014, http://www.tradingeconomics.com/india/gdp-growth

[200] Nair R and Ranjan Mishra A, 'Moody's warns India on structure of government debt', last accessed May 20, 2014, http://www.livemint.com/Politics/3wFRVd6LgI3Tszyla54AKK/Moodys-warns-India-on-structure-of-government-debt.html

[201] Trading Economics, 'India Government Debt to GDP', accessed May 20, 2014, http://www.tradingeconomics.com/india/government-debt-to-gdp

[202] Trading Economics, Home Page, accessed March 24, 2014, http://www.tradingeconomics.com/

[203] The Economist, 'Taking Europe's pulse', accessed April 1, 2014, http://www.economist.com/blogs/graphicdetail/2014/05/european-economy-guide

[204] OECD, 'Spain – Economic forecast summary (May 2014)', accessed April 1, 2014, http://www.oecd.org/economy/spain-economic-forecast-summary.htm

[205] The Economist, 'Labour productivity', accessed February 19, 2013, http://www.economist.com/blogs/graphicdetail/2013/02/focus-3

[206] Trading Economics, 'Spain Productivity', accessed April 1, 2014, http://www.tradingeconomics.com/spain/productivity

[207] OECD, 'Sweden – Economic forecast summary (May 2014)', accessed April 1, 2014, http://www.oecd.org/economy/sweden-economic-forecast-summary.htm

[208] Government Offices of Sweden, 'Economic forecast July 2014', accessed April 1, 2014, http://www.government.se/sb/d/9513

[209] Trading Economics, 'Singapore | Economic Indicators', accessed April 25, 2014, http://www.tradingeconomics.com/singapore/indicators

[210] International Monetary Fund, 'World Economic Outlook Database', accessed April 1, 2014, http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/index.aspx

[211] Matthews C, 'Which Advanced Economy Has the Most Debt?' Time, accessed April 25, 2012, http://business.time.com/2012/05/23/which-advanced-economy-has-the-most-total-debt/slide/south-korea/

[212] The Economist, 'Grist to the Mill', accessed April 1, 2014, http://www.economist.com/blogs/americasview/2014/03/productivity-latin-america, 31 March 2014

[213] OECD, 'Brazil: Economic forecast summary (May 2014)', accessed March 28, 2014, http://www.oecd.org/eco/outlook/brazil-economic-forecast-summary.htm

[214] The Economist, 'Aspiring Africa', accessed March 24, 2014, http://www.economist.com/news/leaders/21572773-pride-africas-achievements-should-be-coupled-determination-make-even-faster

[215] Economic Intelligence Unit, 'China and Africa: a maturing relationship', accessed March 24, 2014, http://country.eiu.com/article.aspx?articleid=760356060&Country=China&topic=Economy&subtopic=Forecast&mkt_tok=3RkMMJWWfF9wsRoiuqrPZKXonjHpfsX96OUtXq%20g38431UFwdcjKPmjr1YcERMN0dvycMRAVFZI5nQIRD7I=

[216] The Economist, 'Gems from Jim', accessed March 24, 2014, http://www.economist.com/blogs/baobab/2013/04/africa%E2%80%99s-economic-prospects-0

[217] Knoema, 'World GDP Ranking 2014 | Data and Charts', accessed March 31, 2014, http://knoema.com/nwnfkne/gdp-ranking-2013-data-and-charts

[218] Commonwealth Bank of Australia, 'Global Markets Report, economics perspectives', published February 2013

[219] CommSec, 'Economic Insights', published March 5, 2014

[220] The Age, 'Strong GDP continues to lift $A', last modified March accessed March 31, 2014, http://www.theage.com.au/business/markets/currencies/strong-gdp-continues-to-lift-a-20140306-3486k.html?utm_source=outbrain&utm_medium=cpc&utm_campaign=outbrainamplify

[221] Trading Economics, 'Australia | Economic Forecasts |2014–2030 Outlook', accessed March 31, 2014, http://www.tradingeconomics.com/australia/forecast

[222] IHS, 'IHS Top 10 Economic Predictions for 2013', accessed April 17, 2014, http://www.ihs.com/info/ecc/a/economic-predictions-2013.aspx

[223] OECD, 'Australia – Economic forecast summary (May 2014)', accessed March 28, 2014, http://www.oecd.org/eco/outlook/australia-economic-forecast-summary.htm

[224] The Australian, 'Signs of productivity turning the corner', accessed April 1, 2014, http://www.theaustralian.com.au/business/opinion/signs-of-productivity-turning-the-corner/story-e6frg9qo-1226594291686

[225] ABC News, 'Does Australia have a revenue problem, as ACOSS chief executive Cassandra Goldie claims?', accessed May 20, 2014, http://www.abc.net.au/news/2014-05-08/does-australia-have-a-revenue-problem/5420474

[226] ABC News, 'Joe Hockey correct on Australia's debt, spending', accessed May 20, 2014, http://www.abc.net.au/news/2014-03-13/joe-hockey-correct-on-australia-debt-and-spending/5310736

[227] OECD, 'New Zealand – Economic forecast summary (May 2014)', accessed April 1, 2014, http://www.oecd.org/eco/surveys/new-zealand-2013.htm ,

[228] New Zealand Treasury, 'New Zealand Economic Outlook', accessed April 1, 2014, http://www.treasury.govt.nz/budget/forecasts/befu2013/006.htm

[229] Trading Economics, 'New Zealand Government Debt to GDP', accessed June 23, 2014, http://www.tradingeconomics.com/new-zealand/government-debt-to-gdp

[230] Withers T, 'N.Z. Raises Key Rate to Become First Developed Nation to Tighten', Bloomberg News, accessed April 1, 2014, http://www.bloomberg.com/news/2014-03-12/n-z-raises-key-rate-to-become-first-developed-nation-to-tighten.html

[231] Trading Economics, 'New Zealand GDP Growth Rate', accessed April 1, 2014, http://www.trading economics.com/new-zealand/gdp-growth

[232] MarketWatch, 'New Zealand business confidence dips slightly', accessed March 31, 2014, http://www.marketwatch.com/story/new-zealand-business-confidence-dips-slightly-2014-03-31?link=MW_story_latest_news

APPENDIX A

LIST OF NAVIGATION AND GLOBAL POSITIONING SATELLITES AS OF 31 JANUARY 2014 [10]

NORAD Number	Name of Satellite, Alternate Names	Country of Operator/ Owner	Operator/Owner	Date of Launch
39199	IRNSS-1A (Indian Regional Navigation Satellite System)	India	Indian Space Research Organization (ISRO)	1/07/2013
37158	QZS-1 (Quazi-Zenith Satellite System, Michibiki)	Japan	Japan Aerospace Exploration Agency (JAXA)	11/09/2010
27436	Parus 93 (Cosmos 2389)	Russia	Ministry of Defense	28/05/2002
27818	Parus 94 (Cosmos 2398)	Russia	Ministry of Defense	4/06/2003
25590	Parus-90 (Cosmos 2361)	Russia	Ministry of Defense	24/12/1998
25892	Parus-91 (Cosmos 2366)	Russia	Ministry of Defense	26/08/1999
26818	Parus-92 (Cosmos 2378)	Russia	Ministry of Defense	8/06/2001
28380	Parus-95 (Cosmos 2407)	Russia	Ministry of Defense	22/07/2004
28521	Parus-96 (Cosmos 2414)	Russia	Ministry of Defense	20/01/2005
32052	Parus-97 (Cosmos 2429)	Russia	Ministry of Defense	11/09/2007
35635	Parus-98 (Cosmos 2454)	Russia	Ministry of Defense	21/07/2009
36519	Parus-99 (Cosmos 2463)	Russia	Ministry of Defense	27/04/2010
36287	Compass G-1 (Beidou G1)	China (PR)	Chinese Defense Ministry	16/01/2010
37948	Compass G-10 (Beidou ISGO-5)	China (PR)	Chinese Defense Ministry	1/12/2011
38091	Compass G-11 (Beidou G5)	China (PR)	Chinese Defense Ministry	24/02/2012
36590	Compass G-3 (Beidou G3)	China (PR)	Chinese Defense Ministry	2/06/2010
37210	Compass G-4 (Beidou G4)	China (PR)	Chinese Defense Ministry	31/10/2010
36828	Compass G-5 (Beidou IGSO-1)	China (PR)	Chinese Defense Ministry	31/07/2010
38953	Compass G-6 (Beidou 2-16)	China (PR)	Chinese Defense Ministry	25/10/2012
37256	Compass G-7 (Beidou IGSO-2)	China (PR)	Chinese Defense Ministry	17/12/2010
37384	Compass G-8 (Beidou IGSO-3)	China (PR)	Chinese Defense Ministry	9/04/2011
37763	Compass G-9 (Beidou ISGO-4)	China (PR)	Chinese Defense Ministry	26/07/2011
31115	Compass M1 (Beidou M1)	China (PR)	Chinese Defense Ministry	14/04/2007
38250	Compass M3 (Beidou 2-12)	China (PR)	Chinese Defense Ministry	28/04/2012
38251	Compass M4 (Beidou 2-13)	China (PR)	Chinese Defense Ministry	28/04/2012
38774	Compass M5 (Beidou 2-14)	China (PR)	Chinese Defense Ministry	18/09/2012

38775	Compass M6 (Beidou 2-15)	China (PR)	Chinese Defense Ministry	18/09/2012
37847	Galileo IOV-1 FM2	ESA	European Space Agency	21/10/2011
37846	Galileo IOV-1 PFM	ESA	European Space Agency	21/10/2011
38857	Galileo IOV-2 FM3	ESA	European Space Agency	12/10/2012
38858	Galileo IOV-2 FM4	ESA	European Space Agency	12/10/2012
37372	Glonass 701 (Glonass-K, Cosmos 2471)	Russia	Ministry of Defense	26/02/2011
28509	Glonass 712 (Glonass M, Cosmos 2413)	Russia	Ministry of Defense	26/12/2004
28915	Glonass 714 (Cosmos 2419)	Russia	Ministry of Defense	25/12/2005
29672	Glonass 715 (Glonass 35-1, Cosmos 2424)	Russia	Ministry of Defense	25/12/2006
29670	Glonass 716 (Glonass 35-2, Cosmos 2425)	Russia	Ministry of Defense	25/12/2006
29671	Glonass 717 (Glonass 35-3, Cosmos 2426)	Russia	Ministry of Defense	25/12/2006
32276	Glonass 719 (Glonass 36-2, Cosmos 2432)	Russia	Ministry of Defense	26/10/2007
32275	Glonass 720 (Glonass 36-3, Cosmos 2433)	Russia	Ministry of Defense	26/10/2007
32393	Glonass 721 (Glonass 37-1, Cosmos 2434)	Russia	Ministry of Defense	25/12/2007
32394	Glonass 722 (Glonass 37-2, Cosmos 2435)	Russia	Ministry of Defense	25/12/2007
32395	Glonass 723 (Glonass 37-3, Cosmos 2436)	Russia	Ministry of Defense	25/12/2007
33378	Glonass 724 (Glonass 38-1, Cosmos 2442)	Russia	Ministry of Defense	25/09/2008
33379	Glonass 725 (Glonass 38-2, Cosmos 2443)	Russia	Ministry of Defense	25/09/2008
33380	Glonass 726 (Glonass 38-3, Cosmos 2444)	Russia	Ministry of Defense	25/09/2008
33466	Glonass 727 (Glonass 39-1, Cosmos 2447)	Russia	Ministry of Defense	25/12/2008
33467	Glonass 729 (Glonass 39-3, Cosmos 2449)	Russia	Ministry of Defense	25/12/2008
36111	Glonass 730 (Glonass 41-1, Cosmos 2456)	Russia	Ministry of Defense	14/12/2009
36400	Glonass 731 (Glonass 42-1, Cosmos 2459)	Russia	Ministry of Defense	1/03/2010
36402	Glonass 732 (Glonass 42-3, Cosmos 2460)	Russia	Ministry of Defense	1/03/2010

36112	Glonass 733 (Glonass 41-2, Cosmos 2457)	Russia	Ministry of Defense	14/12/2009
36113	Glonass 734 (Glonass 41-3, Cosmos 2458)	Russia	Ministry of Defense	14/12/2009
36401	Glonass 735 (Glonass 42-2, Cosmos 2461)	Russia	Ministry of Defense	1/03/2010
37139	Glonass 736 (Glonass 43-1, Cosmos 2464)	Russia	Ministry of Defense	2/09/2010
37138	Glonass 737 (Glonass 43-2, Cosmos 2465)	Russia	Ministry of Defense	2/09/2010
37137	Glonass 738 (Glonass 43-3, Cosmos 2466)	Russia	Ministry of Defense	2/09/2010
37829	Glonass 742 (Glonass-M, Cosmos 2474)	Russia	Ministry of Defense	2/10/2011
37867	Glonass 743 (Glonass 44-2, Cosmos 2476)	Russia	Ministry of Defense	4/11/2011
37868	Glonass 744 (Glonass 44-3, Cosmos 2477)	Russia	Ministry of Defense	4/11/2011
37869	Glonass 745 (Glonass 44-1, Cosmos 2475)	Russia	Ministry of Defense	4/11/2011
37938	Glonass 746 (Glonass-M, Cosmos 2478)	Russia	Ministry of Defense	27/11/2011
39155	Glonass 747 (Glonass-M, Cosmos 2485)	Russia	Ministry of Defense	26/04/2013
20959	Navstar GPS II-10 (Navstar SVN 23, PRN 32, USA 66)	USA	DoD/US Air Force	26/11/1990
22014	Navstar GPS II-14 (Navstar SVN 26, PRN 26, USA 83)	USA	DoD/US Air Force	7/07/1992
22700	Navstar GPS II-21 (Navstar SVN 39, PRN 09, USA 92)	USA	DoD/US Air Force	26/06/1993
22877	Navstar GPS II-23 (Navstar SVN 34, PRN 04, USA 96)	USA	DoD/US Air Force	26/10/1993
23027	Navstar GPS II-24 (Navstar SVN 36, PRN 06, USA 100)	USA	DoD/US Air Force	10/03/1994
23833	Navstar GPS II-25 (Navstar SVN 33, PRN 03, USA 117)	USA	DoD/US Air Force	28/03/1996
23953	Navstar GPS II-26 (Navstar SVN 40, PRN 10, USA 126)	USA	DoD/US Air Force	16/07/1996
25030	Navstar GPS II-28 (Navstar SVN 38, PRN 08, USA 135)	USA	DoD/US Air Force	6/11/1997
22779	Navstar GPS II-35 (Navstar SVN 35, PRN 30, USA 94)	USA	DoD/US Air Force	30/08/1993
36585	Navstar GPS IIF-1 (Navstar SVN 62, PRN 25, USA 213)	USA	DoD/US Air Force	28/05/2010

37753	Navstar GPS IIF-2 (Navstar SVN 63, PRN 01, USA 232)	USA	DoD/US Air Force	16/07/2011
38833	Navstar GPS IIF-3 (Navstar SVN 65, USA 239)	USA	DoD/US Air Force	4/10/2012
39166	Navstar GPS IIF-4 (Navstar SVN 66, USA 242)	USA	DoD/US Air Force	15/05/2013
28129	Navstar GPS IIR-10 (Navstar SVN 47, PRN 22, USA 175)	USA	DoD/US Air Force	21/12/2003
28190	Navstar GPS IIR-11 (Navstar SVN 59, PRN 19, USA 177)	USA	DoD/US Air Force	20/03/2004
28361	Navstar GPS IIR-12 (Navstar SVN 60, PRN 23, USA 178)	USA	DoD/US Air Force	23/06/2004
28474	Navstar GPS IIR-13 (Navstar SVN 61, PRN 02, USA 180)	USA	DoD/US Air Force	6/11/2004
24876	Navstar GPS IIR-2 (Navstar SVN 43, PRN 13, USA 132)	USA	DoD/US Air Force	23/07/1997
25933	Navstar GPS IIR-3 (Navstar SVN 46, PRN 11, USA 145)	USA	DoD/US Air Force	7/10/1999
26360	Navstar GPS IIR-4 (Navstar SVN 51, PRN 20, USA 150)	USA	DoD/US Air Force	11/05/2000
26407	Navstar GPS IIR-5 (Navstar SVN 44, PRN 28, USA 151)	USA	DoD/US Air Force	16/07/2000
26605	Navstar GPS IIR-6 (Navstar SVN 41, PRN 14, USA 154)	USA	DoD/US Air Force	10/11/2000
26690	Navstar GPS IIR-7 (Navstar SVN 54, PRN 18, USA 156)	USA	DoD/US Air Force	30/01/2001
27663	Navstar GPS IIR-8 (Navstar SVN 56, PRN 16, USA 166)	USA	DoD/US Air Force	29/01/2003
27704	Navstar GPS IIR-9 (Navstar SVN 45, PRN 21, USA 168)	USA	DoD/US Air Force	31/03/2003
28874	Navstar GPS IIR-M-1 (Navstar SVN 53, PRN 17, USA 183)	USA	DoD/US Air Force	26/09/2005
29486	Navstar GPS IIR-M-2 (Navstar SVN 52, PRN 31, USA 190)	USA	DoD/US Air Force	25/09/2006
29601	Navstar GPS IIR-M-3 (Navstar SVN 58, PRN 12, USA 192)	USA	DoD/US Air Force	17/11/2006
32260	Navstar GPS IIR-M-4 (Navstar SVN 55, PRN 15, USA 196)	USA	DoD/US Air Force	17/10/2007
32384	Navstar GPS IIR-M-5 (Navstar SVN 57, PRN 29, USA 199)	USA	DoD/US Air Force	20/12/2007
32711	Navstar GPS IIR-M-6 (Navstar SVN 48, PRN 07, USA 201)	USA	DoD/US Air Force	15/03/2008
35752	Navstar GPS IIR-M-8 (Navstar SVN 50, PRN 05, USA 206)	USA	DoD/US Air Force	17/08/2009

LIST OF SATELLITES IN THE CATEGORIES: EARTH OBSERVATION, EARTH SCIENCE, METEOROLOGY, RECONNAISSANCE, REMOTE SENSING AND SURVEILLANCE AS AT 31 JANUARY 2014 [10]

NORAD Number	Name of Satellite, Alternate Names	Country of Operator/Owner	Operator/Owner	Date of Launch
36798	Alsat-2A (Algeria Satellite 2A)	Algeria	Centre National des Techniques Spatiales (CNTS)	12/07/2010
37673	SAC-D (Satellite for Scientific Applications)	Argentina/ USA	National Space of Activities Commission - Argentina/NASA	10/06/2011
32382	Radarsat-2	Canada	Radarsat International	14/12/2007
38011	SSOT (Sistema Satelital para la Observación de la Tierra)	Chile	Chilean Air Force	17/12/2011
28890	BeijinGalaxy-1 (Beijing 1 [Tsinghua], Tsinghau-2, China DMC+4)	China (PR)	Beijing Landview Mapping Information Technology Co. Ltd (BLMIT)	27/10/2005
33434	Chuangxin 1-2 (Innovation 1-2)	China (PR)	Chinese Academy of Sciences	5/11/2008
37930	Chuangxin 1-3 (Innovation 1-3)	China (PR)	Chinese Academy of Sciences	20/11/2011
36985	Tianhui 1-01	China (PR)	China Aerospace Science and Technology Corporation (CASTC)	24/08/2010
38256	Tianhui 1-02	China (PR)	China Aerospace Science and Technology Corporation (CASTC)	6/05/2012
38038	Ziyuan 1-02C	China (PR)	China Centre for Resources Satellite Data and Application (CRESDA)	22/12/2011
38046	Ziyuan 3 (ZY-3)	China (PR)	China Centre for Resources Satellite Data and Application (CRESDA)	9/01/2012
36508	Cryosat-2	ESA	European Space Agency (ESA)	8/04/2010
39159	Proba V (Project for On-Board Autonomy)	ESA	European Space Agency (ESA)	7/05/2013
36036	SMOS (Soil Moisture and Ocean Salinity satellite)	ESA	Centre National d'Etudes Spatiales (CNES)/European Space Agency	2/11/2009

39019	Pléiades HR1B	France	Ministry of Defense/Centre National d'Etudes Spatiales (CNES) - cooperation with Austria, Belgium, Spain, Sweden	2/12/2012
27421	Spot 5 (Système Probatoire d'Observation de la Terre)	France	Spot Image	4/05/2002
38755	Spot 6 (Système Probatoire d'Observation de la Terre)	France/ Belgium/ Sweden	Spot Image	9/09/2012
38012	Pléiades HR1A	France/Italy	Ministry of Defense/Centre National d'Etudes Spatiales (CNES) - cooperation with Austria, Belgium, Spain, Sweden	17/12/2011
33314	RapidEye-1 (RapidEye-C)	Germany	RapidEye AG	29/08/2008
33312	RapidEye-2 (RapidEye A)	Germany	RapidEye AG	29/08/2008
33315	RapidEye-3 (RapidEye D)	Germany	RapidEye AG	29/08/2008
33316	RapidEye-4 (RapidEye E)	Germany	RapidEye AG	29/08/2008
33313	RapidEye-5 (RapidEye B)	Germany	RapidEye AG	29/08/2008
36605	TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurement)	Germany	German Aerospace Center (DLR)/Astrium	21/06/2010
37839	Jugnu	India	Indian Institute of Technology Kanpur	12/10/2011
37387	Resourcesat 2	India	Indian Space Research Organization (ISRO)	20/04/2011
32376	COSMO-Skymed 2 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	9/12/2007
33412	COSMO-Skymed 3 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	25/10/2008
37216	COSMO-Skymed 4 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	6/11/2010
33493	Prism (Pico-satellite for Remote-sensing and Innovative Space Missions, Hitomi)	Japan	University of Tokyo	23/01/2009
39423	WNISat-1 Weather News Inc. Satellite 1)	Japan	Weathernews, Inc.	21/11/2013

25063	TRMM (Tropical Rainfall Measuring Mission)	Japan/USA	National Space Development Agency(NASA)/Japan Aerospace Exploration Agency (JAXA)	27/11/1997
37789	NigeriaSat-2	Nigeria	National Space Research and Development Agency (NASRDA)	17/08/2011
29228	Resurs-DK1 (Resurs - High Resolution 1)	Russia	TsSKB Progress (State Research & Production Space Rocket Center)	15/06/2006
39186	Resurs-P1	Russia	Russian Space Agency (RKA)/Ministry of Defense	25/06/2013
37389	X-Sat	Singapore	Centre for Research in Satellite Technology (CREST)	20/04/2011
38338	Kompsat-3 (Arirang 3, Korean Multipurpose Satellite-3)	South Korea	Korea Aerospace Research Institute (KARI)	17/05/2012
39227	Kompsat-5 (Arirang 5, Korean Multipurpose Satellite-4)	South Korea	Korea Aerospace Research Institute (KARI)	22/08/2013
35681	Deimos 1	Spain	Deimos Imaging/DMC International Imaging (DMCII)	29/07/2009
33396	THEOS (Thailand Earth Observation System)	Thailand	Geo-Informatics and Space Technology Development Agency (GISTDA)	1/10/2008
39030	Göktürk 2	Turkey	Turkish Ministry of National Defense	18/12/2012
37791	RASAT	Turkey	Space Technologies Research Institute	17/08/2011
35682	DubaiSat-1	UAE	Emirates Institution for Advanced Science & Technology (EIAST)	29/07/2009
39419	DubaiSat-2	UAE	Emirates Institution for Advanced Science & Technology (EIAST)	21/11/2013
37794	Sich 2	Ukraine	State Space Agency of Ukraine (NKAU)	17/08/2011
35683	UK-DMC-2 (BNSCSat-2, British National Science Center Satellite 2)	United Kingdom	UK/DMC International Imaging (DMCII)	29/07/2009
24920	FORTÉ (Fast On-orbit Recording of Transient Events)	USA	Los Alamos National Labs/ DOE	29/08/1997
26953	Quickbird 2	USA	DigitalGlobe Corporation	18/10/2001

32060	Worldview 1	USA	DigitalGlobe Corporation	18/09/2007
35946	Worldview 2	USA	DigitalGlobe Corporation	8/10/2009
27424	EOS-PM Aqua (Advanced Microwave Scanning Radiometer for EOS, EOS PM-1)	USA/ Japan/Brazil	NASA - Earth Science Enterprise/Japan Meteorological Agency/ Brazilian Space Agency	4/05/2002
39160	VNREDSat 1A (Vietnam Natural Resources Environment and Disaster monitoring small Satellite)	Vietnam	Space Technology Institute-Vietnam Academy of Science and Technology (STI-VAST)	7/05/2013
26620	SAC-C (Satellite for Scientific Applications)	Multinational	National Commission of Space Activities (CONAE) (with NASA, Denmark, Italy, Spain, France, Brazil)	21/11/2000
31118	Saudisat-3	Saudi Arabia	Riyadh Space Research Institute	17/04/2007
36744	COMS-1 (Communication, Ocean and Meteorological Satellite; Cheollian)	South Korea	Korea Aerospace Research Institute (KARI)	26/06/2010
26619	EO-1 (Earth Observing 1)	USA	NASA Earth Science Office	21/11/2000
29709	LAPAN-Tubsat	Indonesia	Indonesian National Aeronautics and Space Agency (Lembaga Penerbangan dan Antariksa Nasional - LAPAN)	10/01/2007
37790	Nigeriasat-X	Nigeria	National Space Research and Development Agency (NASRDA)	17/08/2011
38735	MiR (Mikhail Reshetnev [MiR], Yubileiny-2/RS-40)	Russia	Joint Stock Company-Information Satellite Systems	28/07/2012
29268	Kompsat-2 (Arirang 2, Korean planned Multipurpose Satellite-2)	South Korea	Korea Aerospace Research Institute (KARI)	28/07/2006
39265	Cassiope (CAScade SmallSat and Ionospheric Polar Explorer)	Canada	Canadian Space Agency	29/09/2013
29640	Fengyun 2D (FY-2D)	China (PR)	China Meteorological Administration	8/12/2006
33463	Fengyun 2E (FY-2E)	China (PR)	China Meteorological Administration	23/12/2008
38049	Fengyun 2F (FY-2F)	China (PR)	China Meteorological Administration	12/01/2012
32958	Fengyun 3A (FY-3A)	China (PR)	China Meteorological Administration	27/05/2008
37214	Fengyun 3B (FY-3B)	China (PR)	China Meteorological Administration	4/11/2010
39260	Fengyun 3C (FY-3C)	China (PR)	China Meteorological	23/09/2013

25635	Ørsted	Denmark	Administration Danish Meteorological Institute (DMI)	23/02/1999
39452	SWARM-A	ESA	European Space Agency (ESA)	22/11/2013
39451	SWARM-B	ESA	European Space Agency (ESA)	22/11/2013
59453	SWARM-C	ESA	European Space Agency (ESA)	22/11/2013
28498	PARASOL (Polarization and Anistropy of Reflectances for Atmospheric Science coupled with Observations from LIDAR)	France	Centre National d'Etudes Spatiales (CNES)	18/12/2004
29108	Calipso (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation)	France/USA	Centre National d'Etudes Spatiales (CNES)/NASA	28/04/2006
25757	DLR Tubsat	Germany	Deutsches Zentrum für Luft- und Raumfahrt	26/05/1999
27391	Grace 1 (Gravity Recovery and Climate Experiment, "Tom and Jerry")	Germany/USA	GeoForschungsZentrum (GFZ)/Center for Space Research, University of Texas	17/03/2002
27392	Grace 2 (Gravity Recovery and Climate Experiment, "Tom and Jerry")	Germany/USA	GeoForschungsZentrum (GFZ)/Center for Space Research, University of Texas	17/03/2002
37838	Megha-Tropiques	India/France	Indian Space Research Organization (ISRO)/Centre National d'Etudes Spatiales (CNES)	12/10/2011
39086	SARAL (Satellite with ARGOS and ALTIKA)	India/France	Indian Space Research Organization (ISRO)/Centre National d'Etudes Spatiales (CNES)	25/02/2013
33492	Greenhouse Gases Observing Satellite (Ibuki, GoSAT)	Japan	Japan Aerospace Exploration Agency (JAXA)	23/01/2009
31304	AIM (Aeronomy of Ice in Mesosphere)	USA	Center for Atmospheric Sciences, Hampton University/NASA	25/04/2007
29107	Cloudsat	USA	NASA/Colorado State University	28/04/2006
39395	Firefly	USA	NASA/Sienna College/ Univ. of Maryland	19/11/2013
25682	Landsat 7	USA	NASA/US Geological Survey	15/04/1999
39084	Landsat 8	USA	NASA/US Geological Survey	11/02/2013

38752	Van Allen Probe A (RBSP-A, Radiation Belt Storm Probes)	USA	NASA/Johns Hopkins University Applied Physics Laboratory	30/08/2012
38753	Van Allen Probe B (RBSP-B, Radiation Belt Storm Probes)	USA	NASA/Johns Hopkins University Applied Physics Laboratory	30/08/2012
25994	EOS-AM Terra	USA/ Canada/ (NASA) Japan	Earth Sciences Enterprise	18/12/1999
33105	Jason 2	USA/France	NASA/Centre National d'Etudes Spatiales (CNES) /NOAA/EUMETSAT	20/06/2008
38337	Global Change Observation Mission - 1 Water (GCOM-1, Shikuzu)	USA/Japan	Japan Aerospace Exploration Agency (JAXA)	17/05/2012
38552	Meteosat 10 (MSGalaxy-3, MSG 3)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	5/07/2012
24932	Meteosat 7 (MTP 1)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	2/09/1997
27509	Meteosat 8 (MSGalaxy-1, MSG-1)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	21/08/2002
28912	Meteosat 9 (MSGalaxy-2, MSG 2)	Multinational	EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	21/12/2005
29499	MetOp-A (Meteorological Operational satellite)	Multinational	ESA/EUMETSAT (European Organization for the Exploitation of Meteorological Satellites)	19/10/2006
38771	MetOp-B (Meteorological Operational satellite)	Multinational	ESA/EUMETSAT (European Organization for the Exploitation of Meterological Satellites)	17/09/2012
23533	DMSP 5D-2 F13 (Defense Meteorological Satellites Program, USA 109)	USA	DoD/NOAA	24/03/1995
24753	DMSP 5D-2 F14 (Defense Meteorological Satellites Program, USA 131)	USA	DoD/NOAA	4/04/1997
25991	DMSP 5D-3 F15 (Defense Meteorological Satellites Program, USA 147)	USA	DoD/NOAA	12/12/1999
28054	DMSP 5D-3 F16 (Defense Meteorological Satellites Program, USA 172)	USA	DoD/NOAA	18/10/2003

29522	DMSP 5D-3 F17 (Defense Meteorological Satellites Program, USA 191)	USA	DoD/NOAA	4/11/2006
35951	DMSP 5D-3 F18 (Defense Meteorological Satellites Program, USA 210)	USA	DoD/NOAA	18/10/2009
29155	GOES 13 (Geostationary Operational Environmental Satellite, GOES-N)	USA	NOAA (National Oceanographic and Atmospheric Administration)	24/05/2006
35491	GOES 14 (Geostationary Operational Environmental Satellite, GOES-O)	USA	NOAA (National Oceanographic and Atmospheric Administration)	27/06/2009
36411	GOES 15 (Geostationary Operational Ennvironmental Satellite, GOES-P)	USA	NOAA (National Oceanographic and Atmospheric Administration)	4/03/2010
25338	NOAA-15 (NOAA-K)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	13/05/1998
26536	NOAA-16 (NOAA-L)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	21/09/2000
37344	Electro-L1 (GOMS 2 [Geostationary Ioperational Meteorological Satellite 2]	Russia	Roshydromet - Planeta	20/01/2011
31113	Haiyang 1B (HY 1B, Ocean 1B)	China (PR)	State Oceanic Administration (SOA)	11/04/2007
37781	Haiyang 2A (HY 2A)	China (PR)	State Oceanic Administration (SOA)	15/08/2011
27714	INSAT 3A (Indian National Satellite)	India	Indian Space Research Organization (ISRO)	9/04/2003
39216	INSAT 3D (Indian National Satellite)	India	Indian Space Research Organization (ISRO)	25/07/2013
28937	MTSAT-2 (Multi-Functional Transport Satellite)	Japan	Japan Meteorological Agency/Meteorological Satellite Center (MSC)	18/02/2006
35865	Meteor-M (Meteor-M1)	Russia	Russian Federal Service For Hydrometeorology and Environmental Monitoring (ROSHYDROMET)	17/09/2009
28654	NOAA-18 (NOAA-N, COSPAS-SARSAT)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	20/05/2005

33591	NOAA-19 (NOAA-N Prime, COSPAS-SARSAT)	USA	National Oceanographic and Atmospheric Administration (NOAA) (part of international program)	6/02/2009
37849	NPP (National Polar-orbiting Operational Environmental Satellite System [NPOESS])	USA	National Oceanographic and Atmospheric Administration (NOAA)/NASA	28/10/2011
22490	SCD-1 (Satélite de Coleta de Dados)	Brazil	Instituto Nacional de Pesquisas Espaciais (INPE)	9/02/1993
25504	SCD-2 (Satélite de Coleta de Dados)	Brazil	Instituto Nacional de Pesquisas Espaciais (INPE)	23/10/1998
28622	MTSAT-1R (Himawari 6)	Japan	Japanese Ministry of Transport/Japan Meteorological Agency	26/02/2005
27525	Kalpana-1 (Metsat-1)	India	Indian Space Research Organization (ISRO)	12/09/2002
37179	Shijian 6G (SJ6-04A)	China (PR)	Chinese Academy of Space Technology (CAST)	6/10/2010
37180	Shijian 6H (SJ6_04B)	China (PR)	Chinese Academy of Space Technology (CAST)	6/10/2010
28470	Zhangguo Ziyuan 2C (ZY-2C, JB-3C)	China (PR)	Chinese Academy of Space Technology	4/11/2004
28492	Helios 2A	France/Italy/ Belgium/ Spain/ Greece	Centre National d'Etudes Spatiales (CNES)/ Délégation Générale de l'Armement (DGA)	18/12/2004
36124	Helios 2B	France/Italy/ Belgium/ Spain/ Greece	Centre National d'Etudes Spatiales (CNES)/ Délégation Générale de l'Armement (DGA)	18/12/2009
32476	TecSAR (Polaris)	Israel	Defense Ministry	21/01/2008
27698	IGS-1A (Information Gathering Satellite 1A)	Japan	Cabinet Satellite Intelligence Center (CSIC)	28/03/2003
29393	IGS-3A (Information Gathering Satellite 3A)	Japan	Cabinet Satellite Intelligence Center (CSIC)	11/09/2006
36104	IGS-5A (Information Gathering Satellite 5A, IGS Optical 3)	Japan	Cabinet Satellite Intelligence Center (CSIC)	28/11/2009
37813	IGS-6A (Information Gathering Satellite 6A, IGS Optical 4)	Japan	Cabinet Satellite Intelligence Center (CSIC)	23/09/2011
37954	IGS-7A (Information Gathering Satellite 7A, IGS Radar 3)	Japan	Cabinet Satellite Intelligence Center (CSIC)	12/12/2011

39061	IGS-8A (Information Gathering Satellite 8A, IGS Radar 4)	Japan	Cabinet Satellite Intelligence Center (CSIC)	27/01/2013
39062	IGS-8B (Information Gathering Satellite 8B, IGS Optical Demonstrator)	Japan	Cabinet Satellite Intelligence Center (CSIC)	27/01/2013
39194	Kondor	Russia	Ministry of Defense	27/06/2013
36095	Lotos-S (Cosmos 2455)	Russia	Ministry of Defense	20/11/2009
39177	Persona-2 (Cosmos 2486)	Russia	Ministry of Defense	7/06/2013
37162	FIA Radar 1 (Future Imagery Architecture (FIA) Radar 1, NROL-41, USA 215, Topaz)	USA	National Reconnaissance Office (NRO)	21/09/2010
38109	FIA Radar 2 (Future Imagery Architecture (FIA) Radar 2, NROL-25, USA 234, Topaz)	USA	National Reconnaissance Office (NRO)	3/04/2012
39462	FIA Radar 3 (Future Imagery Architecture (FIA) Radar 3, NROL-39 , USA 247, Topaz)	USA	National Reconnaissance Office (NRO)	6/12/2013
25744	Keyhole 3 (Advanced KH-11, KH-12-4, Advanced Keyhole, Misty-2, EIS-1, 8X Enhanced Imaging System, USA 144)	USA	National Reconnaissance Office (NRO)	22/05/1999
26934	Keyhole 4 (Advanced KH-11, Advanced Keyhole, Improved Crystal, EIS-2, 8X Enhanced Imaging System, NROL 14, USA 161)	USA	National Reconnaissance Office (NRO)	5/10/2001
28888	Keyhole 5 (Advanced KH-11, KH-12-5, Improved Crystal, EIS-3, USA 186)	USA	National Reconnaissance Office (NRO)	19/10/2005
37348	Keyhole 6 (NRO L49, Advanced KH-11, KH-12-6, Improved Crystal, USA 224)	USA	National Reconnaissance Office (NRO)	20/01/2011
39232	Keyhole 7 (NRO L65, Advanced KH-11, Improved Crystal, USA 245)	USA	National Reconnaissance Office (NRO)	28/08/2013
37728	ORS-1 (Operationally Responsive Space One, USA 231)	USA	U.S. Air Force/ DoD	30/06/2011
37168	SBSS-1 (Space Based Space Surveillance Satellite, SBSS Block 10 SV1, USA 216)	USA	Strategic Space Command/ Space Surveillance Network	26/09/2010
38708	BKA (BelKA 2)	Belarus	National Academy of Sciences	22/07/2012
39150	Gaofen 1	China (PR)	Shanghai Academy of Spaceflight Technology (SAST)	26/04/2013

33320	HJ-1A (Huan Jing 1A)	China (PR)	National Remote Sensing Center (NRSCC)	5/09/2008
33321	HJ-1B (Huan Jing 1B)	China (PR)	National Remote Sensing Center (NRSCC)	5/09/2008
38997	HJ-1C (Huan Jing 1C)	China (PR)	National Committee for Disaster Reduction and State Environmental Protection	18/11/2012
39262	Kuaizhou-1 (KZ-1)	China (PR)	National Academy of Sciences	25/09/2013
28220	Shiyan 1 (SY 1, Tansuo 1, Experimental Satellite 1)	China (PR)	Chinese Academy of Space Technology (CAST)	18/04/2004
36834	Yaogan 10 (Remote Sensing Satellite 10)	China (PR)	People's Liberation Army (C41)	9/08/2010
37165	Yaogan 11 (Remote Sensing Satellite 11)	China (PR)	People's Liberation Army (C41)	22/09/2010
37875	Yaogan 12 (Remote Sensing Satellite 12)	China (PR)	People's Liberation Army (C41)	9/11/2011
37941	Yaogan 13 (Remote Sensing Satellite 13)	China (PR)	People's Liberation Army (C41)	29/11/2011
38257	Yaogan 14 (Remote Sensing Satellite 14)	China (PR)	People's Liberation Army (C41)	10/05/2012
38354	Yaogan 15 (Remote Sensing Satellite 15)	China (PR)	People's Liberation Army (C41)	29/05/2012
39011	Yaogan 16A (Remote Sensing Satellite 16A, Yaogan Weixing 16)	China (PR)	People's Liberation Army (C41)	25/11/2012
39012	Yaogan 16B (Remote Sensing Satellite 16B)	China (PR)	People's Liberation Army (C41)	25/11/2012
39013	Yaogan 16C (Remote Sensing Satlelite 16C)	China (PR)	People's Liberation Army (C41)	25/11/2012
39239	Yaogan 17A (Remote Sensing Satellite 17A, Yaogan Weixing 17)	China (PR)	People's Liberation Army (C41)	1/09/2013
39240	Yaogan 17B (Remote Sensing Satellite 17B)	China (PR)	People's Liberation Army (C41)	1/09/2013
39241	Yaogan 17C (Remote Sensing Satellite 17C)	China (PR)	People's Liberation Army (C41)	1/09/2013
39363	Yaogan 18 (Remote Sensing Satellite 18)	China (PR)	People's Liberation Army (C41)	29/10/2013
39410	Yaogan 19 (Remote Sensing Satellite 19)	China (PR)	People's Liberation Army (C41)	20/11/2013
31490	Yaogan 2 (Remote Sensing Satellite 2, Jian Bing 5-2, JB 5-2)	China (PR)	People's Liberation Army (C41)	25/05/2007

32289	Yaogan 3 (Remote Sensing Satellite 3, Jian Bing 5-3, JB 5-3)	China (PR)	People's Liberation Army (C41)	11/11/2007
33446	Yaogan 4 (Remote Sensing Satellite 4)	China (PR)	People's Liberation Army (C41)	1/12/2008
33456	Yaogan 5 (Remote Sensing Satellite 5, JB 5-C, Jian Bing 5-C)	China (PR)	People's Liberation Army (C41)	15/12/2008
34839	Yaogan 6 (Remote Sensing Satellite 6, Jian Bing 7-A)	China (PR)	People's Liberation Army (C41)	22/04/2009
36110	Yaogan 7 (Remote Sensing Satellite 7)	China (PR)	People's Liberation Army (C41)	9/12/2009
36121	Yaogan 8 (Remote Sensing Satellite 8)	China (PR)	People's Liberation Army (C41)	15/12/2009
36413	Yaogan 9A (Remote Sensing Satellite 9A)	China (PR)	People's Liberation Army (C41)	5/03/2010
36414	Yaogan 9B (Remote Sensing Satellite 9B)	China (PR)	People's Liberation Army (C41)	5/03/2010
36415	Yaogan 9C (Remote Sensing Satellite 9C)	China (PR)	People's Liberation Army (C41)	5/03/2010
27550	Zhangguo Ziyuan 2B (ZY-2B, JB-3B)	China (PR)	Chinese Academy of Space Technology	27/10/2002
31698	TerraSAR-X 1 (Terra Synthetic Aperture Radar X-Band)	Germany	German Aerospace Center (DLR)/Infoterra	15/06/2007
28649	CartoSat 1 (IRS P5)	India	Indian Space Research Organization (ISRO)	5/05/2005
29710	CartoSat 2 (IRS P7, CartoSat 2AT)	India	Indian Space Research Organization (ISRO)	10/01/2007
32783	CartoSat 2A	India	Indian Space Research Organization (ISRO)	28/04/2008
36795	CartoSat 2B	India	Indian Space Research Organization (ISRO)	12/07/2010
32786	IMS 1 (Indian Mini-Satellite, TWSat)	India	Indian Space Research Organization (ISRO)	28/04/2008
28051	IRS-P6 (Resourcesat-1)	India	Indian Space Research Organization (ISRO)	17/10/2003
35931	Oceansat-2	India	Indian Space Research	23/09/2009
26631	EROS A1 (Earth Resources Observation Satellite)	Israel	ImageSat International, NV/Ministry of Defense	5/12/2000
29079	EROS B1 (Earth Resources Observation Satellite)	Israel	ImageSat International, NV/Ministry of Defense	25/04/2006
35578	RazakSat (MACSat)	Malaysia	Malaysian National Space Agency	14/07/2009

38707	Canopus-B (Kanopus Vulcan 1)	Russia	Scientific Production Corporation (joint stock creation of Russian Space Agency)	22/07/2012
28254	Formosat-2 (ROCSAT-2, Republic of China Satellite 2)	Taiwan	National Space Program Office (NSPO)	21/05/2004
29047	COSMIC-A (Formosat-3A, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29048	COSMIC-B (Formosat-3B, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29050	COSMIC-D (Formosat-3D, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29051	COSMIC-E (Formosat-3E, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
29052	COSMIC-F (Formosat-3F, Constellation Observing System for Meteorology, Ionosphere and Climate)	Taiwan/USA	National Space Program Office (NSPO)/University Corporation for Atmospheric Research (UCAR) Boulder, CO	15/04/2006
28376	EOS-CHEM Aura	USA	Goddard Space Flight Center/EOS Data and Operations System	15/07/2004
33331	GeoEye-1 (Orbview 5)	USA	GeoEye	6/09/2008
25919	Ikonos-2	USA	GeoEye	24/09/1999
39418	SkySat-1	USA	Skybox Imaging	21/11/2013
39386	STARE-B (Horus [Space-Based Telescopes for Actionable Refinement of Ephemeris])	USA	National Reconaissance Office	19/11/2013
38782	VRSS-1 (Venezuelan Remote Sensing Satellite, Francisco Miranda)	Venezuela	Bolivarian Agency for Space Activities	28/09/2012
38711	MKA-FKI-1 (Zond PP)	Russia	Lavochkin Research and Production Association (Lavochkin NPO)	22/07/2012
31598	COSMO-Skymed 1 (Constellation of small Satellites for Mediterranean basin Observation)	Italy	Italian Space Agency/ Ministry of Defense	8/06/2007
26957	TES (Technology Experiment Satellite)	India	Indian Space Research Organization	22/10/2001
27434	Ofeq 5	Israel	Ministry of Defense	28/05/2002

31601	Ofeq 7	Israel	Ministry of Defense	10/06/2007
36608	Ofeq 9	Israel	Ministry of Defense	22/06/2010
33433	Shiyan 3 (SY3, Experimental Satellite 3)	China (PR)	Chinese Academy of Space Technology (CAST)	5/11/2008
37931	Shiyan 4 (SY4, Experimental Satellite 4)	China (PR)	Chinese Academy of Space Technology (CAST)	20/11/2011
39455	Shiyan 5 (SY5, Experimental Satellite 5)	China (PR)	Chinese Academy of Space Technology (CAST)	25/11/2013
28371	Saudisat-2	Saudi Arabia	Riyadh Space Research Institute	29/06/2004
26959	Bird 2 (Bispectral InfraRed Detector 2)	Germany	Institute of Space Sensor Technology and Planetary Exploration	22/10/2001
27003	Badr 2 (Badr B)	Pakistan	Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)	10/12/2001
29658	SAR-Lupe 1	Germany	German Federal Armed Forces	19/12/2006
31797	SAR-Lupe 2	Germany	German Federal Armed Forces	2/07/2007
32283	SAR-Lupe 3	Germany	German Federal Armed Forces	1/11/2007
32750	SAR-Lupe 4	Germany	German Federal Armed Forces	27/03/2008
33244	SAR-Lupe 5	Germany	German Federal Armed Forces	22/07/2008
38248	RISat-1 (Radar Imaging Satellite 1)	India	Ministry of Defense	25/04/2012
34807	RISat-2 (Radar Imaging Satellite 2)	India	Ministry of Defense	20/04/2009
25017	Lacrosse/Onyx 3 (Lacrosse-3, USA 133)	USA	National Reconnaissance Office (NRO)	24/10/1997
26473	Lacrosse/Onyx 4 (Lacrosse-4, USA 152)	USA	National Reconnaissance Office (NRO)	17/08/2000
28646	Lacrosse/Onyx 5 (Lacrosse-5, NROL 16, USA 182)	USA	National Reconnaissance Office (NRO)	30/04/2005
23223	Mercury 1 (Advanced Vortex 1, USA 105)	USA	National Reconnaissance Office (NRO)/USAF	27/08/1994
23855	Mercury 2 (Advanced Vortex 2, USA 118)	USA	National Reconnaissance Office (NRO)/USAF	24/04/1996
28891	Topsat	United Kingdom	Ministry of Defence/British National Space Centre	27/10/2005