Future Cities

Trends and Implications

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Executive Summary

Future Cities

As the overwhelming bulk of human interaction shifts to cities, the priorities of decision makers will inevitably follow. Social, economic and political links between urban centres will continue to increase. This will extend the degree to which localised occurrences will impact other cities. As a result, the interests of state-level political actors will become increasingly invested in the affairs of cities, including those which are geographically distant. The potential for tactical actions to have strategic impacts is only made greater as cities become more important, connected and diverse, in terms of both demographics and actors.

- *As the future operating environment is going to be increasingly urbanised, the UK military must consider this environment as a primary driver of capabilities*
- *The military will likely have to change its roles and structure to reflect the growing prominence and changing nature of the urban environment. For example, the possibility of task organising a proportion of the UK military to be optimised for urban operations should be given strong consideration*
- *UK military should focus on developing a database on urban areas where operations may take place. As the bulk of future urbanisation will occur in Africa and Asia, particular focus should be paid to cities within these continents*

Dubai at sunrise

The Smart City

The utilisation of smart city technology will increasingly impact economic and social activity. The cultural context in which smart cities exist will affect how this technology is applied. Routine online usage will no longer be confined to computers and phones. Other devices will increasingly be interconnected to one another through the 'Internet of Things', and will make use of widespread and constant data collection to inform both machine processes and human decision making. This will generate opportunities and vulnerabilities for urban infrastructure. Both state and non-state actors, will have the capacity to disrupt interconnected online systems and the infrastructural processes which rely on them.

- *Smart City technology presents both opportunities and risks to UK military activities. These technologies allow unprecedented information collection and access opportunities; allowing pattern of life generation, identification and access to threat actors and wider population for influence, etc*
- *Adversaries can also exploit these technologies to employ against UK forces and allies. Understanding these vulnerabilities will be critical for operational success*
- *Increasing reliance on Smart technologies will alter what is classed as Critical Infrastructure (some of which may not even be located within the same state as the city of interest)*

Environment

The increasing importance of littoral urban areas will shape the actions of decision makers. These areas will serve as a focal point for increased travel and trade, while simultaneously increasing the impact of hostile action and extreme weather events. As the urbanisation process continues, pollution and waste production will increase, changing the physical environment within cities.

- *Increasingly littoral and globally connected cities will result in greater potential for international impacts from local activities in cities. Activities in one city may have a global 'knock-on' effect that can result in strategic pressure being placed on the UK*
- *Expanding cities may make it impossible to isolate or even by-pass urban areas*
- *Pollution level will pose significant hazards to UK personnel and the local populations (resulting in humanitarian crises), and they may even constrain UK military activities*

Infrastructure

To accommodate growing population densities, cities will continue to see a sharp increase in the amount of occupied vertical buildings, which will form the basis of many people's lives. Verticality will alter hierarchies and territorial boundaries. The desire to mitigate pollution and congestion will lead to increasingly controlled traffic management and in many cities, cycling and walking will be encouraged by physically constraining vehicular movements. Autonomous forms of transport will become more common, becoming part of the smart city infrastructure; likewise many other routine functions of cities will become automated.

- *Increasing verticality and the 'urban canyon' (as well as subterranean) will impose severe constraints on UK ISTAR, Fires and manoeuvre capabilities. Verticality also concentrates the population making them more accessible to both the UK and adversaries posing both opportunities and challenges*
- *Increasing traffic will likely overwhelm transport infrastructure and put severe constraints on urban manoeuvre capabilities. Alternative modes of transport and traffic management systems may alleviate some of these*
- *Climate change and expanding littoral cities will result in greater impacts from natural disasters and more demand for Humanitarian and Disaster Relief (HADR) operations. 'Floating cities' will be more prevalent and very difficult to manoeuvre in*
- *Infrastructure will be increasingly interconnected and vulnerable to cyber (as well as kinetic) attacks*

Demographics

Most cities will increasingly contain a uniquely amalgamated series of intersecting social and cultural networks. The individuals and groups that make up these networks have different outlooks and behaviours, shaped by their own socio-economic and cultural conditions. When these outlooks and behaviours cannot be balanced, conflict will likely emerge.

- *Increasing demographic diversity across global cities will make understanding the human terrain more complex. The diversity will also be concentrated within a relatively small geographical area. Extensive and diverse cultural understanding and language capabilities will be a critical requirement at even the most local level*

Actors

This urbanisation process will occur mainly in Africa and Asia, this will be a focal point for many decision makers. This will increase the impact of non-western concepts of legitimacy and governance, and will bring diverse and conflicting views of how a society should be governed into the same dense space. The political and social loyalties owed to non-state actors will become increasingly impactful and, in some instances, will merge with or replace the state's governance of urban areas.

- *The different forms of governance that the UK will have to interact with could be extensive. National, international, city, district, neighbourhood, street and even sections of a building potentially having their own 'legitimate' leaders, with varying authorities and conflicting roles*
- *The UK may conduct operations in a city at the behest of the host nation, yet find that the city's governance is not aligned with the host nation's ideals or policies. This could put the UK in a very difficult position*
- *The rise in private armed groups (inc. Private Military Companies (PMC)) may increase complexity, but also offer opportunities with PMCs being ideal for certain urban-specific security activities, thus reducing the burden on the UK military*

Toyko, Japan: With a metropolitan area population of over 40 million people, Tokyo is the most populous city in the world. Like many world cities this population rose rapidly, quadrupling since 1950

Preface

The following report has been conducted by the Defence Science and Technology Laboratory (Dstl) as part of the Future Threat Understanding and Disruption (FTUD) programme, on behalf of the MOD's Chief Scientific Advisor.

The FTUD programme assesses the potential impact on UK Defence and Security from emerging challenges raised across the spectrum of developing science, technology and cultural influence, including adversary postures towards threat, deployment, policy, ***changing and emergent environments*** and relevant social, legal and ethical opinion. This enables MOD and other stakeholders to manage or mitigate the risks that these future threats pose.

It is in the context of this highlighted section that this report was envisaged:

> *"For our Armed Forces, the urban environment will be one of the most challenging areas to operate in.* ***The city, and its surrounds, will become an increasingly complex and ambiguous tapestry of multiple actors with shifting allegiances, in which we may be required to operate in a variety of ways,*** *from major conflict at range to peace support and humanitarian operations."*

DCDC – Future Operating Environment 2035 p.25 (emphasis added)

There has therefore been a renewed push across the military to examine the uniquely challenging urban environment and how the UK military can best adapt to it. This has resulted in activities by Army HQ, Field Army and the Experimental Brigade to analyse specific activities or challenges within this environment, focused predominantly on the current challenges.

This work aims to bridge the gap between current urban operations doctrine (our present understanding of cities) with the endorsed future vision of DCDC's Future Operating Environment (2035) and Global Strategic Trends (2050). The output from this report will help the UK military to determine where there are significant challenges on the horizon; allowing examination of potential options to mitigate, or better prepare, for these circumstances before they are encountered in a conflict or humanitarian/disaster relief setting.

It builds upon previous work (within Dstl and outside) to understand the threats, constraints and opportunities posed by the environment (not just physical) within complex urban areas on future UK military operations. Firstly, it examines the high-level current and emerging trends in city development, agnostic of a military context. These focus on the following areas:

- Rapid Urbanisation and the Growth of Smart Cities
- The Physical Environment
- Infrastructure
- Demographics
- Actors

Following this phase, workshops were held with Subject Matter Experts (SMEs) from across defence, including Army HQ, the Land Warfare Centre, Air Warfare Centre, various staff officers from brigades and divisions. These individuals were briefed on the trends and asked to draw out military-specific implications. The implications identified by these SMEs were then collated into the military implications sections dispersed throughout this report.

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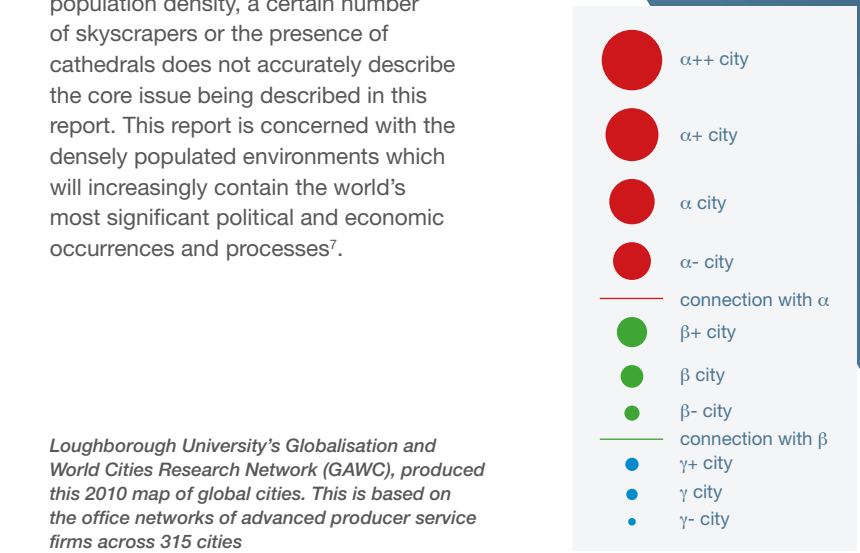
Introduction

The world is undergoing rapid urbanisation. A recent report by the United Nations Department of Economic and Social Affairs (UN DESA) estimates that 55% of the global population now live in urban areas. UN DESA predicts that by 2050 this figure will have risen to 68%[1]. This means that within the next 30 years the world's total urban population will have increased by 2.5 billion, growing from roughly four billion people to over **six and a half billion by 2050**[1]. The urban inhabitants of many countries currently consists of far more than 68% of their total population. For example, the urban populations of Australia and Kuwait respectively consist of more than 86% and 99% of their total populations (See appendix, page 187).

Cities will become increasingly connected with one another and disconnected from their immediate rural surroundings[2,3]. The spread of the Internet and increases in technology have made cities increasingly interconnected across different countries, regions and continents. The graphic opposite highlights this level of interconnectivity between cities around the world. Within the image cities are assigned an Alpha (red circle), Beta (green circle) or Gamma (blue circle) rating depending on their level of connectivity to other cities. London and New York have an Alpha ++ rating, indicating that they are the most interconnected. Internationalised city to city links are fundamental to the daily economic and social routines of the majority of the world's urban areas[4].

Roughly 90% of global population growth will occur in Africa and Asia and will be largely absorbed in cities, contributing to the International Committee of the Red Cross's assertion that 96% of urban growth will take place in 'developing' countries "in cities that already face fragility"[5]. Generally speaking, the 'developed world', constituting regions such as Europe and North America, is likely to see a continued influx of refugees and economic migrants as the global population rises disproportionately elsewhere. Much of the urbanisation process can be attributed to the 'pull factor' of urban wealth and 'push factors' such as conflict and resource scarcity[6].

This report does not subscribe to a fixed definition of urban areas. There are no universally agreed upon definitions of a city and measurements such as population density, a certain number of skyscrapers or the presence of cathedrals does not accurately describe the core issue being described in this report. This report is concerned with the densely populated environments which will increasingly contain the world's most significant political and economic occurrences and processes[7].



Loughborough University's Globalisation and World Cities Research Network (GAWC), produced this 2010 map of global cities. This is based on the office networks of advanced producer service firms across 315 cities

These increasingly complicated and often interconnected urban environments will be further affected by the growth of smart cities, as explored in Chapter 1 of this report. Smart cities refer to cities where urban infrastructure becomes increasingly connected to the Internet to the extent that it is able to work in tandem with the devices and tools around us which are also largely connected.

The interconnectivity this presents is designed to enable data sharing between devices, increasing the efficiency and the capability for the data-informed administration of cities[8,9]. This presents new opportunities for the inhabitants and administrators of cities to improve the processes and routines of urban life, yet also greatly enhances vulnerability to cyber-attacks[10,11,12].

Chapter 2 presents the environmental trends that will affect the fundamental nature of cities, most notably how littoral urban areas will become a point of growing interest to decision makers. Chapter 3 examines the infrastructure that will exist within and support future cities. Chapter 4 will assess how demographic changes will impact future cities and the opportunities and challenges that stem from this. Chapter 5 identifies how different actors determine the dynamics of the city.

As the core nucleus of human, social and economic activity continues to move to urban areas; the need to protect these areas and counter threats emerging amongst the networks of cities will become heightened[13,14]. Military tacticians will increasingly need to operate in the urban environment and therefore must gain an understanding of the dynamics of future urban areas[13,14]. This report highlights a number of military implications which are likely to arise as a result of the future city trends that have been identified.

Incheon, South Korea

Chapter 1

The Growth of Smart Cities

The Concept of the Smart City

The concept of the smart city is an evolving process in which cities aim to:

> *"[…] become more 'liveable' and resilient and, hence, able to respond more quickly to new challenges [as they] bring together hard infrastructure, social capital including local skills and community institutions and [digital] technologies to fuel sustainable economic development and provide an attractive environment for all"*[15].

Therefore, the 'smart' nature of cities should not be seen as a fixed end goal for cities to achieve, but as a guiding concept for how they could utilise technology and human capital to improve the efficiency of urban environments. A growing number of slum communities are sometimes considered to be 'smart', as they make increasing use of technology to respond to community challenges. Slums across Africa, Asia and Latin America are engaged in the *'Know Your City'* Campaign. Residents input data and information about where they live onto an online centralised database, which can be accessed by decision makers[16].

The underlying basis of a smart city is the increasing digitalisation of urban society; as a result of the application of increasingly technological solutions to urban challenges, such as strained infrastructure and climate change. The core of the smart cities concept is rooted in the expanding 'Internet of Things'; where everyday objects and devices become increasingly interconnected, both to other devices and the wider Internet, facilitating data sharing and utilisation of this data to improve processes and functions[17]. Technology company Cisco Systems predicts that 500 billion devices worldwide will be connected to the internet in 2030[18]. This is an increase from roughly 15 billion internet-connected devices in 2015, an increase of 475 billion devices. For this period Cisco reports that the number of such online devices is likely to double every year[18].

Many of the devices that are currently connected to the internet are household items and personal devices such as heating systems, mobile phones and wearable technology. In the future, these devices will be able to more accurately gather greater quantities of data, which will be increasingly accessed by governments and private companies. For example, wearable technologies currently monitor vital signs such as heart rate and track the number of calories individuals consume; largely for the purposes of fitness. In the future the use of such data could be used to send information to healthcare providers, allowing them to monitor patients without them having to come to a clinic or hospital and alerting them to any changes to the patient's health in real-time[19]. This could allow for more proactive healthcare, and potentially alleviate some pressure on the public health sector, as patients would not need to make the same number of appointments with their doctors.

Cities are increasingly connecting their public infrastructure such as water, waste management and transport services, to the 'Internet of Things' allowing for the collection of mass amounts of data to improve the running of these services and the experience of their citizens[20]. Barcelona is one of the leading smart cities, implementing a variety of smart technologies aimed at improving the functionality and sustainability of the city. Sensors have been put under the roads which can detect when parking spaces in multi-storey carparks are empty and direct drivers to them[21]. Also, the Barcelona Lighting Masterplan, published in 2012, is designed to reduce the energy consumption of the city. Sensors installed in the city's lampposts detect when there are no pedestrians around, allowing authorities to dim the light in order to reduce energy consumption, or to brighten them to attract people to public events. Barcelona's lampposts also constitute part of the Wi-Fi network, acting as modems which allow people improved access to the Internet[21,22].

The ‘Internet of Things’ will expand; aided by fifth generation mobile networks (5G), which aim to improve the speed and accessibility of mobile connectivity[23]. This is likely to increase the amount of data that will be gathered by public and personal devices. As a result the interconnectivity and functioning of services and processes across cities will improve. Currently, pre-existing infrastructure such as that in Barcelona is being modified in order to integrate it with the ‘Internet of Things’. In the future, smart technologies will be embedded into much urban infrastructure from the outset.

However, this increasing connectivity may also present some potential security challenges. Infrastructure and the organisational processes within buildings[24] (such as hospitals, schools, homes and commercial entities) will become increasingly reliant on a larger framework of electronic devices within the smart city environment[25]. This will present a series of nodes which may become points of vulnerability for hostile cyber-attacks. This would allow for wider infrastructure, including specific persons and buildings, to be targeted[26,27].

As these threats emerge, the degree of control a state has over buildings in the city will affect its ability to use and defend its infrastructure. Western states are likely to meet legal and political opposition, if they attempt to mandate certain cyber-security measures within domestic and commercial spheres.

Individual houses, resident associations or business owners will likely hire the services of cyber-security firms, specialising in the protection of ‘smart homes’ and other buildings which are connected to the ‘Internet of Things’. However, in some cases, private firms may be perceived as serving the interests of hostile actors.

For example Kaspersky Lab, a multinational cyber-security provider with its headquarters in Moscow, is widely used throughout the world to provide cyber-security and anti-virus software to individuals and businesses[28]. However the presence of Kaspersky Lab within the supply chain for cloud-based products, has led the UK Government’s National Cyber Security Centre to seek “verifiable measures to prevent the transfer of UK data to the Russian state”[29].

Military Implications

Renewed Joint Approach

The growing implementation of the smart city concept into urban infrastructure will increase demand for a joint approach to urban operations. This will present circumstances in which the military will likely be able to influence events within a city through cyber and information activities to a greater extent than it would with conventional kinetic activities.

The coordination of physical, virtual and cognitive effects will be critical to tactical and strategic success. The military must invest in developing a working understanding of how to best exploit these virtual effects and their second and third order effects, and how to integrate them with physical activities.

Engaging the Local Populace

Existing Smart city projects such as delivery or ride share apps, could be exploited by both the UK military, and its adversaries, to acquire knowledge of the operational environment and to gain an advantage in urban operations.

Digital footprints, left by engagement with smart city infrastructure and social media use, will become increasingly important in providing up to date information regarding an urban area’s population. This will likely be more accurate than population census data; as it is not collated frequently, or thoroughly enough, to represent the demography of rapidly changing urban environments.

Some actors may use such data to violate the rights of a specific ethnic or social group. Obscuring or falsifying this information may become necessary within the context of humanitarian intervention operations.

Many people use mobile applications to receive information about a specific city, use services and engage with the government. These and other smart technologies could be used to communicate widely with the local population, and give advice on accessing medicine and food.

continued over

Additionally, mobile applications could direct evacuees to the safest possible routes and muster points.

This capability may be critical in responding to outbreaks of serious contagious disease.

Exploitation of Smart Technology

Existing and emergent smart city technology has the potential to be used by the UK military to gain significant advantages in their operations within urban environments. Depending on the level to which smart city infrastructure is continuing to function during an urban operation, it's points of control and the data generated by it could be used to support a variety of activities, including:

- Rapid Intelligence, Surveillance and Reconnaissance (ISR) assessments of physical, social and digital infrastructure
- Targeting of adversaries with greater precision
- Improve distribution of aid

To make effective use of smart city infrastructure; the UK military needs to have the technical knowledge and ability to synergise with, and utilise, existing civilian systems. The military should look to pre-emptively recruit or contract specialists in these systems, to gain a working knowledge of how to best exploit digital infrastructure. The near-ubiquity of digital technology within physical infrastructure provides economic and military incentives to further invest in cyber-security.

Digital technology can also be exploited by the UK military and adversaries to influence the behaviour of individuals and groups within the city. As digital technology becomes a routine part of daily life, its manipulation could be used to encourage desirable behaviour. For example, smart traffic management systems could be manipulated to increase or decrease traffic in a given area. Messaging campaigns could innovatively exploit digital mediums for reaching a specific target audience, with or without attribution.

Real-Time Mapping

The exploitation of smart technology may permit the ability to map occurrences within a building in real-time; allowing effective collateral damage estimations, to better inform the most suitable form of kinetic strike, and assist in avoiding floors with high concentrations of non-combatants. Additionally, this capability may allow a kinetic strike to target a specific floor, or room, if it has particular troop concentrations.

British troops practicing urban defensive operations with partnered local forces: Skrunda, Latvia

Risks Presented to the UK Military by Smart Cities

Smart City infrastructure poses risks and opportunities for the UK military. If an adversary is able to efficiently control digital infrastructure and deny the UK military access, they will be able to utilise it to gain an advantage. The ability to digitally control this infrastructure, means that adversaries do not need to physically control an area of operations to have an effect.

Defence (as part of wider government) needs to be able to breach and exploit digital systems, limiting the information manoeuvre of adversaries whilst maintaining and enhancing their own. This could extend to advising cities (both domestically and internationally) how to draw up contingency plans, in the event that these system are manipulated by an adversary.

Critical Infrastructure

Within smart city environments, urban populations will become increasingly dependent on the continued functioning of key digital nodes. The disablement, or destruction, of these nodes will have ramifications for infrastructural processes. These nodes can fail as a result of a deliberate kinetic or cyber-attack, natural disaster, human error or simply as a result of system failure.

The failure of one infrastructural process, as a result of nodal failure, may result in a cascading effect in which further damage occurs to the broader city and urban environment. Some of the nodes upon which smart cities are, and will be, dependent on maybe located outside of the city itself. This will require a sustained assessment and evaluation of the health of potentially distant, yet vitally important, infrastructural systems and processes.

The reliance of smart cities on nodes located outside of the immediate area, could provide certain state, or non-state, actors with political leverage; as an important node could be in an area under the actors control or influence. Such nodes could be easily manipulated, or stopped, in order to obtain political concessions, a desired kinetic effect or economic outcome.

Identifying and understanding smart city nodes, their effects and the consequences of their disruption will be a critical requirement for conducting successful urban operations within smart cities. Within the context of smart cities the criteria for ‘critical infrastructure’ should be agnostic of physical location; as a vital node could be located locally, nationally or globally.

The devastation caused by the 2011 Japanese Tsunami

Chapter 2

Environment

Littoral Cities

Cities are often littoral, meaning they are located either on the coast or near it. This means that as urbanisation continues to occur, a growing portion of the world's population will come to inhabit such areas[30]. This allows people and commercial organisations to exist within close proximity to ports, enabling sea based trade[31]. However, they will have to deal with the increasing risks that are posed by issues of climate change. The National Aeronautics and Space Administration (NASA) estimate that if ocean levels continue to rise at the pace that they are currently, then "[…] sea levels will rise 26 inches (65 centimetres) by 2100, enough to cause significant problems for coastal cities"[32]. This will lead to an increase in both the number and impact of extreme weather events, such as flooding and tsunamis.

Port of Hong Kong

The World Bank states there are currently 136 port cities around the world with more than one million inhabitants, 38% of these being located in Asia[33]. As many of these Asian cities are also in deltaic locations, meaning they are at lower elevation levels, the impacts of climate change are likely to be more severe and far-reaching[34,35].

The benefits and consequences of being on the coast, present numerous security challenges. Cities and countries around the world are increasingly reliant on foreign ports, as the global economy becomes increasingly interconnected[36]. Based on estimates from the Office of National Statistics, as much as 50% of Dutch exports to the UK (totalling €40 billion) come from third countries, and have to pass through the Port of Rotterdam[37].

If cities become over reliant on their ports for importing goods, such as food, medicine and luxury items to their population (and exporting these to other countries to support their economy), then this may present multiple motivations for attacks upon port infrastructure, choke points and shipping routes of a city. Primary motivations will include reducing political stability and economic revenue of a city, by disrupting imports and exports, or to launch a physical attack on the city itself. Future cities need to consider how to manage these coastal access routes, to capitalise on the opportunities that these present, while simultaneously mitigating the risks that are posed[38,39,40,41,42].

Urban areas are increasingly developing infrastructure aimed at becoming more sustainable, reducing the production of emissions that lead to climate change[43]; mitigating against adverse effects when extreme weather events do occur[44].

Some responses to extreme weather events, such as flooding, largely occur without state control and tend to be facilitated by the population of the city itself. Slum populations may form stilted, water based communities, such as Makoko in Lagos. Makoko is a series of floating, informal villages totalling approximately 100,000 residents and headed by several chiefs, who control their own respective areas[45,46].

Similar slums have been built in South Asian cities as a result of flooding, where they are commonly known as Kampongs (roughly translated to mean compounds or villages). Traditionally this name referred to raised rural settlements, which were often stilted in order to raise the settlements above water on the ground[47].

Verticalisation offers some effective answers to natural disasters. However, the construction of high-rise buildings in flood zones in New York, have raised concerns that the wealthy may be housed within resilient locations, whilst the poor are forced to directly endure the hardships of natural disasters on the street level[48].

The overuse of underground water reserves can result in flooding. For example, much of coastally situated

Makoko, Lagos

Jakarta is sinking, with a reported 40% of Jakarta now below sea level. This has led to the Indonesian government to declare plans to move the capital away from the city, and towards a planned city on the central island of Borneo[35].

Moving from a reactive to a proactive approach to the threats posed by climate change; future cities will make better use of smart zoning practices. Critical public services that may be required in an adverse weather event, such as hospitals and transport links, are likely to be built away from areas in which they would be threatened in such a scenario[49,50].

The reliance of certain cities, and entire countries, on their ports for the import and export of goods produces vulnerabilities. This was seized upon by a Saudi-led coalition, which began an economic blockade of Qatar in 2017[38], to force a series of political concessions. Those demands included the closure of influential state-run media network Al-Jazeera, and the country to politically and economically align itself with the Gulf Co-operation Council[38]. Amongst other restrictions, the coalition banned Qatari ships from using UAE, Saudi, Bahraini and Egyptian ports[39].

This had a knock on effect, threatening the country's ability to import goods, as prior to the blockade Qatar was heavily reliant on re-exports. These were exported to nearby foreign ports in large container ships, then sent onto Qatar in medium sized ships, able to navigate the shallow waters around Doha Port. Following the blockade, this was not possible, and the country faced "disrupted trade in commodities from crude oil to metals and food"[41].

The restrictions on ports, and the closure of Qatar's land border with Saudi Arabia, led to empty supermarket shelves and caused those living in the country to stockpile food. The Qatari government built several warehouses, designed to house large quantities of food[42]. Concerns about port vulnerability were mitigated by the opening of Hamad Port, located in a deep water area, 26 miles south of Doha, enabling the entry of large container ships into the country[40].

Doha, Qatar

Conurbation and Satellite Cities

As cities expand into formerly rural areas to accommodate their growing population, the geographical distance between urban areas will decrease. For example, between 1990 and 2006, levels of urban sprawl in Rotterdam and Dordrecht (in the Netherlands) shrank the physical distance between the cities significantly, to the extent that the cities are effectively linked by an urban corridor[51]. This process can be clearly seen in the picture below. This massive conurbation stands out in stark contrast to almost every area of France outside of Paris. The level of urban sprawl in the UK is also clearly visible.

Additionally, smaller urban areas often emerge and expand into the outskirts of larger cities. These areas are called Satellite Cities, and can become substantial entities in their own right with distinct characteristics from the larger urban core[52]. Gurugram, a satellite city of Delhi, had a population of almost 900,000 at the time of the 2011 census[53], and has the third largest per capita income by city in India[54].

Connected Urban Areas

The importance of urban areas to the global economy means that many cities are, and will increasingly become, dependent on the wellbeing of each other and be impacted by geographically distant events[55]. For example, the 2010 eruption of Iceland's Eyjafjallajökull volcano, damaged the ability of Hong Kong's restaurants to serve dishes containing European produce[56]. Also, one of the initial causes of the uprising against Syrian President Bashar al-Assad, is thought to be the rising price of food in Syrian cities; partly caused by drought in Australia and an increased production of biofuels in North America[57].

These events are usually difficult to predict and therefore it is almost impossible to mitigate, or prevent, all harmful eventualities[58]. A Harvard business review article advising business executives on risk management advises "less than 0.1% of risky events will cause at least half your losses"[59]. Decision makers within cities will increasingly be forced to adopt measures seeking to limit the impact of disruptive events. Economists at HSBC have argued that Just in Time supply chains should be "fortified with "just-in-case" systems to limit the damage from disruptions"[60].

As well as the economic butterfly effect, events in one city may have a greater impact on cities in other countries and continents, than on towns and villages in the immediate vicinity. This is due to the frequency of social interactions between people who might otherwise not be aware of, or affected by, the phenomena[61] and international links that will be established among diaspora networks and online communities. Political groups can use online messaging tools in order to influence those living elsewhere. For example, Da'esh's social media cells were able to use social networking events to capitalise on feelings of alienation among second and third generation migrants living in Europe. This was used to encourage people to carry out and support terror attacks in their home country, or migrate to the territory occupied by the group[62,63]. Likewise, the presence of diaspora groups within a UK area of operations may result in unexpected political pressure being placed on the UK government, if a group is negatively impacted by military operations. This could be particularly impactful if the group's kinship network extends into the UK.

Global interconnectivity will encourage actors to become increasingly concerned with the events occurring in other cities. Such chain reactions will give rise to attempts to control events outside of one's traditional sphere of influence; and further incentivising city governments to attempt to cooperate with other cities on issues of mutual concern.

Military Implications

Importance of Port Security

A growing proportion of the global population lives in coastal urban areas. This emphasises the effective control, facilitation, and implementation of security in seaports will become increasingly important. The stringent control of seaports provides a means to reduce the ability of adversaries to supply their forces and carry out attacks, within such littoral urban environments.

Much of the distribution and attribution of goods will be defined by the interests and capabilities of whichever actor effectively controls the seaports. Within insecure urban areas, the security of ports will have to become a military priority, if the city is to continue to function.

Seaports can become financially unviable for shipping companies; if maritime insurance rates are forced to rise in response to disruptive attacks. Maritime insurance rates for ships visiting the port of Aden soared, following the terrorist attacks on the USS Cole in 2000 and the MV Limburg in 2002. These attacks, though two years apart, crippled the port economically and had far reaching ramifications for the wider area. The UK Government may need to direct more effort into maritime security, to prevent events which will cause maritime insurance rates to spike to unsustainable levels. Crucial port infrastructure must be considered as 'critical national infrastructure' and, as such, their security must be a priority for both Land and Maritime forces.

Increased Littoral Capability Requirement

The growing relative importance of littoral urban centres will alter the requirements imposed on training, equipment and operational planning. In particular this is likely to place an increased demand on naval forces, which would be tasked with providing an increased level of support to land operations. This may require a higher level of recruitment and retainment, in addition to a broader investment in littoral capabilities.

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Within the littoral urban environment, the UK military may need to utilise a wider range of vehicles, including those with amphibious and riverine specific capabilities. This would allow for manoeuvre within and around littoral, partly submerged and canal-based urban environments.

Tide movements will often define the ease of access to floating areas within cities, with existing examples in major cities like Jakarta and Lagos. Therefore when appropriate this should be factored into operational and tactical planning. The evident challenges facing UK Land Forces in conducting waterway warfare, is likely to incentivise adversaries to exploit the environment to gain an advantage.

Additionally, as climate change results in greater frequency of extreme weather events, coupled with an increasing global littoral population, more people will be at risk from these events. This will likely result in an increased demand for the UK to conduct Humanitarian Assistance and Disaster Relief operations. Urban flooding will similarly present a number of challenges, that forces should be trained to deal with, such as unknown submerged obstacles, and accessing unstable water-filled buildings.

(For more information see Chapter 3, Protecting the City)

Local Action – Global Effect

Urban conflict will vary in intensity across different parts of a city. Some cities may contain areas suffering from substantial armed violence, alongside other areas which are able to successfully position themselves as international tourist destinations or financial hubs. Cities in which the UK military are most likely to intervene are connected to a series of globalised commercial and social networks. As a result, military effects in an urban environment may have second and third order consequences, which are more strongly felt in geographically distant locations than in neighbouring districts.

In some instances, a city may be politically or economically dislocated from the host state. This could lead to tension and resistance from governance structures in the city, if the UK military has been deployed at the request of the national government of the country which is at odds with local characteristics. Therefore, when analysing a highly globalised urban environment, a perception of local, national and global social and commercial networks, must replace an isolated view of individual cities.

continued on page 28

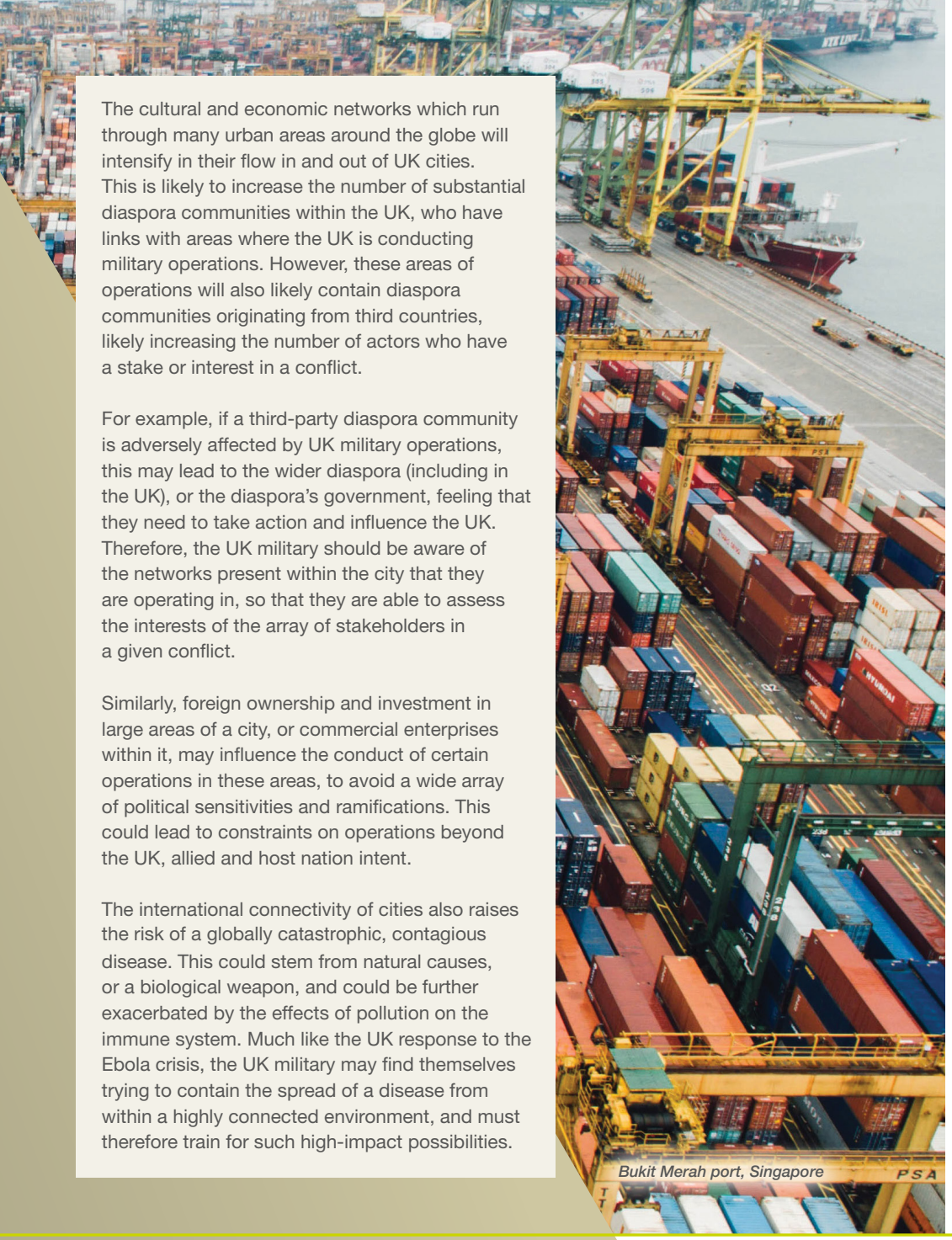
Royal Navy patrol monitoring oil infrastructure near Basra, Iraq. While the focus was on counter-insurgency in Basra city, the Royal Navy provided considerable resources to patrol shipping routes to the city, protect maritime infrastructure offshore and Royal Marines conducted riverine patrols around Basra

The cultural and economic networks which run through many urban areas around the globe will intensify in their flow in and out of UK cities. This is likely to increase the number of substantial diaspora communities within the UK, who have links with areas where the UK is conducting military operations. However, these areas of operations will also likely contain diaspora communities originating from third countries, likely increasing the number of actors who have a stake or interest in a conflict.

For example, if a third-party diaspora community is adversely affected by UK military operations, this may lead to the wider diaspora (including in the UK), or the diaspora's government, feeling that they need to take action and influence the UK. Therefore, the UK military should be aware of the networks present within the city that they are operating in, so that they are able to assess the interests of the array of stakeholders in a given conflict.

Similarly, foreign ownership and investment in large areas of a city, or commercial enterprises within it, may influence the conduct of certain operations in these areas, to avoid a wide array of political sensitivities and ramifications. This could lead to constraints on operations beyond the UK, allied and host nation intent.

The international connectivity of cities also raises the risk of a globally catastrophic, contagious disease. This could stem from natural causes, or a biological weapon, and could be further exacerbated by the effects of pollution on the immune system. Much like the UK response to the Ebola crisis, the UK military may find themselves trying to contain the spread of a disease from within a highly connected environment, and must therefore train for such high-impact possibilities.



Bukit Merah port, Singapore

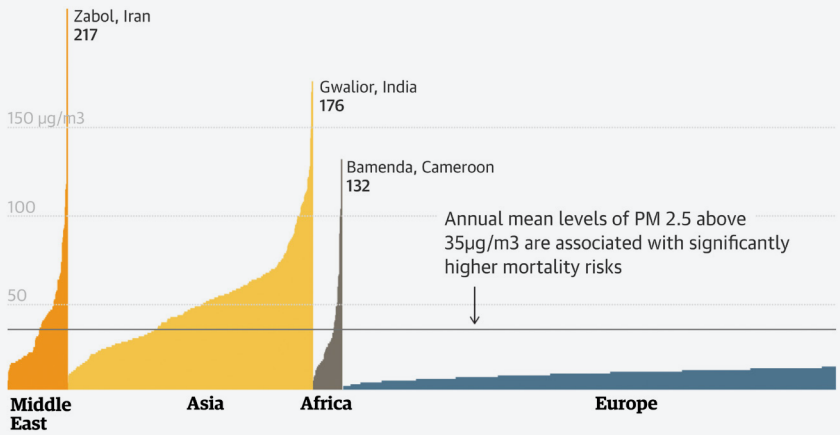
Air Pollution

As urban populations continue to grow, air pollution in cities is rising. The World Health Organisation's Global Ambient Air Quality Database reports that outdoor air pollution increased by 8% globally from 2011 to 2016[64]. High levels of air pollution are closely linked to severe health problems, such as heart disease and strokes, contributing to approximately 7 million premature deaths each year[65].

The areas which are currently the most affected, are cities in the 'developing world' which are amongst the fastest growing in terms of population and size. As can be seen in the diagram below, numerous cities in the Middle East, Sub-Saharan Africa and South Asia are currently experiencing air pollution levels that are 5-10 times higher than World Health Organization recommended levels[65].

Comparative image of Beijing on a day with high pollution below one with a better air quality

Annual mean of PM 2.5 in µg/m3 in each of the 3,000 cities



Air pollution: Delhi, India

As the population of these cities are set to grow rapidly in the future, requiring increasing infrastructure to support this growth, measures will need to be taken to counter the risks posed by high levels of air pollution. Governments and private companies are likely to attempt to use technology such as pollution detectors[66], and building materials able to perform air purification[67].

Other methods include weather modification through cloud seeding, which artificially induces rainfall to disperse smog. This has been used in several large cities including Seoul and Bangkok[68,69].

Processing Rubbish

A major environmental challenge presented by urbanisation, is the unmanaged flow of refuse. Inefficiently governed cities often struggle to facilitate the collection of waste, and as a result, poorer urban areas are often littered with large quantities of potentially toxic material. The World Bank predicts that, by 2050, the amount of waste generated per year is due to surge from 2.01 billion tonnes to 3.40 billion tonnes, an increase of 70%[70]. It should be noted that wealthier countries, including the United Kingdom, often relieve their own waste burden by selling large amounts of waste to South East Asian countries[71].

The poorest countries, such as Nepal and Zimbabwe, produce significantly less waste than what the World Bank classifies as Lower Middle income countries, such as India and Kenya. As the poorest countries develop economically, the amount of waste that they produce will likely increase[72,73].

Within some cities there are specific social groups that informally engage in waste removal[74]. Therefore attempts to formalise the waste economy can result in abrupt unemployment amongst a specific group. Cairo's Zabbaleen (translating from Egyptian Arabic to 'garbage people') are a group of Coptic Christians who, since the 1940s, have collected rubbish from Cairo and recycle it using a method that involves feeding organic waste (containing animal and plant matter) to pigs[75].

Driven by concerns regarding swine flu and the Islamic aversion to swine, the Egyptian government banned the community from handling waste in 2003 and employed multinational waste disposal companies[76]. This resulted in the Zabbalean community suffering from widespread unemployment and social alienation. The Zabbalean's role in waste collection was officially recognised in 2013, after residents of Cairo continued to pay them to unofficially collect the rubbish[76]. This was due to their dissatisfaction with the waste disposal companies, who asked them to carry waste to the bottom floor/street level of the city's apartment blocks, which residents of the city found to be a culturally unfamiliar practice[76].

Dandora, Kenya

It should be noted that some governments may deliberately alienate a community, by interrupting their economic interaction with urban waste. The Chinese government engages in a more deliberate alienation of waste collecting communities, by banning rural migrants from accessing Beijing's rubbish dumps to collect scrap[77]. The alleged purpose of this is to stem the flow of rural to urban migration[77].

Slum life: Jakarta, Indonesia

Military Implications

Operating in a Degraded Environment

The degradation of the natural environment will impact the ability of military personnel to perform their roles in urban areas. The UK Armed Forces will need to train personnel to operate in cities which have hazardous levels of air pollution, large quantities of poorly facilitated waste and limited access to water.

Impact of Degraded Environment on Force Personnel

Failure to protect vulnerable military personnel from environmental challenges, would increase demand on medical resources and present legal vulnerabilities for the Ministry of Defence, whilst decreasing combat efficiency. Therefore, personnel may require updated and brand-new personal protective equipment, that will better enable them to operate amongst conditions of environmental degradation. For example, breathing apparatus may need to be routinely used in order to prevent contamination from toxic chemicals and biological waste, avoid the spread of disease and operate in urban areas with dangerous levels of air pollution. However, such protective measures will need to be balanced with the increasing demand on personnel to carry heavier loads and the potential health and operational challenges that this may present.

Autonomous vehicles and drones could be used to reduce the exposure of humans to adverse conditions.

The deployment of UK military personnel to an environmentally degraded urban area, may have a negative effect on force morale, and increase rates of disease and non-battle related injury. This will likely mean that within degraded urban environments, personnel will have to do more frequent shorter rotations, to mitigate the negative mental and physical effects.

Clean air zones may be a way of mitigating some of the health risks

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posed to personnel. These could be created by reducing the amount of civilian motor vehicles allowed into an area of a city, or banning them altogether. This may allow the military to prioritise duty of care toward personnel, as well as benefit from having fewer civilians in a given area. However, this will need to be balanced against the consequences of any negative social and economic effects, resulting from the limitation of civilian freedom of movement.

Adversary Use of the Environment

Adversaries have, and will likely continue to exploit aspects of the environment against civilians and security forces. The urban context can enhance an adversary's ability to exploit the environment with weaponisation potentially including:

- Attacking infrastructure designed to alleviate waste and pollution problems. This may instigate epidemic diseases or result in slowly materialising or gradually noticeable illnesses
- Disrupting the production of food, medicine and other vital goods, or by disrupting the means by which they are accessed
- Creating or exacerbating water scarcity in order to fuel tensions e.g. disrupting/destroying water facilities
- Releasing dangerous chemicals into the environment. Chemical attacks may be carried out in densely populated indoor and underground spaces to maximise the impact
- Utilising cluttered surface space to hide weapons such as IEDs
- Exploiting heavy smog and its impact on ISTAR performance for covert manoeuvre

Mitigating or Removing Environmental Challenges

By mitigating or removing some environmental hazards, the UK military may be able to achieve a 'quick win' and endear themselves to the local population. This could be achieved by clearing smog or enhancing desalinisation facilitates. Global warming is inherently transnational (with effects and causes unconstrained by state borders), therefore the reduction of pollution and smog may have soft power value for the UK if carried out and communicated correctly.

Conversely, the UK military may come under increasing pressure from otherwise disinterested actors to do the least possible damage to the environment during operations.

Impact of Environmental Legislation

In the future, environmental legislation may restrict the institutional and operational practices of the UK military. In order to ensure compliance with any potential legislation, and respond effectively to any environmental challenges, there may be merit in employing environmental specialists to support operations in a similar manner to how legal and policy advisers are currently used.

The use of such advisors would facilitate capacity building, allowing UK forces to understand, respond to and control the environment. Furthermore, the UK Military may find themselves liable to address any environmental damage that occurs as a result of their operations; similar to the liability that currently follows kinetic activity.

Royal Marine Commandos during live firing training in the USA

Chapter 3

Infrastructure

Verticalisation

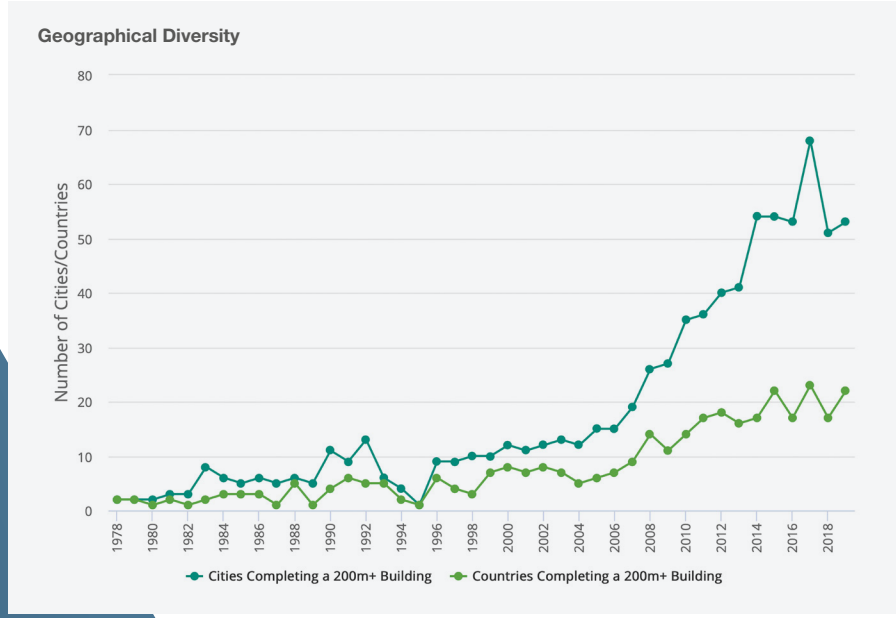
Within cities the spaces in which people work, reside, carry out social functions and interactions, will become increasingly vertical.

As an increasing number of people migrate to urban areas, there is a need to maximise the capacity of the urban space and accommodate growing populations. This will largely be achieved through urban sprawl (see page 23) and the continued vertical expansion of cities. Verticalisation has rapidly escalated in the last few years across a number of cities and countries worldwide as the graph below highlights[78].

Much of this can be attributed to the recent rapid verticalisation of Chinese cities*. Globally, 45% of the total numbers of buildings of 200 metres or higher (200m+) completed in 2019 were built in China. In 2018 this number was even higher, with 62% of completed 200m+ buildings being located within China[78].

However, verticalisation has also occurred substantially elsewhere. 53 cities across 22 countries completed the construction of at least one 200m+ tall building in 2019. In contrast, in 1980 only the United States built three 200m+ buildings, with two in Houston and one in Alanta[78]. The most 200m+ buildings were completed in 2017, when 147 buildings were completed. In 2018 this number fell to 143 and further in 2019 to 126[78]. The reduction in completed tall buildings is likely a long term ramification of the 2008 financial crisis, during which many emergent construction projects were cancelled[78].

** Including Hong Kong, but excluding Taiwan and Macau*



This graph shows the recent rapid increase in construction of 200m+ buildings and geographical breadth of the trend

Interestingly, although the total number of 200m+ buildings has dropped from previous years, 2019 was unprecedented in terms of buildings completed over a height of 300m. In 2019 there were 26 300m+ buildings completed, up from just 18 in 2018. The average height of 200m+ buildings in 2019 was 264m up from 246m in 2018[78].

The Council of Tall Buildings and Urban Habitats has estimated that by the end of 2020, between 115 and 145 200m+ buildings will have been finished. Therefore if the prediction for 2020 proves accurate, the total number of completed 200m+ buildings will number between 1,719 and 1,749, compared to 71 in 1980[79].

As alternative materials are produced and building techniques become easier and faster, vertical buildings are likely to appear in areas currently too fragile to ensure continued investment in such construction projects. This investment includes the planning permissions, materials, labour and expertise needed to construct a large vertical building.

Vertical buildings likely to become increasingly multi-purpose and mixed use. A building can be considered mixed-use, when it simultaneously contains both residential and commercial units[80] (see page 41). The emergence of mixed use buildings stems from an increasing need to efficiently make use of land, and to protect investors from economic shocks, by diversifying the income generated by activities within the building[81,82]. In 2010, 24 of the world's 100 tallest buildings were mixed use, by the end of 2019 this number had risen to 51[79].

Vanity Height

While tall buildings, such as the Burj Khalifa in Dubai (which is 829.8 metres tall)[83], are capable of housing a substantial amount of residents and commercial activities, they also serve a purpose in displaying political and economic prestige.

As a result, large areas of the building may be unoccupied in order to facilitate initial construction and subsequent maintenance. This space within a building is known as 'vanity height'[84]. Vanity height of the Burj Khalifa occupies 29% of the building, and 20% of The Shard in London[85]. In 2013, it was calculated that of all the skyscrapers (buildings of more than 40 storeys) in the United Arab Emirates, 19% was dedicated vanity space[86]. As cities compete with one another in order to attract political prestige, foreign investment and tourism, the presence of vanity height is likely to increase.

Therefore, the level of activity within vertical buildings does not directly correlate with the total physical height of the structure. This can also be attributed to the tendency for much of the space within prestigious skyscrapers to be unoccupied, functioning as a listing on an investment portfolio rather than as a functional space[87].

London, UK. The 95-storey tower known as The Shard. At over 309m, it is the sixth tallest building in Europe. It comprises 72 habitable floors and two separate viewing levels. In an indication of its status and international links, the 2012 opening was attended by both the Prime Minister of Qatar and HRH Prince Andrew.

Mixed Use Buildings

Buildings are becoming increasingly self-contained (see page 43). This means that the day to day routines of a building's residents could become regularly confined to a single building in which inhabitants can own an apartment, work in their office and exercise in the gym, without having to leave the building[80,88,89]. As a result, multi-use buildings will be constantly occupied, compared with single-use buildings which are typically occupied at set times.

The increase of mixed use buildings and the broader trend of mixing residential and commercial functions reflect current zoning trends. Previously, city planning would designate distinct commercial, residential and industrial districts.

However, vertical buildings and city districts themselves are increasingly containing working, living and leisure facilities within the same immediate space[89,90]. Many buildings also contain 'co-working areas', which seek to provide a pleasant environment for those working outside of their organisation's office. This can provide networking opportunities, as the inhabitants of the building can work alongside one another, despite not necessarily working for the same organisation[91].

Mixed use building: Ho Chi Minh City, Vietnam

Diurnal Trends

The emergence of mixed use areas and buildings will continue to affect the diurnal cycle of a city's population, and their physical movement throughout the day[92]. This results in a routine flux in regard to the use of buildings, streets and roads. For example, residential areas are, generally, characterised by having a lower population during the day and a higher population at night. Business and industrial districts tend to have a high population during the day, but maintain a relatively constant population as people work in their respective offices. This contrasts with shopping and entertainment areas, which have high populations at different times, but a much more transitory population as customers come and go.

Monitoring diurnal trends allows decision makers to predict the routine activity of the population, and to tailor their actions accordingly[93]. For example, road maintenance is often carried out at night in order to avoid inconveniencing the majority of road journeys; security and policing organisations routinely adjust their presence, to account for expected footfall[94].

With increases in mixed use areas and buildings, gaining an understanding of the diurnal population trends is more complicated. This has an impact on planning and security monitoring.

This cycle is also altered by technology, such as online dating applications like Tinder, which has reduced attendance to nightclubs[95,96,97]. The popularisation of working from home amongst employees and organisations, reduces the need for some workers to regularly commute to work, or ever travel to a specific office[98,99].

Height and Prestige

Businesses and residents often aspire to occupy the highest floors of apartment buildings; to obtain the prestige and security associated with physical height[100]. This creates an environment in which people measure their areas of exclusivity, and territorial demarcation, vertically[101]. Whilst this informs the pricing and marketing of vertical residential and commercial units, this hierarchy is also reflected in the housing of domestic inhabitants, or low paid service staff, in the immediate area around the tower; creating an informal housing structure and economy around the building. This can lead to tension and violence between the residents of the tower and the surrounding floor based communities, that economically interact with them[102].

This occurred in 2017, at the Mahagun Moderne complex on the outskirts of Delhi, in which the wealthy inhabitants of the complex were confronted by rioting families of the complex's domestic workers[102]. The social tensions, between vertically and hierarchically distinct communities, boiled over after a dispute between a maid and her employer, resulting in the poorer community breaking into the Mahagun Moderne, and ransacking the apartment of the maid's former employer. The workers and their families had established informal housing, and a community which created two socially and economically unequal communities, in close proximity to one another[102].

The DSTL-GUARD project identifies visible horizontal inequality, as a key source and predictor of conflict[103]. As social stratification takes on an increasingly vertical form, social tensions will increasingly stem from the mutual resentment of not only horizontally divided social groups, but also those who are physically vertically divided.

Central core of the 55-storey Ponte City Apartments: Johannesburg, South Africa

Military Implications

Verticality – General Implications

The military should explore multiple means of accessing high portions of buildings, as ladders and grappling hooks will be insufficient for many buildings, both now and in the future. A means of accessing the roof of high-rise buildings, in order to vertically envelop an adversary, will be critical, as per UK urban doctrine. Without such capabilities, an adversary can simply direct all defences at troops on lower floors.

The use of tall buildings as markers of prestige and identity, will result in growing political pressure to secure certain buildings; due to their cultural significance and importance to the overall strategic position of the city, despite the presence of otherwise more strategically and tactically important buildings.

The current understanding of distinct urban terrain zones may soon become outdated. The risks in a conflict, or disaster zone, of mixing residential and industrial zones can have catastrophic results with fire, explosions and Toxic Industrial Chemicals/Materials (TICs/TIMs).

Verticality and ISTAR

Increased verticality will significantly increase the constraints on traditional ISTAR (Intelligence, Surveillance, Target Acquisition, and Reconnaissance) and Joint Fires; by increasing the urban canyon effect and restricting line-of-sight. Methods to allow ISTAR assets to operate within the urban canyon will have to be developed.

However, the military could seek to exploit this verticality, by creating a network of 'vertical bases' (Forward Operating Bases on the tops of high-rise buildings) to provide better situational awareness, command and control, and rapid responses.

Verticality and Joint Fires

High angle Fires capabilities will be required, to ensure the ability to have effects within the urban canyon.

Vertical buildings will provide significant overhead cover to combatants (on all sides); allowing them to be sheltered from airstrikes and artillery, by numerous levels within the buildings. This will allow combatants to operate from an elevated position from street-level, while still being protected by the multitude of stories above them.

The increasing verticalisation of buildings, and urban density, will make it difficult to contain weapon effects within a single building or floor, enhancing the likelihood of collateral damage. The increasing trend for mixed use buildings and districts, containing apartments, offices and commercial units in close proximity, will heighten the risk of civilian causalities from a kinetic strike, regardless of the time of day.

Verticality and Air Assets

Verticality and the increasing urban canyon will put a greater premium on airspace management as ISTAR, Aviation, Close Air Support and C2 aircraft attempt to use the same airspace above the canyon. The ability to conduct activities within the urban canyon should be explored, e.g. troop/resupply transport helicopters that can land in streets.

Anti-air/aviation systems, such as man-portable air-defence systems (MANPADs), will be effectively used by adversaries; taking advantage of the concealment offered by the cluttered rooftops, and unconventionally shaped high rise buildings. Therefore, mitigations such as new TTPs or hard-kill defensive aid suites will have to be explored.

High-rise buildings are also known to produce micro-weather patterns, such as extreme winds and dramatically changing air pressures. The impact on air and aviation assets must be explored, and understood in order to allow such assets to continue to support military operations effectively.

Verticality and the Human Dimension

Social flashpoints can occur in a single building between floors as buildings may contain multiple different, social, ethnic and religious groups. Therefore, control of elevators and stairways between sections of a building will be of particular importance, as these may become public flashpoints. The military must consider how to conduct 'vertical public order' activities.

The large numbers of people that security forces will need to monitor and process within vertical buildings, means that it is possible for unauthorised people to pass by, including combatants. This can be mitigated by biometric recognition processes and software, as well as potential use of underground spaces, as a chokepoint to force city inhabitants to go through more rigorous security checks.

Building-to-building walkways will make navigation more complex, by obscuring the task of security access to and from buildings. However this will also allow UK forces more access points on higher levels, potentially increasing the effectiveness of security/combat operations.

The diurnal population movements we recognise today, will be altered as buildings become more self-contained. Establishing a relatively universal pattern of life within a given building, will become more difficult as a given space in a city may no longer simply be a business district, or residential area. Technology such as biometric tracking and control of access may make monitoring easier, but not all buildings will have this technology effectively or securely installed.

It will be much easier to isolate several thousand people in a single building, than it is to isolate the same number of people who are more spread out. The floors will also make it easier to isolate particular sections. To do this, UK forces will need to have the capability to control access points, such as front entrances, elevator systems and stairways of buildings.

The concentration of large numbers of people to a fixed vertical space will, in some circumstances, make evacuation simpler in a disaster response operation. Evacuating people from a single point may be significantly easier, and more efficient, than evacuating the same number of people from a large urban sprawl. However the greater mass of people will require a larger number of resources.

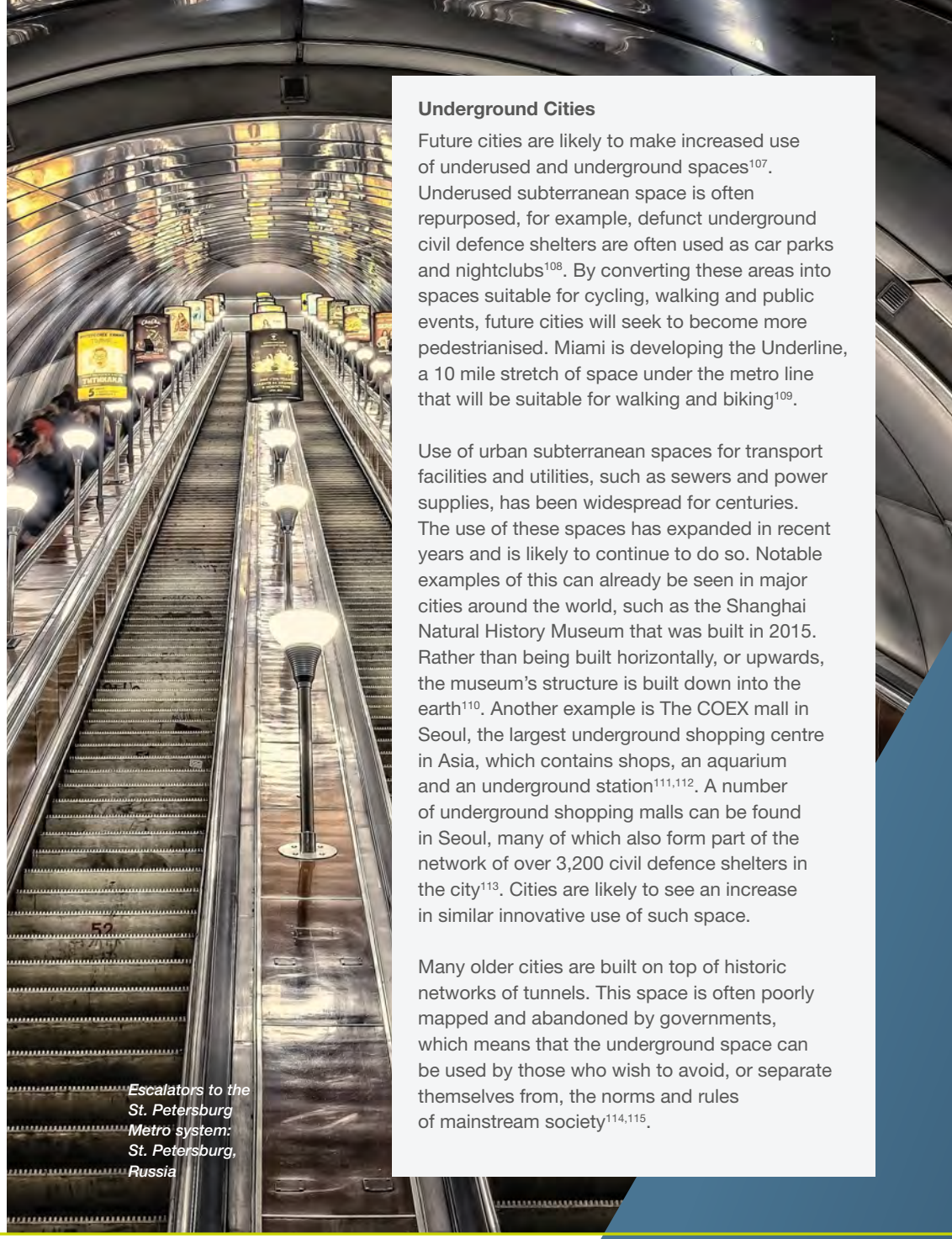
A Danish 3D printed building (walls and foundations): the first in Europe. Known as BOD (Building On Demand)

3D and 4D Printing

As many cities struggle to accommodate their growing populations, one solution to the demand for housing is 3D printing- "[…] a form of 'additive' manufacturing, where a three-dimensional object is "printed" (built) by adding layer after layer of a particular material"[104]. In 2016, the world's supposedly first functional and inhabited 3D printed building, was unveiled in Dubai. The Dubai Government has stated that it wants 25% of the city's buildings to be 3D printed by 2030[105]. The benefit of 3D printing for architecture is that it reduces both material and labour costs.

As 3D printing methods become more effective and cost efficient, this may be a way for governments to quickly build the necessary infrastructure for a growing number of inhabitants, while reducing the amount of informal housing and slums in urban areas.

In the future 4D printing will emerge, this will allow objects to be created from a wide variety of material that can reshape itself, or self-assemble, over time[106]. These items will range from car parts and building materials, to drugs and ammunition.



Escalators to the St. Petersburg Metro system: St. Petersburg, Russia

Underground Cities

Future cities are likely to make increased use of underused and underground spaces[107]. Underused subterranean space is often repurposed, for example, defunct underground civil defence shelters are often used as car parks and nightclubs[108]. By converting these areas into spaces suitable for cycling, walking and public events, future cities will seek to become more pedestrianised. Miami is developing the Underline, a 10 mile stretch of space under the metro line that will be suitable for walking and biking[109].

Use of urban subterranean spaces for transport facilities and utilities, such as sewers and power supplies, has been widespread for centuries. The use of these spaces has expanded in recent years and is likely to continue to do so. Notable examples of this can already be seen in major cities around the world, such as the Shanghai Natural History Museum that was built in 2015. Rather than being built horizontally, or upwards, the museum's structure is built down into the earth[110]. Another example is The COEX mall in Seoul, the largest underground shopping centre in Asia, which contains shops, an aquarium and an underground station[111,112]. A number of underground shopping malls can be found in Seoul, many of which also form part of the network of over 3,200 civil defence shelters in the city[113]. Cities are likely to see an increase in similar innovative use of such space.

Many older cities are built on top of historic networks of tunnels. This space is often poorly mapped and abandoned by governments, which means that the underground space can be used by those who wish to avoid, or separate themselves from, the norms and rules of mainstream society[114,115].

This is demonstrated by the discovery of over 400 people living in an underground bunker, underneath a luxury apartment complex in Beijing in 2017. The inhabitants of this underground space, were rural migrants who are prohibited by the state from accessing public services, and face substantial discrimination from more urbanized Beijingers[116]. These communities can become separate societies in their own right. In Bucharest, communities made up of Romania's communist orphanage system live underground, and have their own rules based systems and recognised leadership[117].

The subterranean environment can also host tunnels, which can be used to transport material goods and people without being observed by surveillance systems, or passing through chokepoints on the surface. This has the potential to not only by-pass security apparatus for illicit activities, but also to gain access to otherwise secure facilities. This has been observed in Syria, where rebel groups have used tunnels to emplace explosive beneath heavily fortified buildings[118,119,120].

The openings of these tunnels are often located within buildings in urban environments, allowing the entrances themselves to be hidden within apartment or warehouse complexes[121]. This can allow for the flow of goods and people emanating from the tunnels, to be masked by the dense traffic and footfall of the city.

Tunnels reaching depths of up to 25 meters are widely used in the Gaza Strip by Hamas, to smuggle goods into the territory from Egypt[122]. These smuggling tunnels serve as large commercial ventures in their own right, and can generate a large return of investment to the wealthy Arab families who fund their creation[123]. They are reportedly constructed by employing a large number of local men, in districts of high unemployment[123]. It was found that during the 2008-2009 conflict, the tunnels were largely resilient against Israeli air strikes, which targeted and damaged the easily repairable openings of the passageways[124].

In June 2019, an 80 meters deep tunnel built by Hezbollah was discovered. It reached from Lebanon into northern Israel. This is roughly the equivalent of 22 underground storeys[125].

Mexican cartels have built tunnels in order to move drugs and people into the United States[126].

Such tunnels often connect northern Mexican cities to southern cities in the United States, for instance Tijuana to San Diego. Tunnels have been found that are as deep as 21 meters, with some containing ventilation ducts, lighting systems and hydraulic lifts[127]. U.S. Immigration and Customs Enforcement has estimated that some of these tunnels cost as much as $2.7 million to construct[127].

The underground of a city can be utilised by criminals, who seek to escape detection and physical obstructions to their operations, such as traffic and law enforcement. For example the area known as the Napoli Sotterranea (Neapolitan Subterranean, picture below), is a series of tunnels running underneath the city of Naples. This tunnel system has a long history, containing pre-Christian places of worship and ancient Roman aqueducts. Sections of the tunnels have been used as parking garages, railway lines, theatres and warehouses. In 1991, a Mafia clan was found to be running a drugs lab in the tunnels. They had protected it with closed-circuit television cameras (CCTV), alarms and watertight doors; in order to create an exclusive network, allowing weapons to be distributed throughout the city[128].

Historic Neapolitan Subterranean areas: Naples, Italy

Military Implications

The Military and 3D Printing

Access to 3D and 4D printing technologies will allow the UK Military to carry out more rapid reconstruction, enabling vital functions within the city to continue functioning during urban operations.

This technology will dramatically increase the speed and effectiveness of Humanitarian Assistance, and Disaster Relief operations (HADR). UK forces will be able to rapidly construct temporary, or replacement, housing and infrastructure.

Subterranean

The development of ISTAR assets that can identify subterranean features (including ingress/egress points), and map out interior spaces must continue. This would significantly reduce the manpower burden in clearing subterranean spaces, and allow the identification of potential manoeuvre routes.

As underground spaces have a finite number of ingress/egress points, these have the potential to allow security forces to 'filter' the populations entering/exiting these spaces, namely for actors or combatants, using biometric scanners as well as other security measures.

There is also a need to train and equip for accessing collapsed underground areas for HADR. Within a conflict scenario there may be reduced civilian casualties, if robust underground shelters are widespread and accessible. These shelters could also be used and controlled by combatants who may grant access to favoured groups. The presence of shelters could allow for more relaxed rules of engagement in a warfighting context, due to the reduced risks to civilians.

Subterranean spaces can channel and enhance the blast effects from blast weapons and Improvised Explosive Devices (IEDs); allowing the clever use of such weapons to have a disproportionate impact. Secondary effects of collapse such as smoke, dust and inhalation, will also amplify the effects of an attack.

Soldiers move along a tunnel during a Multinational exercise: Lithuania

These effects are actor agnostic and may be achieved intentionally or otherwise. The UK must be aware of weapon effects in confined spaces.

Unofficial tunnels will not be ubiquitous as some regions are more suitable to tunnelling than others, e.g. Iraq and Syria (as evidenced by the extensive tunnels being built by violent non-state actors). Understanding the geology of a region will give an indication of the level of threat from unofficial tunnelling. Additionally, the ability to map, search and clear unofficial tunnels will become a critical capability, if they are encountered. This may be possible through technological means, but Tactics, Techniques and Procedures (TTPs) for infantry operating tunnels will also have to be developed and trained.

Urban Mobility

As the population of cities continues to increase rapidly in the future, much transport infrastructure will come under increasing pressure. The public transport systems of many cities has been described by the United Nations as “unsuitable unsafe, inefficient, inaccessible or unaffordable”[129].

Traffic Congestion

A recurring feature of cities is the prevalence of traffic congestion[130]. This can be exacerbated in cities that lack the infrastructure to deal with large, or rapidly expanding numbers of road users[131,132]. Traffic congestion can impede vehicles such as cars, lorries, mopeds and motorbikes, as well as non-motorised road users such as cyclists, rickshaw drivers, passengers and animals.

Within some cities, enduring traffic congestion constitutes a significant proportion of a person’s daily routine. On average residents of Los Angles sit for 102 hours per year in traffic jams[133]. The Satellite Navigation company TomTom uses its devices to evaluate the level of traffic in a number of the world’s cities. During 2018, traffic congestion added 65% more time to the road journey’s of TomTom users in Mumbai, 63% in Bogota and 37% in London[133]. Such congestion delays and impedes economic and social activity[134].

Traffic congestion also causes significant air pollution[135]. This is because slower moving road vehicles typically emit more fumes than faster moving vehicles traveling for the same period of time. Slower moving traffic also prolongs journeys and a vehicle’s usage. This can help create areas of extreme air pollution, in addition to contributing to global greenhouse gas emissions[136].

Traffic jams can also become the site of human interaction. Road users caught in traffic jams are approached by people selling items or offering to wash vehicles[137,138,139,140]. In some countries, such as the United Kingdom, drivers will get out of their car and talk to one another if traffic has ground to a halt for a significant amount of time[141]. Congested traffic provides an opportunity to carjackers; some drivers in South Africa habitually ignore red traffic lights, to avoid being robbed and killed by criminals looking to steal their car[142]. Cities may seek to lessen traffic congestion, by widening traffic routes and appealing to their residents to use alternative forms of transport[143,144].

Within smart city environments, information collected can be used to regulate the flow of traffic, and inform the authorities and emergency services of any immediate and impending situations[145,146,147]. Quantum computing, which is capable of rapidly processing interlinking variables, is particularly suited to traffic management software. As this technology becomes increasingly sophisticated and widely adopted, so will the effectiveness of smart city traffic systems[148].

In 2016, Delhi trialled an ‘odd-even’ traffic system to ease pollution in the city. This system restricted car use on alternate days, depending on whether a car’s registration plate ended in an odd or even number[149,150]. Taxis, two-wheeled and emergency vehicles were exempt from the scheme. Women travelling by themselves, or with children under the age of 12, were also exempt from the scheme; due to concerns regarding sexual assault in taxis and on public transport[150]. The ‘odd-even’ rule was briefly reintroduced in 2017 during a period of particularly heightened air pollution[151]. Jakarta utilised the method in 2018 during the Asian Games[152], and Beijing has used such a scheme on weekdays since 2008, with other Chinese cities following suit since then[153].

Powerful people or groups carrying out certain tasks, such as the transfer of nuclear weapons, will often seek to avoid traffic by travelling in convoys, known as motorcades, which deploy a range of tactics to quickly navigate through congested traffic[154,155,156]. This can involve traveling at high speeds in a set formation, using police sirens and lights, to indicate that other drivers should move off the road. Cars move off the road as a result of a learned response to sirens, or by the threat of immediate physical force. For example, those who inconvenience Zimbabwean presidential motorcades, are often beaten up by security forces escorting the convoy[157]. Sometimes, entire roads can be closed to allow motorcades to travel through them[158,159].

Motorcades are a sign of privilege and signify the importance of whoever is using them to travel, thus prioritising the security and convenience of a limited number of people, at the expense of others, and can cause irritation and resentment. Thailand’s royalty habitually travel in motorcades which can cause large scale disruption. In 2012, the palace instigated revised handbooks to police, which reflected concerns that traffic delays were harming the image of the royal family[160,161].

Modes of Transport

The autonomous (or self-driving) car has attracted increasing amounts of attention in recent years. Fully autonomous cars are not currently available. General Motors, Walmart and Uber are currently testing fleets of cars capable of 'level 4 autonomy', which means that the cars are largely self-driving, yet unexpected hazards may need to be countered by human intervention. 'Level 5 autonomy' refers to a situation in which human control of the vehicle is not necessary, or even desirable[162].

The impact of these self-driving cars on future cities will be substantial. Self-driving cars could lead to a blurring between private and public modes of transport, with the potential for ride sharing akin to an autonomous Uber or Lyft service[163].

Rather than driving a car to work and then leaving it in a parking structure for a set number of hours a day, self-driving cars could be used by other inhabitants of the city to move from one place to another. Therefore, there will be less need for large parking structures which could be repurposed. It is estimated that such technology could reduce the number of cars on the road in Lisbon by 80-90%, leading to less congestion, freeing up substantial space for further urban development[164].

Advancing technology will also increase the efficiency of public transport in future cities. As mobility sensors develop, it will become increasingly possible to predict the "best route, the existing traffic conditions, how much parking is available close by to where you are going, how the buses and trains are running, where the closest bike share is, [...], where peer-to-peer car shares are located, and when someone in your ridesharing network is going to be arriving"[165].

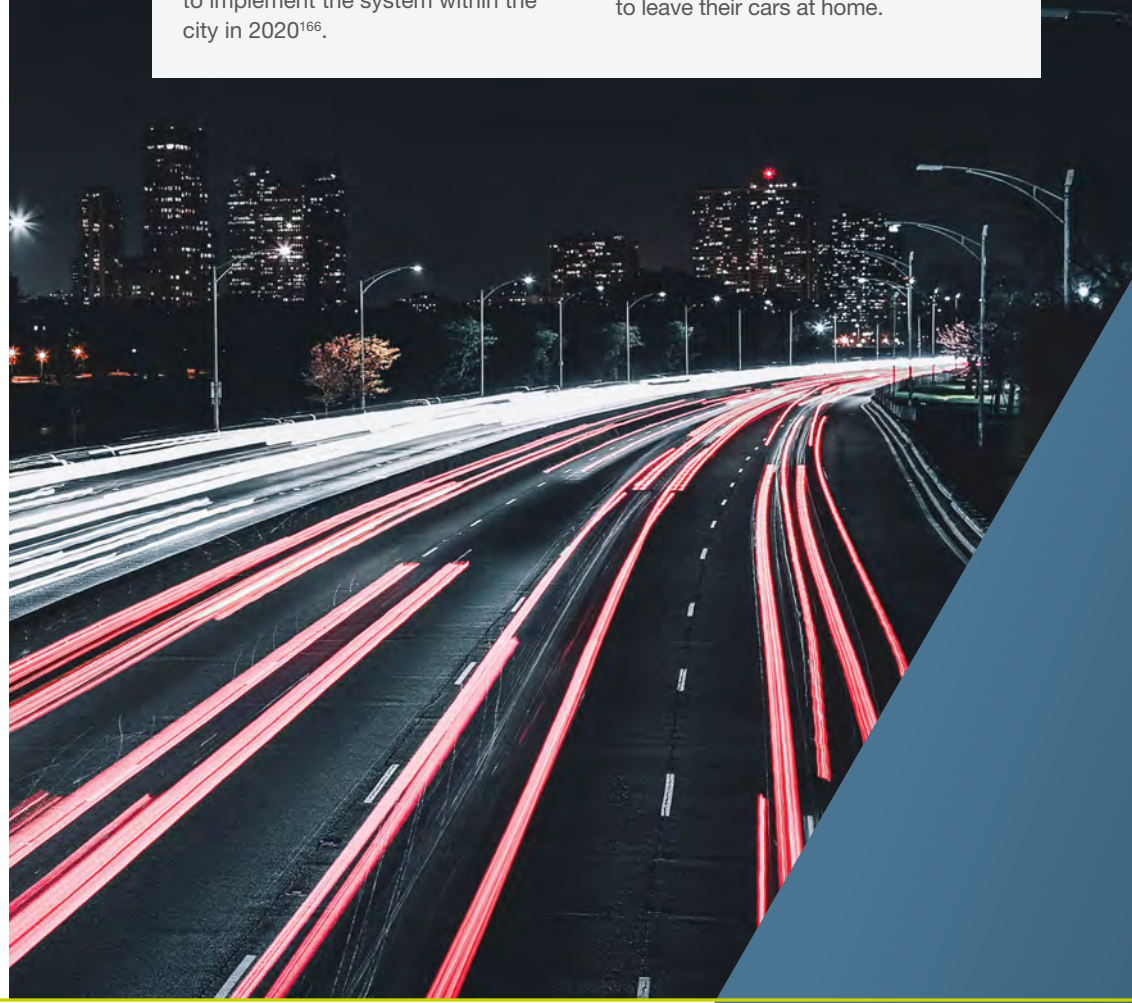
Sensors will allow for two way monitoring of movement; a city's population will be able to get real-time data on the location of public transport and any disruptions, and transport operators will be able to know what stops and stations passengers are waiting at. Digitised transport infrastructure will be marketed as making public transport more efficient, and as a means to reduce congestion.

New modes of transport will be installed in the city. One example of this is the SkyTran system, an autonomous monorail that is currently in development.

Using magnets, these driverless pods are designed to cruise at roughly 100mph[166]. By using a mobile application on which users can register their arrival location and destination, this transportation system aims to reduce commute times, as it does not need to stop at every station on route. Skytran has test facilitates in Tel Aviv, California and Texas, Dubai's Road's and Transport Authority aims to implement the system within the city in 2020[166].

Low-Tech Transport

Some cities are promoting more man-powered forms of transport, such as walking and cycling, in order to make cities more sustainable and reduce levels of pollution and congestion[167]. By reducing the number of cars present in urban areas, as well as designing cities with pedestrians and cyclists in mind, urban planners and governments hope to encourage their populations to leave their cars at home.



Military Implications

British troops conducting a patrol in Mastiff armoured vehicles: Basra, Iraq

Urban Manoeuvre

The ability to rapidly clear hundreds of vehicles, in order to open routes, will have to be developed. In HADR and warfighting situations, roads will likely be clogged prior to UK Forces arrival (as inhabitants try to evacuate/get medical and food supplies), and will need to be cleared to allow access.

To encourage walking and cycling, many cities are developing specially designed routes for these modes of transport. These are specifically designed to reduce and prohibit access for regular vehicles (e.g. raised platforms, narrower routes). This will make access for mounted units difficult or impossible, and therefore such areas may only be accessible to dismounted units; thus reducing logistical and firepower potential for forces deployed into these areas, unless the obstacles are removed.

Aviation will remain one of the most effective means of manoeuvring into and within a city. The difficulties noted above with the terrain, traffic congestion, and littoral restrictions mean that in order to move quickly in a city, a force must have the capability to fly over it and land troops near to where they are needed. Despite the clutter, all cities have open spaces where helicopters can land, e.g. parks, playing fields, large traffic junctions and rooftops.

An alternative could be forces mounted on motorcycles. Just like police units in large cities, this mode of transport allows rapid movement while still carrying one or two fully equipped troops on each platform. Force protection is a clear concern and this is likely only exploitable in a more permissive environment. The risk to the individual is no less than dismounted troops, but they would arguably have greater mobility than mounted troops. This concept should be explored.

Self Driving Cars

The capability of cars and other forms of transport to self-drive is one that presents both opportunities and challenges for the military. While the military is exploring the use of self-driving vehicles to carry out tasks, such as logistics resupply and aid

continued over

delivery, in order to reduce the number of military casualties and freeing up personnel to carry out other activities, there should be consideration of how adversaries could use this same technology. Adversaries could use self-driving cars to transport explosive devices into urban centres, increasing the impact of vehicular attacks while reducing the risk to the attacking force.

Vehicle Recognition Technology

Vehicle recognition capabilities such as Automatic Number Plate Recognition (ANPR) enables the locating, tracking and targeting of specific individuals within an urban area, allowing UK forces to more quickly and accurately target adversary high value targets and reduce collateral damage. The adversary may be able to make use of the same technology. This capability may also be challenged by the blurring of public and private vehicle ownership. As a result, individual vehicles may no longer be tied to a single individual, lessening the validity of ANPR as a way of locating and tracking individuals. Local context will be important.

Traffic Management Systems

As cities become increasingly dependent on traffic management software, the interruption or manipulation of these systems will likely lead to intense traffic congestion and reduce the trust the society places in the traffic system. This could be exploited by UK Forces or adversaries. Traffic management software could be used to facilitate the evacuation of civilians away from dangerous areas.

Local traffic management systems can be exploited to give a ready supply of information for developing "Pattern of Life" at the start of an operation, and a means of tracking changes over the course of a deployment. It can also be used to provide real-time monitoring of surface level movements and quickly highlighting deviations from the routine flow of vehicles.

Within some cities, traffic congestion will make it almost impossible to maintain safe distances between military and civilian vehicles, such as the 100m buffer employed during the Iraq War. This will reduce the effectiveness of force protection. Therefore, new TTPs for manoeuvring in heavy traffic will have to be developed and integrated into training. Traffic congestion adds impetuses to the need to explore alternative modes of transport.

The Role of Elevators

The role of elevators as a transport mechanism will grow in importance as cities become increasingly vertical. The growth of tall buildings, as explored in the previous section of this report, will result in "[…] elevator shafts [that] consume a higher proportion of overall space as the floor-plate of buildings shrink in size as they reach greater heights (from 7% to 20% as towers rise from 70 to 100 storeys)"[168].

Currently, the world's fastest elevator can be found in the Rosewood hotel in Guangzhou, which has a maximum speed of 47 miles per hour[169]. Advancing technologies allow for elevators to become lighter and faster, as well as using algorithms to assign riders to a specific elevator based on their desired destination. As elevators becoming increasingly capable of travelling further distances, tall buildings will become increasingly accessible. This will facilitate their continued growth.

Urban Mapping

Humans have traditionally territorially divided themselves along horizontal lines, marked by physical borders and metaphorical 'lines in the sand' as detailed on maps[170]. These lines have traditionally been used to mark the end of one domain, and the start of another.

The changing urban environment means that such territorial divides are becoming increasingly vertical. As previously discussed, socio-economic groups draw vertical divides, with increased height signifying increased prestige[171]. In some circumstances, wealthier groups seek to avoid contact with the street level, a space associated with the lowest classes in society, via building to building walkways[78,172].

This dynamic is represented in the book *"Cities without Ground: A Hong Kong Guidebook"*, which maps the city through its building to building walkways rather than its streets and roads[173]. As verticalisation occurs, these maps will become of increasing use when capturing the layout of a city and its social dynamics.

A Satellite Image of Dubai's coastline and the Palm Island and The World artificial archipelago

Satellite imagery will become increasingly ingrained into the way in which people perceive the physical environment, as they make use of tools such as Google Earth/Maps, Uber and Deliveroo[174].

Businesses and governments will increasingly seek to enhance the prestige of cities, by ensuring that the bird's eye view of a location conveys the desired image, and is clearly visible to those viewing it online. Therefore, the top down perspective will increasingly be built into the architectural design of the urban environment[175].

Dubai's artificially created archipelagos have been shaped to form recognisable images, when viewed from above. For example, Palm Jebel Ali (as seen on the left) depicts a palm tree crowned with an Islamic crescent, and The World Islands (above) resemble a map of the Earth.

It has been argued that as those in positions of power and wealth become increasingly located on physically higher floor levels, and view the world via Google Earth or similar digital tools, there is a risk that they will increasingly 'look down' upon the poor, removing them from having to see the 'up close' graphic unpleasantries of less privileged day to day life[175]. This may present difficulties, as decision makers increasingly become removed from the floor-based reality of the urban poor.

Image: Interlaced 'vertical village' in Singapore. This building, which won the World Building of the Year award in 2015, is part of a trend away from simple tower blocks to more complex designs.

Powering Urban Areas

As urbanisation and population growth intensifies, the demand for electricity will also expand. Electricity will most likely continue to be derived from numerous sources, although a desire to avoid the adverse effects of climate change and reduce pollution, will mean that renewable energy will become increasingly politically desirable[176,177].

The generation of renewable electricity will likely become further ingrained into the infrastructure of cities. Energy production will likely become increasingly localised via micro grids[178]. Whilst a micro grid is still connected to the main energy system, it "[…] can break off and operate on its own using local energy generation in times of crisis, like storms or power outages"[179]. For example, the planned Pertamina Energy Tower in Jakarta, is designed be able to hold and distribute wind generated through four wind turbines located at its pinnacle[180]. Emergent technologies include a glass-based system (typically a prominent material used in skyscraper production), which harnesses both solar energy, and technology that generates electricity through the minute movements of infrastructure, such as "the natural sway of a skyscraper, or the juddering contractions of a bridge"[180].

This technology is enabled by blockchains which keep track of electricity use, allowing for electricity to be precisely allocated, attributed and costed [181].

Micro-grids will help to alleviate blackouts which can occur after natural disasters. In 2018, a Cyclone left 2 million residents of the US East Coast without electricity after destroying powerlines[182]. Japan's Hokkaido Eastern Iburi earthquake left more than 2 million people without power, after damaging a thermal power station[183]. These blackouts can result in failure of critical national infrastructure and major economic disruption[184].

Lights and Behaviour

Lights are a common feature of built up areas, used for both physical utility to make dark places accessible, and for influencing behavioural choices[185]. The colour and strength of the light can be used to establish ambiance in an environment and associate a certain area, advertisement, or situation with specific emotions[186].

This can leave lasting psychological associations (as is often intended with advertisements)[186] and inspire immediate action; as can be seen in traffic and emergency vehicle lights. It should be noted that there are cultural variations in what colours are associated with. For example, many older Japanese traffic lights display a blue light to indicate that drivers should move forward. The government reported that this is compliant with international regulations on traffic signalling, because the exact shade of blue that is used is considered to be a shade of green, when described in Japanese[187].

Lights are often used to highlight or obscure things, for the purpose of influencing human behaviour[188].

For example, in many cities aircraft warning lights are often placed on top of tall buildings, to prevent aircraft from flying into them[189]. Lights can also be used to obscure visibility. Some businesses use blue lights in their toilets to deter drug injection[190]. This is because blue lights obscure the visibility of a person's veins. However, this can result in the drug user missing the vein and injecting the surrounding tissue, which can cause a greater level of harm to the user[191].

The Petronas Towers: Kuala Lumpur, Malaysia

In most of the world, lights are typically more prominent at night than during the day[192]. However, parts of Sweden, Norway, Iceland, Finland, Alaska and Canada typically experience the 'midnight sun', during which the sun is present at night during the summer, and nightfall continues into the morning and afternoon during the winter[193]. This affects the periodic usage of lighting. Prolonged daylight and nightfall is typically associated with Seasonal Affective Disorder, resulting in disproportionate levels of suicide[194,195,196,197]. People seek to alleviate this by using light boxes to replicate the sunshine, during periods of prolonged darkness[198,199,200].

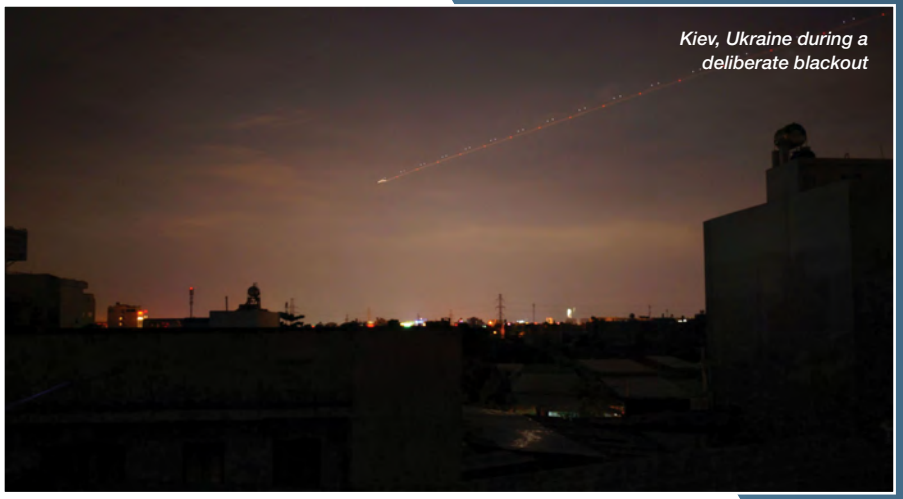
Lights and Security

Lighting can be used to emphasise that someone's actions will be clearly visible. This is used to deter trespassing onto certain sites and reduce street crime[201,202]. However, some studies indicate that lighting does not decrease crime, but only reassures those who believe themselves to be potential victims. This is because increased visibility, better allows criminals to identify and assess targets[195]. CCTV cameras that do not utilise night vision technology, such as infrared lighting, typically require certain threshold of light (with coloured CCTV requiring more than black and white cameras)[203].

The ability of light to create certain ambience and influence people is a concern for police forces. In 2014 the Association of Chief Police Officers issued a guide to architects which states that:

> *"The aesthetic value of a lighting installation is an important consideration as the day time street scene suffers greatly if fittings, materials or paint finishes are of lesser quality. The shabby appearance of lighting street furniture can send the wrong signals to the community and contribute to a cycle of grime, crime and decline"*[204].

Urban lighting can be disrupted by black/brownouts, during which electricity is unable to power lights, causing them to switch off[205]. This can be a deliberate policy to save electricity, obscure targets from military attack, or simply a result of weak infrastructure. In some situations blackouts can trigger rioting and looting, as famously occurred in 1977 in New York. This is thought to have occurred because the cessation of normalised urban life, indicated that the societal rules had ceased to apply[206].



Kiev, Ukraine during a deliberate blackout

Lights and Infrastructure

In cities in which such blackouts are a deliberate policy to avoid overuse of power plants, the loss of power and subsequent light pollution will become scheduled beforehand, to allow those affected to prepare. This policy of deliberate power cuts and blackouts is known as 'load shedding'[207,208], and results in a loss of electricity for those who do not have access to home generators.

Additionally governments may order a blackout for military purposes. During the 1991 Gulf War, the Iraqi government ordered blackouts in Baghdad as part of broader civil defence exercises[209,210]. However, modern technology, such as night vision and persistent surveillance platforms, largely makes this less effective than it once was.

Blackouts can also be induced to cause disruption, for example Russia allegedly hacked into Ukraine's civil power grid, in order to induce blackouts (see image above)[211].

As lighting uses electricity and carries a financial cost, people typically seek to utilise electricity only when required. For example, Oslo, Glasgow and San Diego utilise 'Intelligent Lighting' which uses sensors to collect data on footfall, allowing for assessment of when street lights can be brighter and dimmer, and adjustment of lighting to account for adverse weather conditions, such as snow[212,213,214].

Some countries have unreliable electricity production and distribution systems[215]. This is illustrated by the picture on the next page. It shows a satellite image of North Korea, with only limited lighting outside of the capital Pyongyang[216].

Night-time satellite view of the Korean Peninsula, showing the stark disparity in light pollution between North Korea and the surrounding region. Note the small point of light emanating from the North Korean capital, Pyongyang

Light Pollution

Light pollution refers to the collection of artificial light, visible in the night sky. Although light pollution stems from a variety of light sources and types, the manner in which it presents itself can nonetheless be categorised.

The US 2011 Army Research Laboratory report *"Sky Glow from Cities; The Army illumination Model v2"* describes four overlapping components of light pollution[192]:

- *Urban Sky Glow – the brightening of the night sky over inhabited areas*
- *Light Trespass – light falling where it is not intended, wanted or needed*
- *Glare – excessive brightness which causes visual discomfort. High levels of glare can decrease visibility*
- *Clutter – bright, confusing and excessive groupings of light sources, commonly found in over-lit urban areas*

Light pollution generally corresponds with the level of human activity which occurs within the environment. This causal relationship can be distorted by blackouts, poor infrastructure[217] and environmentalist legislation; such as that found on the island of Hawaii, which places restrictions on the brightness of outdoor lighting[218]. Light pollution can have an adverse effect on wildlife, agriculture and human sleep cycles[219,220]. Humans have evolved to synchronize their sleep cycles with daylight, and those living in areas with a high level of light pollution experience constant 'mini jet lag'[221].

Automation

Future cities will increasingly feature robots working alongside one another, assisting humans, and supporting the wider electronic infrastructure established by the 'Internet of Things'. This will increase the economic and procedural efficiency of society. Robots will increasingly be used to perform tasks which are physically impossible, dangerous, expensive or comparatively inefficient for humans to carry out[222,223,224]. These will be tasks such as filling potholes, inspecting sewers and directing traffic, jobs that are considered *"dirty, dangerous and dull"*. Many jobs that follow a linear set of rules are at risk of being replaced by automation[225]. However, it should be noted that this does not mean that the human workforce will be entirely replaced by robots.

The World Economic Programme estimates that "robots will displace 75 million jobs globally by 2022, but create 133 million new ones"[226,227]. These jobs are likely to include data analysts, software developers and social media specialists. Moreover, robotics will contribute to a future in which a large number of the UK's primary school children will eventually work in jobs that currently do not exist[228].

Culturally, there are and will continue to be, wide disparities between cultures regarding the specific roles which are deemed to be appropriate for a robot to perform. For instance, cultures which prioritise care for the elderly as a social function, are likely to be uncomfortable with robots designed to perform a nursing role. Similarly, different cultures will have different levels of comfort with humanoid robots, and some may insist on strict physical and social segregation between humans and machines[229].

Unmanned Aerial Vehicles

In the future unmanned aerial vehicles (UAVs) will be increasingly used for infrastructure inspection, agriculture, delivery of goods and the transport of humans[230,231]. A 2018 report by investment think tank Nesta, predicts that as technology progresses, and legislation expands, UAVs will increasingly be used for a variety of tasks in cities[232].

A notable example is the medical profession, where UAVs could be used to transport equipment, organs and blood supplies. In an urban environment, UAVs will require the ability to effectively navigate physical objects, and potentially involve integrated air-traffic management systems, to direct and monitor UAV flights[232].

A 2019 report by BIS Research states that by 2029, the global UAV market is due to be valued at 70.28 billion US dollars, an increase of over 40 billion dollars from the market's 2018 valuation of 25.59 billion dollars. This growth is likely be driven by the increased use of drones by militaries, police forces and commercial organisations[233].

UAV's will likely continue to be used as a tool of disruption. This was seen between the 19th and 21st December 2018, when a commercially purchased UAV repeatedly flew over Gatwick Airport, affecting the travel of roughly 140,000 passengers and costing the airline industry between £50-£70 million[234].

Military Implications

British troops conducting a night time patrol: Basra, Iraq

Lighting and Military Activity

The UK Military should explore the utility of lighting in Information Operations (IOs), through the ability to influence people's behaviour using street lighting. For example, lighting could be used to discourage inhabitants from going out at certain times, or not to enter certain areas of the city.

Consideration needs to be given to the effect of high levels of light pollution on ISR assets and sensors.

Energy Independence and Resilience

Integrated renewable energy production will make cities further dislocated from the host state, but will also increase resilience. National blackouts and whole-city blackouts will become less frequent, or impossible, and it will become harder to besiege a city and cut it's electricity. Even in instances where key city neighbourhoods lose power, the presence of micro-grids will make it easier to adopt an 'ink-blot' strategy, and restore power.

Military Mapping

There is a need for the UK military to update how they map urban areas, in order to accurately visualise contemporary and projected trends. In addition to mapping the streets and buildings on the surface levels, maps should incorporate the significance of urban subterranean spaces and increasing verticality, the latter of which requires detail of building to building walkways.

Smart City infrastructural nodes should also be mapped, so that personnel can identify, access and utilise these key nodes that support the functioning of the city.

The UK military should map how the demographic makeup of the city, pertains to the physical environment. Particular effort should be put into mapping the demographic nature of certain districts, and the demography within and between large vertical buildings. A single UK Battlegroup's area of responsibility may incorporate dozens of different ethnic, cultural, religious and linguistic groups, which will have a 'knock-on' effect on the UK's military ability to effectively perform non-kinetic activities, information operations, and the generation and mitigation of complex second and third order effects.

These maps will need to continuously update, in order to detail any changes in the physical environment, as well as demographics and relationships between different groups.

Automation

As the UK military invests more in autonomous capabilities, they will need to understand different cultural perceptions of robotics and automation in areas where they will be operating. This may inform which autonomous capabilities the UK military deploys, and whether they can use alternative methods of capability delivery if local populations, or aspects of it, are hostile towards automation.

However, in some areas, over-reliance on automation, recruitment and retention challenges, might lead to a lack of human skills and capabilities, that can only be filled by automation.

This could have an impact on HADR and post-conflict reconstruction operations; if the local population is lacking the skills to physically conduct much of the required tasks manually. Additionally, over-reliance on automation can lead to a lack of resilience in a society, that has had many of these systems disrupted through conflict, criminality or natural disaster.

Mapping the Physical, Demographic and Virtual Domains

In many situations, it will be vital to obtain a working understanding of the relationships and interactions between various groups. This will involve conceptualising and understanding these interactions, hierarchies and the wider national and global circumstances, which inform these relationships and their effects. This will allow the UK military to understand how their decisions may reinforce or alter these relationships and ties.

The necessity of understanding the increasing scale and complexity of urban areas, means that the UK military should focus on developing a dossier of key future cities in which these operations are likely to take place. Because the bulk of urbanisation is occurring in Africa and Asia, particular focus should be paid to the dynamics of cities in these continents. This dossier should be kept up to date, to ensure an accurate picture is maintained of key cities, and should take into account a variety of variable factors including:

- A historical analysis of how a city has developed and it's ramification for the contemporary environments, including political and cultural narratives and sensibilities
- Demographic analysis, including the perceptions and behaviours of different groups
- Physical and digital infrastructure (including critical national infrastructure and key buildings of interest)
- Local, national and international network analysis

A vertical farm producing lettuces on stacked rows of hydroponic systems. Such controlled conditions make vertical agriculture systems more resilient than traditional agriculture

Vertical Agriculture

Food production will likely become increasingly urbanised, due to a growth in vertical agriculture, in which crops are grown within a smaller surface area within buildings[235].

This would make farming more efficient, by reducing logistic and labour costs. This is partly because of the ability to concentrate a large amount of crops in a given fixed space, but also the ability to grow crops regardless of seasonal or weather conditions[236].

Vertical agriculture will alter the relationship of cities with their immediate rural environment, as the cities become less reliant on rural areas for produce. Instead, they will become further economically intertwined with other cities[2]. This is currently being enhanced by efficient 'Internet of Things' logistics, allowing perishable goods to be shipped across substantial geographical distances, whilst remaining marketable and consumable[237]. This ability for areas to engage with one another will be facilitated by the, potentially fragile, Just in Time (JIT) economic system; which manufactures and transports at short notice to meet demand[238,239].

Water Scarcity and Wastewater

According to UN projections, the world may face a 40% shortfall in water availability by 2030[240]. UN-endorsed projections estimate that Cairo will suffer critical water shortages by 2025, with Mexico City already suffering such shortages. 1 in 5 residents of Mexico City get "just a few hours from their taps a week and another 20% have running water for just part of the day"[241].

These water shortages also prevent ground stabilisation, resulting in areas of the city sinking into the ground. As much as 40% of Mexico City's water is imported from 'distant' sources, requiring transport into the city. Responding to this challenge, the city has built the world's largest drainage tunnel, which is 62km long and 200m deep[242].

Water and Whitewater International reports that Russian Regulatory waters believe that "between 35% to 60% of total reserves of drinking water in Russia" currently do not meet sanitary standards, with 40% of surface, and 17% of underground spring water, considered unsafe for humans to drink[243].

The use of unclean water in agriculture is becoming an increasingly urban phenomenon. A 2017 study found that globally speaking "65% [...] of downstream irrigated croplands were located in catchments with high levels of dependence on urban wastewater flows. These same catchments were home to 1.37 billion urban residents"[244].

Singapore recycles wastewater so that it can be drunk, despite some residents finding this unhygienic. As a response, the government sought to acclimatise people to its use, by randomly introducing recycled wastewater into the country's reservoirs and holding tanks[245].

A polluted river near by slums: Chennai, India


London, UK

Security Infrastructure and Crime

Building security measures into urban infrastructure is not a new phenomenon. The 'fortress architecture', erected in Northern Ireland in the 1970s and 1980s as a response to the Troubles, is an early example of anti-insurgent designs being built into cities[246]. More recently, the events of 9/11 and the surge of vehicular terrorist attacks in London, Nice and Berlin, have generated an increased political impetus to incorporate physical security measures, against disruptive violence into urban infrastructure[247,248].

The installation of physical elements in the urban environment aims to reduce the accessibility of potential targets and locations, e.g. bollards, walls and hardened benches and lampposts[249]. While these can be designed in such a way as to blend in with the urban environment, and even enrich it, these methods are often overt. This has ramifications for the culture and psyche of a city's inhabitants, by constantly reminding them of physical threats[249].

Observable examples of subtle incorporated security measures into urban design, are attempts to counter urban vehicular attacks, by reducing the ease with which vehicles can hit targets at high speeds. Road features, such as bends and turns in the road, near high-profile targets such as public parks and gathering places, may reduce the damage caused by vehicle attacks[249]. Overt measure such as gates, bollards and visible security cameras, can deter individuals from attacking vulnerable and/or important targets[249].

Surveillance Technology

Cities are monitored by surveillance cameras for a variety of reasons; to prevent, respond to and investigate violent terror attacks, civil unrest and crime, in addition to locating missing persons and reuniting people with lost property[250,251,252].

The presence of surveillance cameras has become commonplace within urban areas[253]. The United Kingdom has a heavy presence of CCTV cameras, with a 2013 British Security Industry Association (BSIA) estimate placing the total number of cameras in the country being approximately 4 million, with half a million of these cameras located in London[254]. However, it should be noted that accurate figures on cameras are difficult to compile, as many are privately owned or covert.

A 2015 report by information provider IHS Markit, found that 245 million professionally installed surveillance cameras were operational in 2014[255]. Notably, 65% of these were installed in Asia[255].

In order for large datasets of CCTV images to be of significant use in identifying the movements of individuals, technology must be able to recognise the same individual as they pass through fields of view of CCTV cameras in multiple locations[250].

Currently, much of the analysis of the CCTV footage is still carried out by humans, who must watch it in order to make deductions about the activities of people recorded by CCTV cameras. This process can be made more efficient by the utilisation of technology, such as facial recognition software, which is able to identify a person in one image as being the same in other images, and correlate that with related pieces of information[250].

Japanese electronics company Hitachi is developing a system, that identifies hundreds of details about a person's appearance, which can then be cross-referenced across numerous cameras to track the individual[250]. This means that a change in appearance, such as a change of clothing or hairstyle, will have minimal influence on the Hitachi system's detection ability.

Surveillance cameras can also be mounted on platforms and people[256]. For example, UAVs can be used in a variety of situations, including searching for missing people and dealing with serious traffic accidents[257]. Many new cars are sold with built-in cameras (known as dash cams) to support potential insurance and legal disputes[258,259]. Body cameras are sometimes used to record the actions and experiences of police officers, for the purpose of evidence collection[260]. These technologies can be used by states to generate increased oversight of public behaviour, they also allow the general population to monitor and share the behaviour of one another and the state itself.

The internet has enabled non-state actors to partake in extensive open source surveillance and intelligence gathering. Although governments, journalists and researchers have long made use of open source data; the accessibility of records, media articles, and the availability of personal information posted online amongst social media, means that online, open-source data is increasingly an available and effective tool for gathering information[261].

This is used by commercial organisations, that use the information to tailor commercial marketing campaigns, logistical assumptions and product design. Individual members of the public, and non-state groups, can use the information to challenge the narratives of government organisations. For example, investigation website Bellingcat was able to find and publish the identities of the two GRU agents, who attempted to assassinate former Russian spy Sergei Skripal in Salisbury in 2018, partly using open source-data[262].

Concerns have also been raised about the disruptive capabilities of emerging 'Deepfakes' technology, which refers to false audio augmented videos, which are increasingly indistinguishable from genuine recordings[263]. This may allow hackers to gain access to surveillance databases, and replace genuine footage with fake images[264].

China's Social Credit System

Expected to be fully operational on a national scale by 2020, local governments in China have been piloting a 'social credit system' since 2014[265]. By monitoring the behaviour of the population through their internet usage and facial recognition in surveillance cameras, individuals will be assigned a 'social credit score' which will impact their access to certain systems and services.

Individuals who pay bills on time, obey traffic regulations and engage in other *"good"* behaviours, may benefit from discounts on their bills and reduced interest rates at banks[265]. In 2018, Chinese social credit systems were used to prevent 17.5 million, and 5.5 million, attempted purchases of flight and train tickets respectively[266].

Cyber-crime

Technological advancements and accessibility are increasing the opportunities for criminals and hackers (both state and non-state), to anonymously steal data, defraud people and sell illegal goods; potentially from a remote, undetectable transnational location[267,268]. The increased digitalisation and globalised nature of urban societies, makes them particularly sensitive to cyber-crime.

Silk Road was an online market place, accessible via the Dark Web, where users could order an often illicit product or service, based on his or her previous user rating and reviews. For example, you could order drugs on Silk Road and have these delivered through the post. Like many Dark Web activities, Silk Road utilised cyber-currencies to conceal records of online financial transactions, which totalled over $200 million (USD) between February 6th 2011 and July 23rd 2013. Such estimations are, however, difficult due to the dramatic fluctuation in the value of cryptocurrency. For example, a previous revision held the value of transactions made on Silk Road over the same period to be $1.3 billion (USD)[269].

The establishment of a market based on reviews, rather than held 'territory', and the inability of users and dealers to physically attack one another, probably led to a widespread global decline in drugs based violence[269,270]. When the website was shut down, the sudden interruption of deliveries and payments created a physical backlog, indebting smaller drug dealers to their suppliers[271].

Dark web administrators continue to operate on similar premises, in an atmosphere of reduced user to user trust. Some administrators practice a scamming technique known as an 'exit scam', by which the scammer consolidates the reputation of a site as a trustworthy platform for trade, and then suddenly takes the website offline, keeping the digital currency which is being held by the website as part of the trade mechanism. The owners of the web site Evolution Marketplace allegedly stole over $12 million (USD) of Bitcoin in such a scam[269,272].

Phnom Penh contains several offices, which employ a mix of foreign and local nationals, who use their linguistic skills to defraud those living abroad who speak the same language as the scammer[273]. However, these scammers are often at the mercy of changing international relationships. Groups of Taiwanese scammers operating in Phnom Penh, who target the Chinese mainland and diaspora, once operated under the assumption that the lack of formal ties between Taiwan and Cambodia would protect them from prosecution by Taiwanese authorities, if they were to be deported. However, as Chinese investment and influence in Cambodia increases, Cambodia is adopting the Chinese narrative of Taiwan as a rogue state. Therefore, the Cambodian authorities have deported such Taiwanese scammers to China[274,275].

As urban environments become increasingly concerned with protecting their electronic infrastructure within a smart city environment, identifying and arresting cyber-criminals operating abroad will become more desirable. However, as previously mentioned, it will remain exceedingly difficult. After surpassing proxy networks, investigators will frequently find that organised crime groups engaging in cyber-crime, will have positioned themselves in regions they deem difficult for concerned law enforcement to reach. Countries will need to develop, maintain and utilise the technical expertise needed to identify criminals working abroad. They will also require the diplomatic capacity to encourage the country where the criminal is operating, to meaningfully prosecute or extradite them[276,277].

Stated Backed Hacking

Cyber-crime and hacking can also be carried out or supported by states. For instance in May 2017 a ransomware virus, known as Wanacry and originating in North Korea, infected 300,000 computers across 150 countries[278,279]. This affected organisations such as the NHS, FedEx, O2, Hitachi, Nissan Motors and the Deutsche Bahn railway company[280,281]. Ransomware prevents targeted pieces of infrastructure from functioning, unless money is sent by a digitalised financial unit known as cryptocurrency, such as Bitcoin, to the virus's originator.

State and non-state actors will continue to use malicious computer viruses, in order to access otherwise unavailable information, extort money and obtain political advantages. With increasing connectivity (including digitally connected critical infrastructure), the threat from malicious use of computer viruses will increase in kind. Some of these, like the Stuxnet virus which targets certain Supervisory Control and Data Acquisition systems[279], will have physical effects as well as non-physical. Cyber-attacks on digital medical equipment, vehicles with electronic control systems and transport infrastructure, such as traffic lights, rail systems or air traffic control, may cause an immediate loss of life. Additionally, the use of cyber to disrupt routinely functioning infrastructure, could exacerbate social tensions and facilitate economic harm, in both the short and long term.

This in turn could be used to strategically hinder an actor by forcing it to divert resources, and political attention, away from the military towards civil contingencies.

Cyber–attacks also provide a means for adversaries to undermine the political resolve of the homeland, by causing widespread damage to the infrastructure of UK cities. This capability may be available to actors who would be unable, or unwilling, to target the United Kingdom through conventional kinetic means.

It should be noted that the indirect effects of cyber-attacks can be difficult to predict, and may therefore cause undesired damage to systems, other than their intended target. This presents difficulties in regards to mitigating collateral damage and attributing the attacks. Within the context of hyper-connected smart city environments, the infrastructure of cities may suffer from such collateral damage more than in recent history. This collateral damage may propagate and eventually affect the attacking country's infrastructure. For example, in 2008 the United States military shut a seemingly Islamist internet forum, hosted in Saudi Arabia. The concurrent effects included internet outages in Texas[282].

Communicating in Cities

Approximately, two-thirds of the world's population are currently connected by mobile devices, and by 2020 the Global System for Mobile Communications has estimated that 75% of the globe will be connected by mobile[283]. This has occurred at the same time as a decline in the use of landline phones. The Smart City concept is becoming increasingly supported by mobile phones, which act as tools for users to access services and communicate.

Building upon the existing concept of the 'cloud', where devices are connected to central information storage zones, the 'fog' will allow personal devices to connect directly with each other, allowing for the flow of personal information between these devices[284,285].

If current trends continue, the popular use of mobile technology, at the expense of the landline, is likely to continue. This removes the requirement for a functioning network of wires and cables, enabling far more flexible access to mobile networks[286,287]. This allows those who do not have regular access to functioning urban infrastructure, to communicate with other people over large distances.

Military Implications

Pervasive Surveillance

The military will increasingly operate in an environment of pervasive surveillance. This will reduce their ability to operate undetected. An adversary may also have the ability to track UK forces through a city, thus allowing them to predict likely sites for a kinetic attack.

Any activities conducted by UK forces will likely be filmed, increasing the risk that negative actions (real, perceived or faked) can be exploited by an adversary.

Urban Agricultural Infrastructure

During natural disasters such as flooding, vertical farms may offer better protection for agricultural space and crops than traditional farmland. However, if a vertical farm is destroyed or damaged, then it will have greater impact than if the same surface area of traditional farmland was destroyed. This is because vertical farming condenses a larger amount of agricultural production capacity into a smaller area.

Water supplies, from outside a city, are a critical target for control during military operations, because they allow significant influence and control over a city's population.

Understanding the water resilience of a city before, and after, an operation will be critical for ensuring the appropriate civil engineering support, and information strategy. A failure to ensure or restore access to safe drinking water, may result in negative sentiment and undermine the reputation of the UK.

Physical Security Barriers

Cities will already have significant counter-mobility obstacles in place, even before an adversary creates additional obstacles. These may need to be removed and/or replaced during and after combat operations.

Physical barriers can also be exploited and enhanced by UK forces for their own security operations. This will reduce the logistical and engineering burden on constructing these systems.

With physical barrier systems becoming more common, it is likely that populations will become more accustomed to security obstacles and therefore, less adverse to their installation by security forces in a counter-insurgency or counter-terrorism operation.

Building Construction – Kinetic Effects

The materials and architectural techniques used in building projects are constantly evolving. Understanding the impact of these new materials and methods on kinetic weapon effects is crucial to planning military activities.

Cyber

The potential impacts of the future cyber environment on UK operations are too great, and potentially sensitive, to include in this report.

However, it is imperative that UK military cyber capabilities keep pace with civilian systems and practices. Additionally, military cyber specialists must have an understanding of the types of systems that will be encountered in cities throughout the world.

The number of potential cyber threat vectors is enormous, and the challenges of ensuring both force protection and protection of Critical National Infrastructure (domestically and internationally) will be significant. This subject requires substantial further investigation.

Building Construction Communications

The materials used in contemporary building projects are becoming increasingly detrimental to the use of wireless communications equipment. As cities become denser and more vertical, these constraints will only worsen.

Verticality may also impose further constraints. While the physical distance between two points may not be far, each floor of the building is degrading the signals. The impact of verticality on communications must be investigated and understood, in order to enable communications planning.

Future communications equipment may have to piggy-back off the same systems that enable mobile communications form within buildings. This may pose a security implication, but may be necessary due to existing environmental constraints.

Chapter 4

Demographics

Rural-Urban Migration

As increasing numbers of individuals from traditionally rural areas migrate, or are subsumed, into the rapidly expanding and emerging urban areas, there will be a shift in the demographic makeup of the urban environment. It has been estimated that since 1970, the number of people living in urban areas has more than tripled, from 1.35 billion to 4.3 billion in 2019. This figure is expected to be roughly 6.68 billion by 2050[288]. These estimates include both internal migrants from rural areas, as well as international migrants, who will increasingly feature as a factor in emergent population trends[288,290]. International migration will be discussed in the next sub-section of this chapter.

Delhi, India

The increase in migration from rural to urban areas, will affect the challenges that will need to be managed within the urban space. The cultures of those who grew up in rural areas, are often broadly distinct from those who came of age in an urban environment[289]. These can manifest in differences in outlook and behaviour, between the rural and urban population, with rural populations more commonly adhering to 'community' based principles, centred on familiarity and kinship. This is in contrast to the urban experience, which features more brief interactions with strangers, and relationships based on compatible personalities[289].

As those of a rural background and mind-set find themselves part of the urban environment, and the urban populace encounter the culturally different (and generally poorer) newcomers, intercommunity grievances are likely to emerge[290]. Routine concerns of the urban poor, such as the devaluing of unskilled labour, are likely to be exacerbated[291,292,293,294].

In many cities, rural to urban migration is likely to alter the voting patterns and broaden the political landscape. In some situations, the contrasting economic and social circumstances of the rural and urban populations, could lead to conflict, whereby the dominant political intuitions cannot peacefully manage the differences between these populations.

Former Governor of Hong Kong, Chris Patten, has stated that he believes that rural migrants will become a source of unrest, within the context of a stagnating Chinese economy[295]. Distinctions between rural and urban populations, can continue for several generations. In Delhi, many of the long settled Urdu speaking inhabitants consider themselves to have a distinct social identity from the populations that have migrated to the city, since the 1947 partition of India[296,297,298].

As rural to urban migration continues to impact upon future cities, the tensions between these two groups is likely to become an increasing source of potential conflict. As social and economic ties, and networks, become increasingly globalised, localised conflicts are likely to have more international ramifications[299].

International Migration, Culture and Social Groups

Within compact spaces in urban areas, it is increasingly common for different ethnicities, nationalities and linguistic groups, to work and live alongside one another. In part this is because an increasing number of rural and international migrants, have moved to urban areas, as they may typically hold the belief that there are greater economic, and social opportunities in cities[300].

The United Nations 2019 World Population Prospects Report states that:

> *"More than half of the projected increase in the global population up to 2050 will be concentrated in just nine countries: the Democratic Republic of the Congo, Egypt, Ethiopia, India, Indonesia, Nigeria, Pakistan, the United Republic of Tanzania, and the United States of America.*
>
> *[…] Trends in population size and age structure are shaped mostly by levels of fertility and mortality, which have declined almost universally around the globe. In some countries, international migration also has become an important determinant of population change"*[301].

The Organisation of Economic Cooperation and Development (OECD), attributes much of the migration of people from poorer to wealthier countries; to population growth in low-income countries, and the need to fill labour shortages in aging high-income countries[302].

Predictions regarding international migration, have been referred to by the Global Migration Data Analysis Centre as "beyond unpredictable", as they rest on assumptions of complex and interacting demographic, economic and political trends[303,304]. Occurrences, such as the mass-influx of migrants into Europe in 2015, and the departure of over 3 million Venezuelans following the country's economic collapse, can result in massive disparities between estimates and real world occurrences[305,306]. Furthermore, holistic examinations of migration are difficult; because different countries do not share the same criteria for classifying someone as a migrant. For example, Japan, Korea, and much of Europe, tends to place emphasis on those legally classified as foreign residents[307]. Whilst settlement countries, such as the United States, Australia, and New Zealand, focus on those who are foreign born[308].

Additionally, different countries have different levels of efficiency and accuracy, in regards to collecting and revising information. This presents difficulties for countries and organisations seeking to precisely allocate resources and investment[309].

Despite difficulties predicting the exact nature of future trends of international migration, it is highly likely that the issue will continue to play a role in the changing demographic makeup of the societies to and from which migrants move.

It is worth noting many people from Western countries will continue to travel and live abroad[310]; often in order to benefit from a higher purchasing power, and lower taxation[311]. Some will also be attracted by the social and economic dynamism of comparatively younger populations.

Downtown Dubai, UAE

In cohesive societies, diverse social groups will develop a shared cosmopolitan identity; based on loyalty to their city or country, rather than an exclusive loyalty to their ethnic and religious community[312]. This cosmopolitan identity can exist in tandem with a personal identity, which incorporates religious, ethnic and national characteristics[313].

However, within cities containing unintegrated communities, there are often areas viewed as belonging to a separate cultural or ethnic identity, whose interests may differ from those of the state, or other groups within that municipality[314,315,316]. This can lead to inter-group tension, due to visible inequality between groups[317].

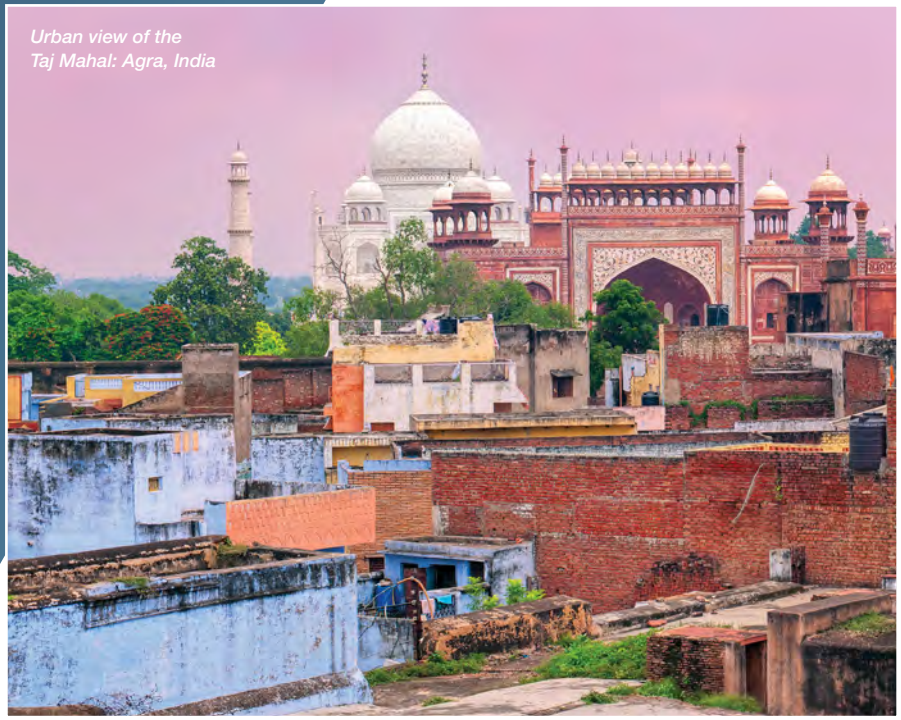
For example, the apparent self-segregation of several Muslim communities, has become an issue of contention across several European countries[318]. The Islamic self-segregation within France, is cited by the Singaporean Government's Centre for Strategic Futures as justifying the country's state-led integration process. This process mandates ethnic diversity across the country's substantial social housing developments[319].

When a wealthy social group seeks to engage in cultural practices, separate from the culturally different majority in a city, there are often segregated building complexes and gated communities[320,321]. These areas are often inhabited by wealthy resident ethnic or social minorities, and expatriates or migrants.

Market stall: Turin, Italy

In cities such as Shanghai[322] and Dubai[323], there are often substantial Western populations living apart from the majority of the city's residents. In contrast to ethnic enclaves for typically poorer communities, these areas are often clearly marked by gates and walls, and are overseen by private companies, who carry out functions such as security and maintenance[324,325].

Segregation can stem from legislation, as policy can create divides between ethnicities, both intentionally and unintentionally. Some legislation explicitly seeks to apply different behavioural standards, to different groups. In some cases, governments deem it necessary to practice segregation, as a means to attract tourists, or an expatriate/migrant workforce; by making behaviour that is perceived to be socially harmful, and which is often illegal, permissible for some people. For example, only non-Muslims in the United Arab Emirates are permitted to apply for alcohol licences[326], and only foreigners in Cambodia are legally permitted to gamble and visit casinos[327].

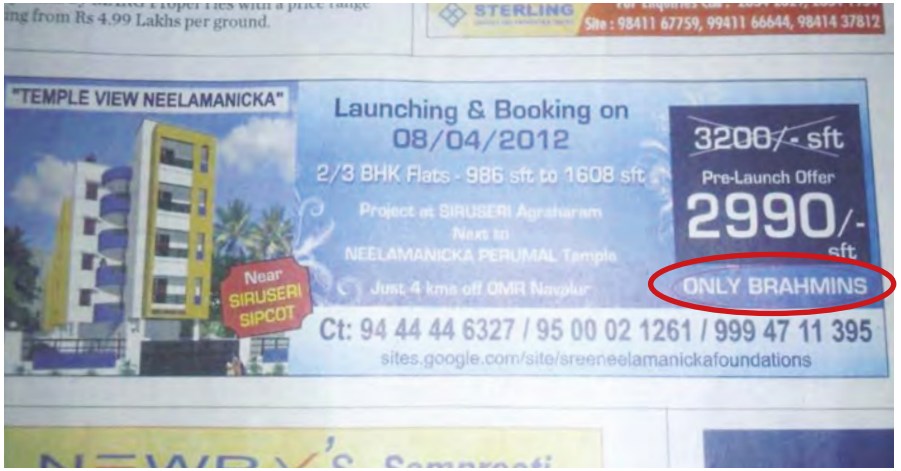


Urban view of the Taj Mahal: Agra, India

Rules-based segregation also exists outside of state legal systems. The South Asian caste system designates status, economic and social roles in society, on the basis of hereditary lineage[328]. The Brahmin are widely viewed as being at the top of the caste hierarchy, due to their historical associations with priesthood[329,330]. They are often afforded a great deal of respect within caste societies. Caste is overtly present within many Hindu and Buddhist societies. Caste also occasionally influences social dynamics in South Asian Muslim, Sikh and Christian communities[330].

In contrast the Dalit caste, widely known as untouchables, typically carry out the most unpleasant and menial roles[331]. They are expected to demonstrate subservience to others, and are barred from sharing certain spaces with other castes.

India, the country most closely associated with the caste system, has criminalised caste discrimination since 1950[331]. However, the caste system still heavily informs social, political and economic life within the country[332]. The Indian and Nepalese governments have afforded certain social and economic privileges to castes, which are legally classified as disadvantaged[333,334]. In 2016, members of the influential mercantile Jat Caste, clashed with Indian security forces, and



blockaded a major supply route into Delhi. They demanded reclassification as an 'Other Backwards Caste', which would afford them certain state mandated social and economic advantages[335].

The caste system also exists amongst some South Asia diaspora communities. The United Kingdom recently stated that casteism is unlawful, under existing discrimination law. This occurred after lower caste South Asians complained that they experienced discrimination within their community[336,337].

The DSTL-Alan Turing GUARD project identifies different cultural groups passing one another in the same space as a common factor in the occurrence of conflict. An example of this is the 2007 sectarian clashes between Sunni and Shi'a groups in Baghdad[95]. This manifested into the emergence of sectarian death squads, who targeted and killed members of their respective rival group[338].

As the core of human activity becomes overwhelmingly centred in heterogeneous urban areas, administrators in some countries have prioritised positive ethnic relations amongst urban communities. This is expressly intended to mitigate potential conflict between ethnic groups. An example of a country that has sought to promote positive ethnic relations betweenits inhabitants is Singapore, as can be seen on the next page[339].

Singapore's Social Defence

The Singaporean Government's Centre for Strategic Futures (CSF), identifies its willingness to implement social engineering as a key component of the city-state's largely peaceful existence as an ethnically diverse society. The Singaporean government policies, such as ethnic quotas for housing, contrasts France's political unease discussing ethnicity, and the terrorism and violence it suffers as a result of its social disparities[319].

Notably, Singapore practices a strategy known as "*Total Defence*". This merges the military component of national defence with social factors that underpin the military, and the willingness and ability of Singaporeans, to support the country in times of conflict. This framework is taught in schools and is marked by an annual holiday. Within this strategy, Social Defence frames Singapore's shared national identify and promotes social harmony amongst the country's different races, as both a military priority and a social responsibility[339].

This serves as a means to prevent internal violence, and wide support of a culturally and ethnically diverse population; in the face of external threats.

Age and Gender Demographics

The majority of future cities are likely to be inhabited by young people, and be affected by Asia and Africa's population booms. The population of cities are becoming increasingly younger, with the UN Human Settlements Programme estimating that 60% of urban populations will be under the age of 18 by 2030[340]. Concurrently, longer life expectancies and decreasing birth rates in many Western countries, is leading to an increase in elderly and retired people, relative to the younger working population[341]. Aperion Care, an American healthcare provider, report that by 2050 the proportion of the global population aged 65 and older, will have doubled, from 10% to 20%. 70% of this population will live in urban areas[342].

In countries with an increasingly elderly population, there will be growing pressure on governments to spend public money, and tailor urban infrastructure, to the benefit of older segments of society[343]. Within societies that do not have sufficient resources to cover this cost, younger people in society will bear much of the brunt[343]. Taxes may be raised or money may be diverted from other public services, such as education and defence, to cover this expense[344].

However, the current trend is to mitigate this economic challenge, by reassessing the concept of old age. This has resulted in some countries raising the retirement age, and a higher age requirement for public assistance geared towards the elderly[345].

Youth Bulge

Population growth can serve as a conduit for economic growth in developing countries. Advanced medical care and health standards have drastically reduced child mortality. As a result many of those who would have died at birth or in early childhood, are living into adulthood[341]. Therefore, many poor and previously poor countries, are undergoing a demographic change, known as a 'youth bulge', characterised by a large working population, relative to its economically inactive elderly[346]. Thus as young people increasingly move to the city, they will provide opportunities for economic growth[347].

However, this demographic trend also brings risks. Conflict predictors often correlate the number of young men in an area, with the likelihood and severity of armed conflict[348,349]. This is because young men are more willing to engage in risk-taking behaviour, such as criminal activity and warfighting[350,351,352]. While this can be tempered by the stabilising influence of having a family, in societies where there is a gender imbalance, many men will struggle to find a partner[353]. An example scenario would be as a result of female infanticide, or gender specific migration. Partially for this reason, conflict is prone to arising in societies where wealthy men frequently have several wives[354]. Conversely, the armed forces of aged countries often struggle to recruit[355,356,357].

Greek youths riot following the shooting of a teenage boy by the Greek police. The shooting was the catalyst for wider violence thought to be rooted in economic inequality and perceived government corruption: Athens, Greece 2008

Insufficient youth employment also contributes towards conflict. The World Economic Forum's 2018 Global Risk report states that:

> *"[…] concerns are rising about the growing prevalence of low-quality employment and the rise of the "gig economy". Youth unemployment is set to remain an important global challenge – particularly as demographic shifts in developing countries gather pace — and will continue to amplify numerous domestic and global risks, including social exclusion, mass migration and generational clashes over fiscal and labour-market policies"*[358].

Urban areas often contain large numbers of young people, living in close proximity to each other, seeking to prove themselves[348]. When unemployed people are unable to find a role within civil society, they (particularly young unemployed men) may come to consider themselves socially separated from the mainstream. Criminal gangs and armed groups appeal to potential recruits, as a result of these mind-sets and grievances. Potential recruits may already support causes themselves, through varying levels of engagement with criminality and black markets[349].

The youth unemployment rate across rapidly urbanizing Middle Eastern and North African countries, is thought to contribute to the region's instability[359].

Wealth and Social Status

Cities are also likely to see significant wealth divide between its inhabitants, particularly those who live in interconnected, but economically disparate urban areas[360,361]. Many of the world's major cities currently see significant levels of inequality between its inhabitants[362,363]. Italian statistician Corrado Gini invented the GINI coefficient in 1912, and is now a widely accepted measure of income inequality; with 100% measuring a situation whereby only one person in a country possesses all the resources, and 0% in which they are evenly shared. In 2013, Salvador, Rio de Janeiro and Sao Paulo were found to be the three cities with the highest GINI coefficients[362], with scores of 65%, 62% and 55% respectively[363,364].

As wealth inequality becomes more apparent in compact urban areas, comparatively poorer inhabitants become more aware of the differences, resulting in social tensions[365,366]. Horizontal inequality between different social groups, is often a feature of areas with high levels of violent crime[367,368].

It should be noted that wealth-based social tension, is not strictly a result of discomfort over relative differences in wealth, but rather stems from a natural urge to achieve individual, and collective, social rank and status, of which wealth is often representative[369].

Digital Segregation

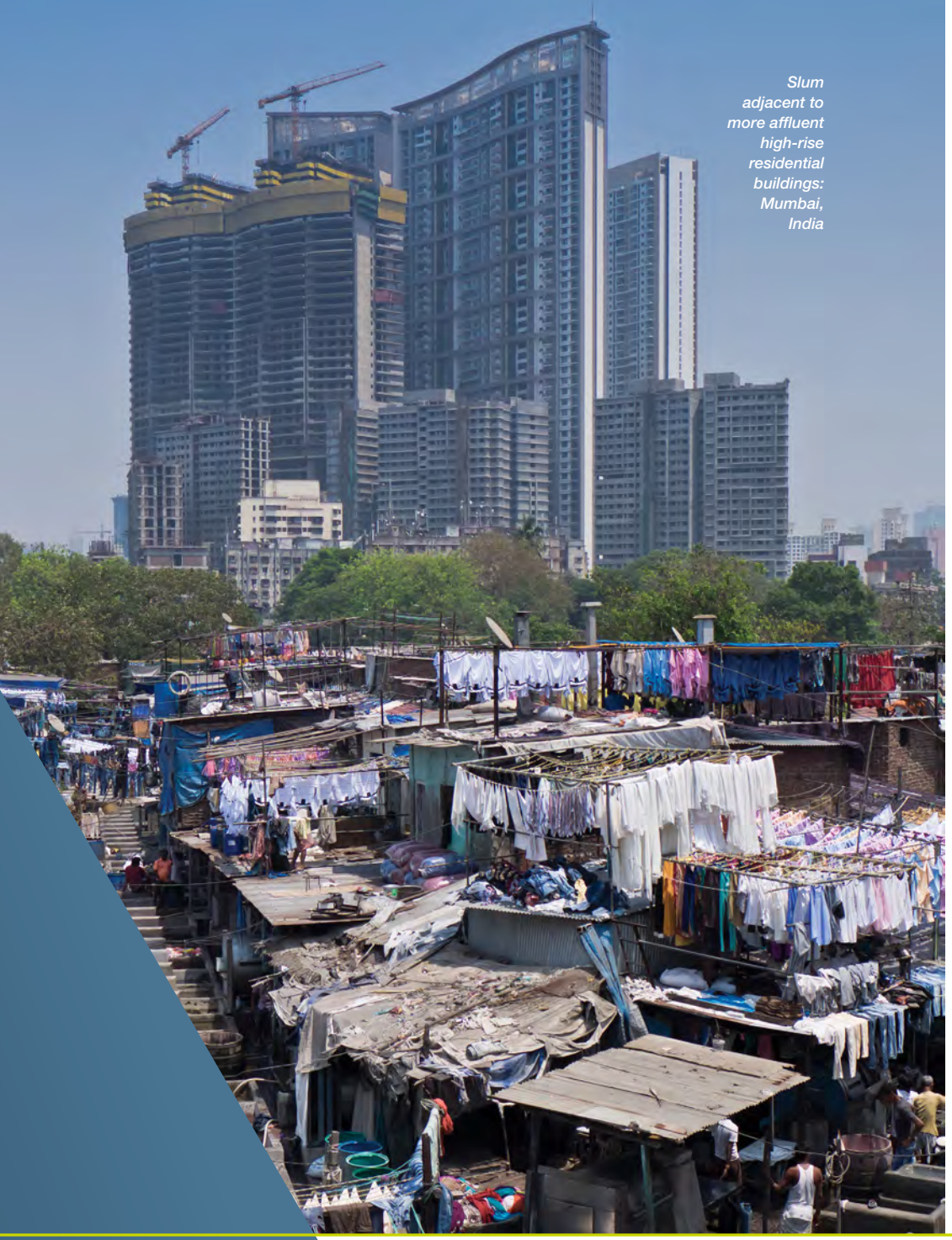
The Townsend Centre for International Poverty Research, has said that people can be considered improvised when their "[...] resources are so seriously below those commanded by the average individual or family that they are, in effect, excluded from ordinary living patterns, customs and activities"[369].

In a smart city environment, there will be people who are impoverished, or excluded from "ordinary living patterns, customs and activities", by their inability to engage with the digital mediums, upon which Smart Cities function[370].

Many people may not be able to afford the online tools, or services, upon which the smart city processes are accessed and utilised[371]. Further exclusion may stem from an inability to understand the language in which information is shared[372].

In China internet users are banned from searching, or accessing information, that is not approved by the state. This online censorship, carried out through a large intranet system popularly known as 'the Great Firewall of China', prompted former Google CEO Eric Schmidt to predict that the Internet will split in two, with one half "led by China"[373,374].

Favelas: Rio de Janeiro, Brazil



Slum adjacent to more affluent high-rise residential buildings: Mumbai, India

Military Implications

Mixed Demographics

The increasingly mixed demography of cities, within specific districts and individual buildings, will result in different groups of inhabitants which adhere to distinct routines, and hold different, yet occasionally intertwining, cultural perceptions. This is not a new phenomenon, but the scale, density and complexity of emerging urban societies, will necessitate the UK Military to be aware of the diversity of cultural considerations, inherent in many urban operations. These include, but are not limited to:

- Differing conceptions of political legitimacy; and therefore the channels for obtaining and maintaining leadership positions, the recognised decision making processes, as well as expectations of civil administration, security and law enforcement
- Religious, cultural and social routines and events
- Differing attitudes towards the UK Military presence, and acceptance of their activities. For example, security measures such as curfews, and a visible presence in culturally sensitive areas of the city
- Influential actors such as:
  - Local Militias
  - Gendarmeries
  - Private Military and Security Companies
  - Criminal gangs
  - Tribal and local leaders
  - National governments and institutions

Ultimately, urban operations of the future, will put an even greater emphasis on the importance of information operations; regardless of whether the operation is war-fighting, counter-insurgency, humanitarian assistance or disaster relief.

Continued investment will need to be made by the UK military in training cultural advisors. These should be consulted regularly to understand how the perceptions and practices, of different groups in a multicultural urban environment interact, and potentially contradict each other. These advisors should also be employed in the development of the pre-conflict city database.

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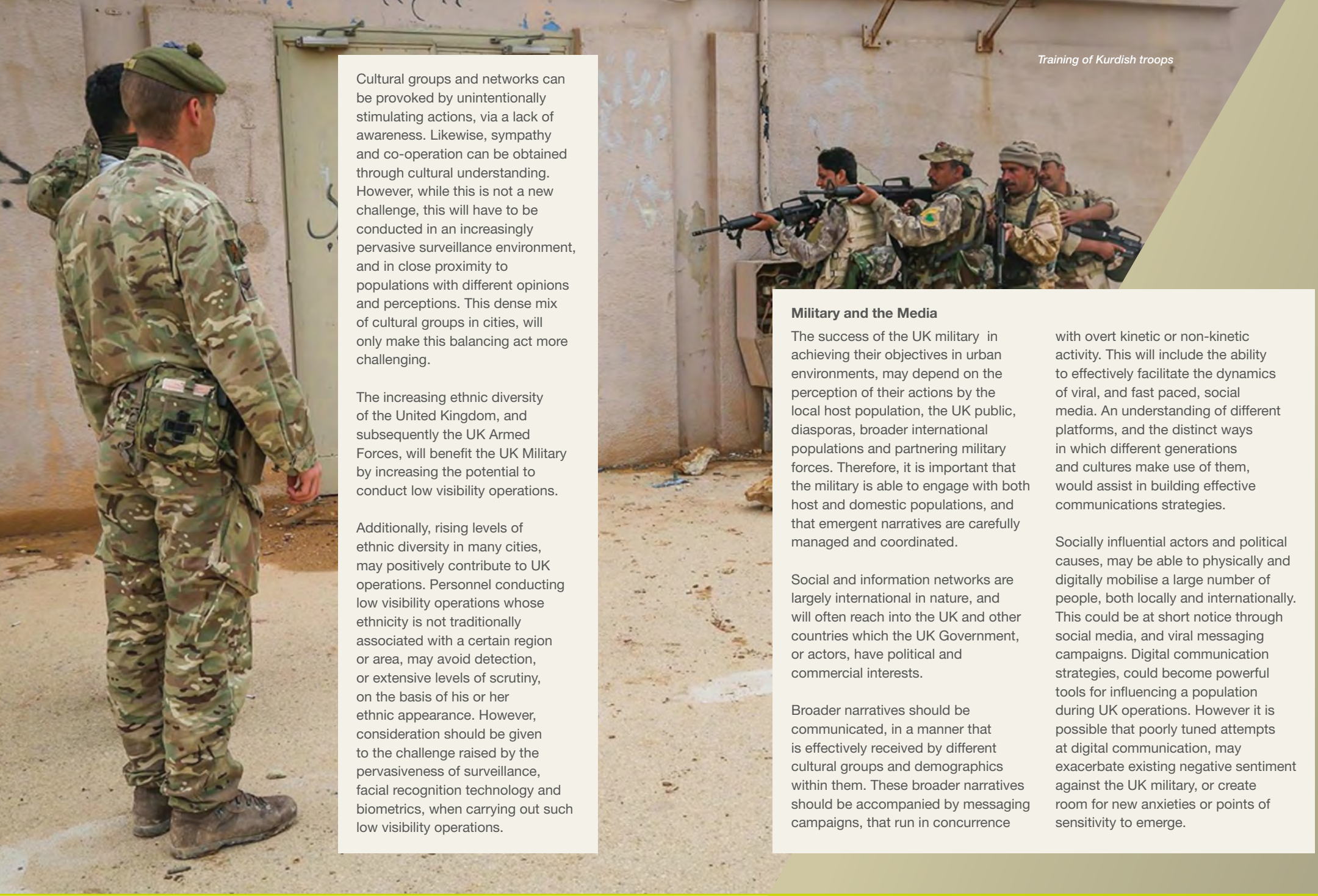


Training of Kurdish troops

Cultural groups and networks can be provoked by unintentionally stimulating actions, via a lack of awareness. Likewise, sympathy and co-operation can be obtained through cultural understanding. However, while this is not a new challenge, this will have to be conducted in an increasingly pervasive surveillance environment, and in close proximity to populations with different opinions and perceptions. This dense mix of cultural groups in cities, will only make this balancing act more challenging.

The increasing ethnic diversity of the United Kingdom, and subsequently the UK Armed Forces, will benefit the UK Military by increasing the potential to conduct low visibility operations.

Additionally, rising levels of ethnic diversity in many cities, may positively contribute to UK operations. Personnel conducting low visibility operations whose ethnicity is not traditionally associated with a certain region or area, may avoid detection, or extensive levels of scrutiny, on the basis of his or her ethnic appearance. However, consideration should be given to the challenge raised by the pervasiveness of surveillance, facial recognition technology and biometrics, when carrying out such low visibility operations.

Military and the Media

The success of the UK military in achieving their objectives in urban environments, may depend on the perception of their actions by the local host population, the UK public, diasporas, broader international populations and partnering military forces. Therefore, it is important that the military is able to engage with both host and domestic populations, and that emergent narratives are carefully managed and coordinated.

Social and information networks are largely international in nature, and will often reach into the UK and other countries which the UK Government, or actors, have political and commercial interests.

Broader narratives should be communicated, in a manner that is effectively received by different cultural groups and demographics within them. These broader narratives should be accompanied by messaging campaigns, that run in concurrence with overt kinetic or non-kinetic activity. This will include the ability to effectively facilitate the dynamics of viral, and fast paced, social media. An understanding of different platforms, and the distinct ways in which different generations and cultures make use of them, would assist in building effective communications strategies.

Socially influential actors and political causes, may be able to physically and digitally mobilise a large number of people, both locally and internationally. This could be at short notice through social media, and viral messaging campaigns. Digital communication strategies, could become powerful tools for influencing a population during UK operations. However it is possible that poorly tuned attempts at digital communication, may exacerbate existing negative sentiment against the UK military, or create room for new anxieties or points of sensitivity to emerge.

Vertical Buildings as Territory and Symbols of Power

Within densely populated areas, displaced and marginalised groups may increasingly seek to create their own society, outside of the rules based system of the governing state. As a result, slums can emerge as distinct political entities[375,376]. According to the UN's Slum Almanac 2015/2016, one-eighth of the world's population live in slums. As cities become more crowded, and the population of slums struggles to expand horizontally, informal societies will become increasingly vertical[377]. Vertical informal housing is built and utilised without the explicit permission or support of the state, and may include the occupation of dilapidated or unfinished buildings by 'squatters'[378].

Kowloon Walled City (below) was a large vertical slum, originally a 19th century Chinese military fort. The settlement was the world's most densely populated area for two years, until its demolition in 1993. This compact collection of vertical slums was a self-contained community[379], overseen for much of its history by the Triads, a group of organized Chinese criminal networks. They established brothels, gambling parlours and opium dens, amongst the compact vertical housing and stores. During the Walled City's existence, the residents of the slum managed to avoid the regulations and taxation, which affected much of the rest of Hong Kong[380].

Kowloon Walled City: Hong Kong, 1989

As the population density of Asian cities increases, areas akin to the Kowloon City are highly likely to emerge. For example, Dharavi is a densely populated slum in Mumbai, comprising of an estimated 1 million residents within a space of 2.16 square kilometres[381], making it one of the most densely populated areas on earth[382]. Many buildings within the slum are multi-storied, and the area contains a variety of religious and ethnic communities[383]. The origins of the slum can be traced back to the 19th century, and it has an estimated annual turnover of over 1 billion US dollars[384,385]. A portion of Dharavi's economic output stems from the slum's 15,000 single room factories[385].

As certain areas of cities become more densely populated, governments are becoming less tolerant of informal settlements or slums. These are often perceived to be detrimental to investment[386,387]. Such areas inherently exist outside of the formal rules based systems, and typically house those who are unable, or unwilling, to move to formal housing; for financial, social or legal reasons. These areas can become safe-havens for organised crime[388]. Within the future urban environment, those attempting to deal with areas outside of state control, will increasingly encounter vertical buildings, which are either illegally constructed or occupied.

Ponte City Apartments: Johannesburg, South Africa

Torre de David, Caracas, Venezuela

The occupation of abandoned buildings by criminal actors, is often a challenge for urban security forces. Criminal gangs in Johannesburg, have invaded dilapidated apartment and office blocks in the city centre, and illegally collect rent from the urban poor who squat within them[389]. Legally recognised property owners, seeking to reclaim and develop these buildings, have hired private security firms who specialise in clearing these vertical spaces[390,391].

Prominent vertical buildings are often symbolic of the cities which host them, alluding to their political and economic condition[392]. Johannesburg's Ponte City Apartments (see page 115) is one of the most renowned on the city's skyline. The once fashionable apartment complex's abandonment, criminal 'hijacking' and eventual reclamation, have been used to comment on the condition of the host city, being indicative of the municipal and national aspiration[393].

Occupied buildings can fall into neglect, due to the carelessness or incompetence of their criminal management; while still maintaining an internal economy, and function as both residential and commercial centres.

From 2007 to 2014 Caracas's 45 floor tower "Torre De David" (see opposite) was occupied, and according to some estimates reached an approximate peak population of 5,000[394]. The occupied skyscraper contained gyms, shops, a beauty salon and a dental practice[395,396].

The tower block was governed by gangsters, and soon became known as a safe haven for criminals, and a rumoured prison for at least one kidnap victim[397].

The criminal government of the building, applied the relatively sophisticated system used by Venezuelan prisons to govern detainees[396]. The system comprised of three 'departments':

1. surveillance and security
2. healthcare
3. recreation activties[396]

Eventually, the government relocated the block's inhabitants to social housing[397]. Their willingness to leave was likely a result of widespread grievances, with broken elevator systems, criminality, and flawed water and electric systems[396].

Social Housing

Physical height, including that of buildings, is traditionally associated with wealth and social prestige[398]. Thus various governments have sought to elevate the standing of society's poor, by ordering the construction of vertical social housing. The concept in which the poor are given access to the prestige associated with physical height, informed much of the architecture of Western social housing developments, between the 1930s and 1970s[399]. Verticalisation continues to inform the social housing projects of Asian countries. In Singapore roughly 80% of the city state's inhabitants live in government provided housing, managed by the government's Housing and Development Board[400].

Social housing can also be used to encourage, or discourage, certain behaviours. In the United Kingdom, residents of social housing can be evicted for "serious anti-social behaviour", such as drug-dealing[401]. In Singapore, the design and management of social housing, is intended to facilitate government schemes, in which people receive grants and tax cuts for living near their elderly parents. Additional housing incentives encourage couples to marry and become parents, in order to boost the country's falling fertility rate[402,403,404].

Social housing: Singapore

When specifically designed for society's poor, social housing can concentrate people, who may resent societal inequality, due to their own comparatively low income and social status[405]. This may lead to crime being concentrated within more deprived social housing. It has been argued that social housing is largely peaceful, and this reputation stems from highly publicised, yet unrepresentative cases, and that opinions of such housing developments are distorted by racial prejudice[399].

One of the most politically useful purposes of social housing, is that it allows the urban poor to exist within the sphere of legality, and when administered and policed correctly, live away from predatory slum landlords[406,407]. Housing can also be formalised by issuing legally recognised property deeds, to the residents of slums[408].

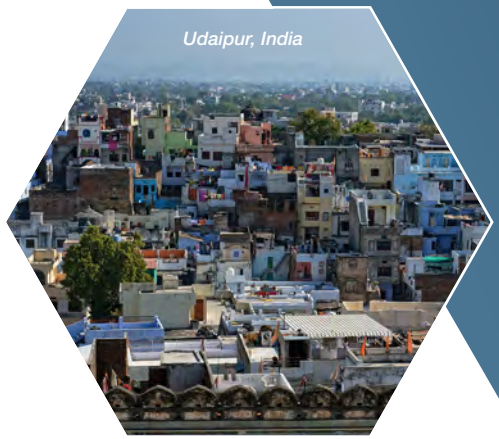
In some countries, the vast majority of houses are owned by the state, to ensure social stability. As previously mentioned, 80% of Singapore's housing is supplied by the state, this is usually done on a 99 year lease[402,409]. 93% of Israeli land is owned by the state, with leases typically lasting either 49 or 98 years[410], and in China residential leases from the state last 20 or 70 years[411]. Leases can usually be renewed for a fee, generating income for the state.

States which own or otherwise directly control land, will often use this land for geostrategic purposes. For example, Singapore's social housing constitutes part of its Total Defence policy[339]. This seeks to reduce social tensions between different ethnic and racial groups, ensuring that internal threats do not arise out of societal disharmony within the city state. In Israel, applications to lease land can be denied, "in order to prevent the transfer of land ownership to unwanted entities, to implement security policies, and to allow for the execution of national projects such as the absorption of immigrants, the dispersion of the population, and agricultural settlement"[412]. In urban areas in China, the state can appropriate land according to a loose definition of the 'public interest'[413].

Citizenship and Land Possession

In some countries, direct foreign ownership of property is limited by the state. New Zealand bans non-citizens and those without a residence permit, with the exception of Australians and Singaporeans, from owning existing homes; in order to prevent demand from foreigners driving up market prices, to the extent they are unaffordable for locals[414,415].

Thailand insists that 51% of a building is owned by Thai Citizens, meaning that foreigners can only fully own a minority of units in condominiums or apartment blocks, or indirectly own a building through a commercial company[416,417].



Udaipur, India

India prevents non-residents from owning land, unless inherited, with the exception of "Non-Residential Indians and Persons of Indian Origins"; those of Indian descent, but not citizenship. This last group is permitted to buy residential and commercial property, but not designated agricultural land[418].

By allowing foreigners of Indian descent to purchase land, Indian cities are becoming increasingly globalised; with much of its internationalisation being facilitated by those whose loyalty is presumed on the basis of their ethnicity, or national origin.

As immigration leads to greater complexity in the social and economic landscape of cities; many countries that produce a significant number of migrants, are likely to seek the political and economic assistance and support of their diaspora. This may be done through distinctions, such as those made by the Indian government[419].

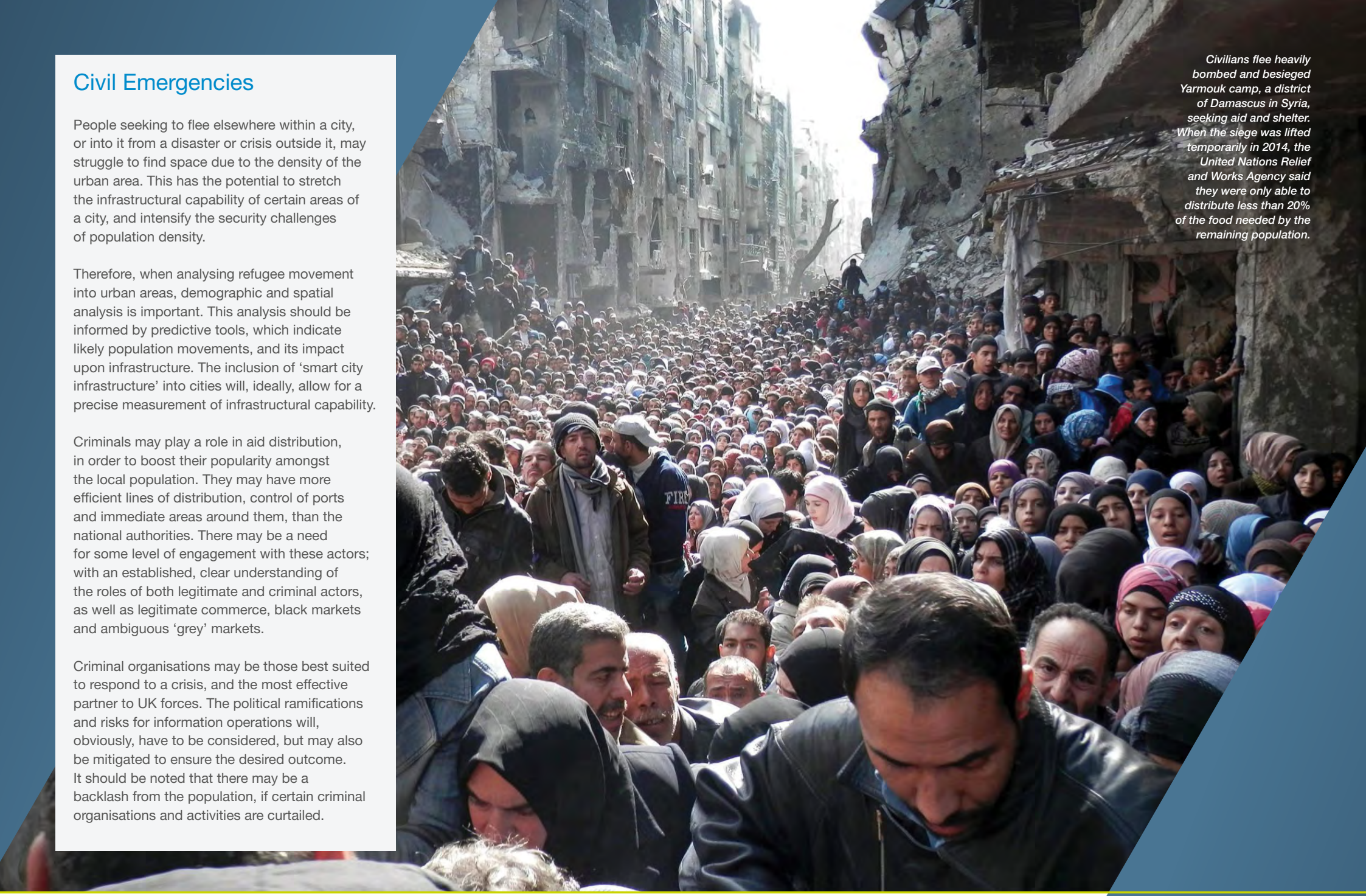
Civil Emergencies

People seeking to flee elsewhere within a city, or into it from a disaster or crisis outside it, may struggle to find space due to the density of the urban area. This has the potential to stretch the infrastructural capability of certain areas of a city, and intensify the security challenges of population density.

Therefore, when analysing refugee movement into urban areas, demographic and spatial analysis is important. This analysis should be informed by predictive tools, which indicate likely population movements, and its impact upon infrastructure. The inclusion of 'smart city infrastructure' into cities will, ideally, allow for a precise measurement of infrastructural capability.

Criminals may play a role in aid distribution, in order to boost their popularity amongst the local population. They may have more efficient lines of distribution, control of ports and immediate areas around them, than the national authorities. There may be a need for some level of engagement with these actors; with an established, clear understanding of the roles of both legitimate and criminal actors, as well as legitimate commerce, black markets and ambiguous 'grey' markets.

Criminal organisations may be those best suited to respond to a crisis, and the most effective partner to UK forces. The political ramifications and risks for information operations will, obviously, have to be considered, but may also be mitigated to ensure the desired outcome. It should be noted that there may be a backlash from the population, if certain criminal organisations and activities are curtailed.



Civilians flee heavily bombed and besieged Yarmouk camp, a district of Damascus in Syria, seeking aid and shelter. When the siege was lifted temporarily in 2014, the United Nations Relief and Works Agency said they were only able to distribute less than 20% of the food needed by the remaining population.

Chapter 5

Actors

Sovereignty and Legitimacy

As the world becomes increasingly urbanised, an increasing proportion of the global population will live within ethnically and culturally diverse environments[420]. In environments whereby not all segments of society have, or prioritise a shared identity, it will become difficult for governments to obtain sovereignty, and act with the political support of their populations[421,422].

The different cultural groups, which make up the urban population, are likely to be different from one another with regard to requirements they will impose on those wishing to be perceived as a legitimate authority, possibly causing conflict[423]. In cities there are numerous groups, to whom different sections of the population owe allegiance[424]. This reflects some non-western conceptions of political allegiance and decision making[425]. States which share power with such alternative governance structures, are known as 'hybrid-states'[426,427].

Some states exist in partnership with non-state groups, such as private corporations and criminal actors[428,429]. Some of these actors partake in activities, that undermine what the UK deem to be acceptable civil administration[430,431].

Governments may recruit combatants from the rural area, to confront opposition from segments of the urban population. A clear example of this occurred in 1990, when the Romanian government used rural miners to attack students protesting in Bucharest[432]. More recently, Egypt's military regime recruited street fighters from Cairo's surrounding areas, to reinforce the police force during the 2011 battle in Tahrir Square[433].

Cairo, Egypt: Protesters occupy Tahrir Square during anti-establishment demonstrations, 2012. This was part of the much wider Arab Spring, a mostly urban centric, popular revolution that saw several long-established governments fall across the Islamic world.

Istanbul, Turkey

The Growing Political Autonomy of Cities

As the economic and social bonds between rural and urban populations weaken[2], the two are increasingly likely to seek a level of political separation from one another, as sentiments of shared symbols and experiences fade. Irritated by divergent material, political and social interests; cosmopolitan cities, and the more homogenous rural areas are likely to be increasingly opposed being bound by one another's political priorities, and electoral decisions[2,434,435].

This type of divide was highlighted during the UK's 2016 referendum, on membership of the European Union. There was a noticeable difference between rural and urban voting patterns and London, which particularly voted to remain, with a significant difference from the rest of England[436]. During the 2017 Turkish constitutional referendum granting Turkish President Recep Tayyip Erdoğan extended powers, there was a divide between the electorate in cities such as Ankara, Istanbul (above) and Izmir, compared with rural populations[437].

London Mayor Sadiq Khan has endorsed a report arguing the city should have "[…] greater tax-raising powers and the freedom to implement policies to stimulate the local economy without Whitehall interference"[438].

PriceWaterhouseCoopers advises poorer governments to increase tax rates, and make it's collection more efficient, in order to meet the short term costs of urban population growth. This immediate financial cost to the generally wealthier urban population, is likely to contribute to tensions between urban residents and national governments[291,439].

This socio-economic divide lends weight to the argument of those advocating urban decentralisation. Divisions between cities and their hinterlands, have given rise to several variations on what some political scientists and geographers have forecasted, as a return of the 'city state'. Under such forecasts, cities will obtain varying degrees of political autonomy, in order to prioritise their own interests[440,441,442]. The current and emerging situation of the majority of the population will reside in an internationally linked but highly localised environment.

Mayors as International Statesmen

As mayors increase in political relevance, at the local and national levels, their international presence also increases[443]. Throughout his tenure as Mayor of London from 2008-2016, Boris Johnson conducted numerous high profile international visits, including trips to Southeast Asia and the United States. The picture left features the (then) US Secretary of State John Kerry, holding a joint press conference, and question and answer session, alongside the Mayor of London, Sadiq Khan in 2016[444,445,446].

Several American cities have opened Mayoral offices for international engagement, including New York, Detroit and Los Angeles[447,448,449]. These offices seek to maintain positive relations between the city and foreign nations. International engagement by cities was praised by then Secretary of State John Kerry, stating that "[…] the State Department…understand[s] the very valuable role that cities can play […] in the space where foreign policy and urbanisation meet on issues ranging from economic opportunity to security"[450].

Japanese Yakuza members publicly display their gang tattoos at an annual festival: Tokyo, Japan

Criminals

The UK designates certain actors as criminals, whose presence and actions are undesirable. It should be stressed that it's perception is not universal. Different cultures have context specific beliefs over what constitutes a transgression, against a collectively established set of rules[451]. The perspective that criminal groups are equivalent actors to formal states, can be reinforced by the failure of governments to develop and maintain the necessary infrastructure and resources, to support the increasing urban population[451].

In the absence of security, employment, basic needs such as sanitation, water and housing; many cities around the world are turning to non-state actors, including criminal networks, as an outlet for obtaining social status[452].

The acceptance of criminal actors, as legitimate administrators of the public order, is not limited to impoverished communities who feel abandoned by the state. In many instances, actors who are recognised as legitimate by the international community, such as local and national governments, commercial, ethnic, tribal and religious organisations, may recognise those deemed to be criminal actors as playing an important societal role[453,454].

In those cities around the world, such as Karachi[455], Naples[456] and the Favelas of Rio De Janeiro[457], criminal gangs perform tasks which are widely assumed to be the sole remit of the state. As the state becomes unable to secure the loyalties of increasingly populated urban areas, criminals may further come to assume the role of the state; obtaining a degree of loyalty amongst sections of the population[458].

Criminals as Community Leaders

Pablo Escobar was responsible for the deaths of more than 4 thousand people, as part of his involvement in the cocaine trade between 1975 and his death in 1993[459]. However, there are still many who consider Escobar to be a folk hero, within a strand of South American culture known as 'Narcoculture', which views drug traffickers to be romantic outlaws, and symbols of social and financial aspiration[460]. The local government has attempted to publicly oppose this, by demolishing his former home[461]. However Escobar is seen as having provided economic and social opportunities and support to the local population, when the Colombian state did not[462].

A visible example of this is the barrio (neighbourhood) Escobar built, founded and financed in Medellin. It is still referred to by the local populace, as "Barrio Pablo Escobar". Formerly, this area had been underdeveloped, and many of the people living there had been destitute. However, Escobar built housing, schools and even a library in the area, which were then used by the local community[463].

Criminal gangs will often try to endear themselves to the broader population, by providing material support that would normally be provided by the state. For example, following the 2011 Japanese Tsunami, the Japanese Yakuza were amongst the first to distribute food, water and blankets[464].

Another example, is the notorious New Zealand based Mongrel Mob Biker Gang, heavily known to be involved in distributing methamphetamine. They have partnered with the Salvation Army to run a rehab scheme, to help those addicted to the drug[465,466].

Jesús Malverde is a Robin Hood-like legend in the Mexican state of Sinaloa where he is viewed as a 'patron saint' of the illegal drugs trade, for many he is a religious and cultural icon

Commercial Organisations

As cities become increasingly complex and globalised, much of the infrastructure and resources, including critical national infrastructure (such as water, transport and electricity), will be managed by profit orientated businesses, and supported by the expertise of their employees and contractors[467,468]. In 2018 the UK government reported that the majority of critical national infrastructure is privately owned, with a 2011 estimate stating that the proportion was possibly as high as 80%[469]. In many areas, the private sector has superior technical competencies and organisational capabilities, compared to governments. Therefore urban development is often a collaborative effort, between public and private sectors[470,471,472].

Private companies can be obliged, or incentivised, to act on behalf of a state. This may involve acts such as espionage, a willingness to have its assets commandeered by the government, or simply align its financial investment or corporate identity with a government's geopolitical interest[473].

States can influence domestic, foreign and transnational businesses; private companies will attempt to influence governments, to make decisions that they perceive to be beneficial to their commercial interest[474]. Companies that align closely to a certain state, will sometimes experience backlash from other governments.

For example, Huawei, which is legally obliged to assist the Chinese state in loosely defined matters of national security, has been excluded from 5G networks by the governments of Australia, the United States and New Zealand[475].

Apple Store: New York City, USA

In the future governments may seek economic growth, by allowing specific cities exemptions from national legal and commercial frameworks; in order to attract international investment, and increase economic productivity. Much of these separate legal systems will be designed by private companies, further entrenching the influence of private commercial companies, in urban life and governance.

For example, Saudi Arabia plans to build a large city, called Neom, on its border with Jordan and Egypt. The Saudi Arabian government seeks to attract the "world's greatest minds and best talents", in order to create the "largest city globally by GDP" (Gross Domestic Product). However, it is acknowledged that in order to attract a skilled international population, there will have to be exemptions to Saudi Arabia's conservative legal system and social norms. Therefore the planned city, designed partly with the help of consultancy firms such as McKinsey and Company and Boston Consulting[476], seeks to have a separate legal system, which is currently being designed by American law firm Latham and Watkins[476].

The Official Logo of Neom

NEOM نيوم

Military Implications

Military Operations and Alternative Governance

Within many cities the UK military will increasingly come into contact with decision making institutions; which are distinct from legitimate governmental institutions, as recognised by the UK government. The UK military and wider government may need to explore their willingness to tolerate, or potentially cooperate with, 'white', 'orange', 'green' and 'black' actors*; including private companies, non-governmental organisations, non-state militias and criminals.

The different forms of governance that the UK will have to interact with could be extensive with national, international, city, district, neighbourhood, street and even sections of buildings; having their own 'legitimate' leaders, with varying authorities and potentially conflicting roles.

The UK may conduct operations in a city at the behest of the host nation, yet find that the city's governance is not aligned with the host nation's ideals or policies. This could put the UK in a very difficult position.

Some organisations owe political loyalties to different states and socio-cultural groups, and will act accordingly. There will likely be situations in which the UK military will encounter groups, that challenge seemingly established boundaries, regarding private involvement in international politics and warfare. There is therefore an incentive, for the UK government to ensure it can leverage transnational linkages, between communities for strategic purposes. It should be noted that any substantial manipulation of the private sector, will have significant second and third order effects, which may then lead to unpredictable outcomes.

* *Actor Colour Guidance from MOD Wargaming handbook:*

White: *National and supranational political organisations and diplomats, humanitarians, international organisations and non-government organisations*

Orange: *Armed non-state actors*

Green: *Indigenous security forces*

Black: *Organised and transnational organised criminals*

Cities and Private Military and Security Companies

The majority of buildings and many urban spaces, are considered to be private and semi-private spaces. In such environments, private security is generally considered more acceptable, than it would be patrolling the streets. Using Private Military and Security Companies (PMSCs) for securing buildings, might become a significant force multiplier, and this option should be explored; as it would allow PMSCs to focus on securing a single building, while the military can focus on patrolling the external areas.

Much of a city's infrastructure will be owned by private companies, who will employ large numbers of a city's population. It is possible that corporate competition, will extend beyond contemporary industrial espionage, into orchestrating cyber-attacks and even carrying out kinetic attacks. This is already the case in Beirut, where rival electricity generator companies have held running gun battles with one another.

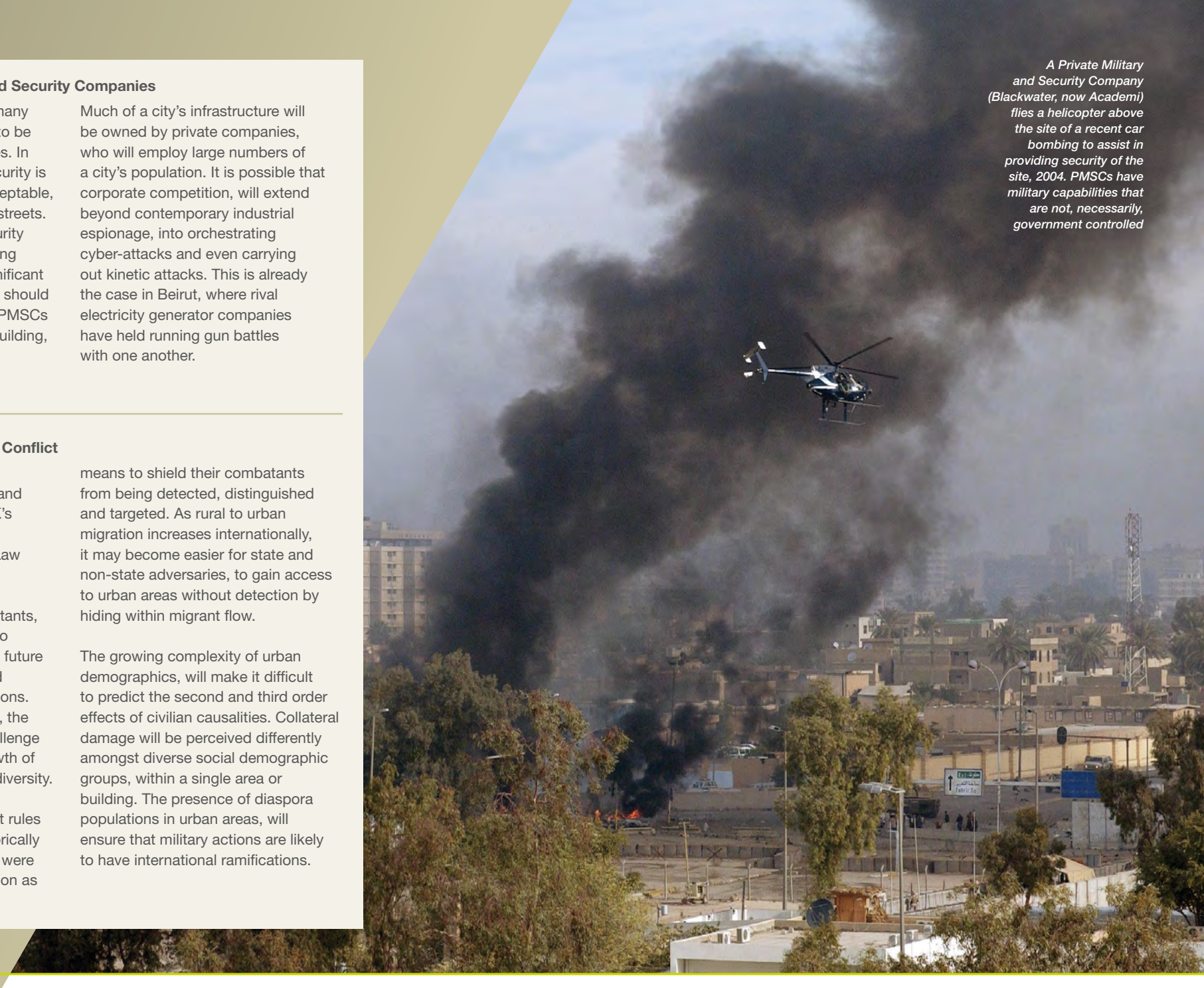
Upholding the Law of Armed Conflict

Changes within the urban environment, will present new and evolving challenges, for the UK's military ability to adhere to the fundamental principles of the Law of Armed Conflict (LOAC).

Distinguishing between combatants, and non-combatants, is likely to become increasingly difficult in future cities; due to large, diverse and densely located urban populations. While this challenge is not new, the scale and frequency of the challenge will only intensify, with the growth of population density and social diversity.

The need to adhere to stringent rules of engagement, has been historically leveraged by adversaries, who were able to use the civilian population as means to shield their combatants from being detected, distinguished and targeted. As rural to urban migration increases internationally, it may become easier for state and non-state adversaries, to gain access to urban areas without detection by hiding within migrant flow.

The growing complexity of urban demographics, will make it difficult to predict the second and third order effects of civilian causalities. Collateral damage will be perceived differently amongst diverse social demographic groups, within a single area or building. The presence of diaspora populations in urban areas, will ensure that military actions are likely to have international ramifications.



A Private Military and Security Company (Blackwater, now Academi) flies a helicopter above the site of a recent car bombing to assist in providing security of the site, 2004. PMSCs have military capabilities that are not, necessarily, government controlled

Conclusion

As the overwhelming bulk of human interaction shifts to cities, the priorities of decision makers will inevitably follow. Social, economic and political links between urban centres will continue to increase. This will lead to localised occurrences within cities increasingly impacting other cities. As a result, the interests of state-level political actors, will become increasingly invested in the affairs of cities, including those which are geographically distant. The potential for tactical actions to have strategic impacts, is only made greater as cities become more important, connected and diverse (in terms of both demographics and actors).

The utilisation of smart city technology will increasingly impact economic and social activity; whilst the cultural context in which smart cities exist, will affect how this technology is applied. Routine online usage, will no longer be confined to computers and phones. Other devices will increasingly be interconnected to one another through the 'Internet of Things'. This will make use of widespread and constant data collection, to inform both machine processes and human decision making. It will, inevitably, generate opportunities and vulnerabilities for urban infrastructure. Both state and non-state actors, will have the capacity to disrupt interconnected online systems, and the infrastructural processes which rely on them.

The increasing importance of littoral urban areas, will shape the actions of decision makers. These areas will serve as a focal point for increased travel and trade, while simultaneously increasing the impact of hostile action and extreme weather events. As the urbanisation process continues, pollution and waste production will increase, changing the physical environment within cities.

To accommodate growing population densities, vertical spaces will become increasingly occupied and will form the basis of many people's lives. Verticalisation will alter hierarchies and territorial boundaries. The desire to mitigate pollution and congestion, will lead to increasingly controlled traffic management. In many cities cycling and walking will be encouraged through physically altering the environment. Autonomous forms of transport will become more common, becoming part of the smart city infrastructure; likewise many other routine functions of cities will become automated.

Sao Paulo, Brazil

Houses of Parliament: London, UK

As the environment and demography of cities change, so will its Critical National Infrastructure. Climate change, cyber-crime and the impact of urban attacks, will require physical protective measures, aimed at mitigating current and emergent vulnerabilities.

Every city will increasingly contain a uniquely amalgamated series of intersecting social and cultural networks. The individuals and groups that make up these networks, have different outlooks and behaviours, shaped by their own socio-economic and cultural conditions. When these outlooks and behaviours cannot be balanced, conflict will emerge.

This urbanisation process will occur mainly in Africa and Asia, becoming a focal point for many decision makers. This will increase the impact of non-western concepts of legitimacy and governance, and will bring diverse and conflicting views of how a society should be governed, in the same dense space. Political and social loyalties, owed to non-state actors, will become increasingly impactful. In some instances they will merge with, or replace the state's governance of urban areas.

Trends outlined in this document, will have significant impact on how the UK conducts urban operations in the future. This document should be used by military thinkers and decision makers, to start the process of preparing for this evolving and increasingly complex operating environment.

What is known is that ongoing, recent and historical conflicts have demonstrated the advantages urban terrain can grant an asymmetric force. The UK's contemporary and future adversaries, will continue the trend of offsetting conventional advantages, through the exploitation of complex urban terrain.

The UK should seek to demonstrate world-class urban operational capabilities. In particular to deter potential adversaries, who may be less assured of their ability to utilise the urban terrain advantage, from meeting their aims and objectives.

As urbanisation continues, the military must dedicate more time and effort to conducting urban operations training. Current limitations of contemporary UK urban training estates, versus real-world cities, are only going to increase with time. Therefore, serious efforts must be made to explore alternative training methods for large scale urban training, in particular virtual training options.

Preparation of UK personnel for operating in the urban terrain, should be a consistent theme throughout all levels of military training. This should include evaluations on themes, such as the suitability of protective equipment and small arms.

The increasing scale and complexity of urban areas, as well as the challenge of rapidly generating an understanding of these, means the UK military should focus on developing a database on urban areas where operations may take place. As the bulk of future urbanisation will occur in Africa and Asia, particular focus should be paid to cities within these continents. This database should be kept up to date, to ensure an accurate picture is developed on cities of interest, and take account of a variety of key factors including:

- Historical analysis of how individual cities and their networks have grown and developed
- Demographic analysis
- Information on the cultural perceptions, behaviours and routines of different demographic groups
- The identification of critical nodes, including both physical and digital infrastructure (including critical national infrastructure, key military sites, politically and culturally important sites, etc)
- Local, national and global network analysis

Due to the sprawling size of cities, mixed demographics and infrastructure, the UK military will have to increasingly engage in '3 block war'. This type of warfare refers to a situation where across different areas of the city (blocks), the military may need to be simultaneously engaged in different types of operations, such as peacekeeping, warfighting and humanitarian aid.

The UK Government should give serious consideration, to how they will ensure that the relevant forces have the adaptability and capabilities, to engage in such an operation.

As urbanisation continues, many cities are likely to become increasingly globally intertwined. The national interest will become increasingly dependent on the condition of geographically distant urban centres. Traditional tactics of isolating an urban area, or manoeuvring around them, will become increasingly incompatible with military aims and objectives. Thus the military must explore means of isolating districts within a city, as well as manoeuvring through large and urban areas.

Additionally, it is highly unlikely that the UK will be engaged independently in urban operations, and will be conducting increasing numbers of operations with allies and partners, including host nations. In many instances, the UK will not be the lead partner in an urban operation.

To prepare the UK should work to strengthen alliances and pan organisational compatibility, with potential host nations and partners, focusing specifically on overcoming the interoperability challenges posed by the urban environment.

Forces will likely have to change their roles and structure, to reflect the growing prominence and changing nature of the urban environment. For example, the possibility of 'task organising' a proportion of the UK military, to be optimised for urban operations, should be given strong consideration. There is precedent within the UK military for the specialisation of certain units for specific environments. For instance, the Royal Marines for littoral, mountainous and arctic regions, and the Royal Gurkha Rifles for jungle. These 'urban leads' could then provide subject matter expert advice to other commands, when conducting urban training and operations. This is the case with the Finnish Guard Jaeger Regiment, which is the urban specialist and leading urban training unit for the rest of the Finnish Defence Forces.

It is often thought that it is easier to adapt from urban to rural operations than vice versa, having a specialised urban environment lead would mitigate this difficulty.

As the future operating environment is going to be increasingly urbanised, the UK military must consider this environment as a primary driver of capabilities. As such, equipment procurement must focus on how these systems are relevant to urban operations, and what constraints the environment will place on them. Potential adversaries are currently procuring and fielding urban-specific systems, and the UK should too.

UK defence should explore the strengths and limitations of establishing a non-military force, to access desirable skills not traditionally maintained within the military. This would be akin to the United States Army Corps of Engineers (USACE), which employees approximately 37,000 personnel, the majority of which are civilians. USACE is able to support and perform a wide range of engineering tasks, such as responding to and mitigating the effects of natural disasters and handling toxic waste. It delivers these services to a variety of customers, including civil and military organisations. Such an entity could also provide an enhanced capability and capacity, to address the potential environmental challenges that have been identified in this report.

Ultimately, the urban environment is evolving. By recognising the trends identified in this report, the UK has the opportunity to adapt for and mitigate any challenges this evolution presents.

Royal Navy frigate HMS Westminster at West India Docks: London, UK

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Image Referencing

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5	GaWC 2010 map of Alpha Cities	ARE (Architecture Research)	https://www.lboro.ac.uk/gawc/visual/globalcities2010.pdf ***Description Reference*** https://blogs.lse.ac.uk/gild/2018/11/21/cities-multinationals-and-trade/
6-7	Incheon, South Korea buildings	(@ryoji__iwata) Ryoji Iwata	https://unsplash.com/photos/82wqqzlq2Qw
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Appendix

Urban population as a total percentage of total population.
2018 World Urbanization Prospects.

Country Name	1980	2018
Afghanistan	15.995	25.495
Albania	33.762	60.319
Algeria	43.542	72.629
American Samoa	74.33	87.153
Andorra	92.064	88.062
Angola	24.298	65.514
Antigua and Barbuda	34.618	24.599
Arab World	44.84658	58.92542
Argentina	82.887	91.87
Armenia	66.05	63.149
Aruba	50.472	43.411
Australia	85.552	86.012
Austria	65.391	58.297
Azerbaijan	52.777	55.68
Bahamas, The	73.102	83.025
Bahrain	86.101	89.287
Bangladesh	14.851	36.632
Barbados	40.102	31.147
Belarus	56.498	78.595
Belgium	95.381	98.001
Belize	49.374	45.724
Benin	27.339	47.312
Bermuda	100	100
Bhutan	10.132	40.895
Bolivia	45.451	69.425
Bosnia & Herzegovina	35.543	48.245
Botswana	16.479	69.446
Brazil	65.468	86.569
British Virgin Islands	22.741	47.723
Brunei Darussalam	64.949	77.629
Bulgaria	62.1	75.008
Burkina Faso	8.805	29.358
Burundi	4.339	13.032
Cabo Verde	23.518	65.732
Cambodia	9.898	23.388
Cameroon	31.921	56.374
Canada	75.663	81.411
Caribbean small states	46.41478	51.19936
Cayman Islands	100	100
Central African Republic	33.874	41.364
Central Europe & The Baltics	57.70226	62.33208
Chad	18.787	23.059

Country Name	1980	2018
Channel Islands	32.209	30.914
Chile	81.243	87.564
China	19.358	59.152
Columbia	63.738	80.778
Comoros	23.215	28.965
Congo, Dem. Rep.	27.072	44.46
Congo, Rep.	47.857	66.916
Costa Rica	43.099	79.34
Cote d'Ivoire	36.829	50.779
Croatia	47.285	56.947
Cuba	68.106	77.037
Curacao	81.769	89.145
Cyprus	58.614	66.81
Czech Republic	75.167	73.792
Denmark	83.723	87.874
Djibouti	72.096	77.777
Dominica	46.759	70.483
Dominican Republic	51.29	81.074
Early-demographic dividend	30.63371	45.13126
East Asia & Pacific	27.73037	59.05279
East Asia & Pacific (excluding high income)	21.33861	55.63359
East Asia & Pacific (IDA & IBRD countries)	20.87503	55.55509
Ecuador	46.961	63.821
Egypt, Arab Rep.	43.858	42.704
El Salvador	44.099	72.023
Equatorial Guinea	27.872	72.143
Eritrea	14.39	
Estonai	69.711	68.88
Eswatini	16.478	23.799
Ethiopia	10.41	20.763
Euro area	69.92332	76.99173
Europe & Central Asia	64.95402	72.18351
Europe & Central Asia (excluding high income)	58.18913	66.94738
Europe & Cental Asia (IDA & IBRD countries)	58.05068	66.28683
European Union	68.90985	75.66565
Faroe Islands	31.186	42.064
Fiji	37.769	56.248
Finland	71.727	85.382

Data for China does not include data for Hong Kong Special Administrative Region, Macao Special Administrative Region, or Taiwan.

Country Name	1980	2018
Fragile & conflict affected situations	27.43591	41.50683
France	73.282	80.444
French Polynesia	59.003	61.834
Gabon	54.682	89.37
Gambia, The	28.414	61.27
Georgia	52.497	58.632
Germany	72.844	77.312
Ghana	31.163	56.06
Gibraltar	100	100
Greece	69.343	79.058
Greenland	76.121	86.816
Grenada	32.912	36.272
Guam	93.753	94.78
Guatemala	38.724	51.054
Guinea	23.617	36.14
Guinea-Bissau	17.804	43.36
Guyana	30.488	26.606
Haiti	20.541	55.278
Heavily indebted poor countries (HIPC)	20.82743	36.00847
High income	71.67909	81.33498
Honduras	34.87	57.096
Hong Kong SAR, China	91.478	100
Hungary	64.191	71.351
IBRD only	33.10516	55.01243
Iceland	88.26	93.813
IDA & IBRD total	31.00835	50.4222
IDA blend	26.20433	42.38043
IDA only	19.15443	34.31597
IDA total	21.50024	37.05187
India	23.098	34.03
Indonesia	22.104	55.325
Iran, Islamic Rep.	49.693	74.898
Iraq	65.521	70.473
Ireland	55.333	63.17
Isle of man	51.784	52.588
Israel	88.583	92.418
Italy	66.64	70.438
Jamaica	46.739	55.674
Japan	76.175	91.616
Jordan	60.029	90.979
Kazakhstan	54.142	57.428
Kenya	15.583	27.03
Kiribati	32.284	54.057
Korea, Dem. People's Rep.	56.9	61.899
Korea, Rep.	56.72	81.459
Kosovo	–	–
Kuwait	94.781	100
Kyrgyz Republic	38.627	36.351
Lao PDR	12.377	35.004

Country Name	1980	2018
Late-demographic dividend	32.74738	62.4451
Latin America & Caribbean	64.50314	80.58329
Latin America & Caribbean (excluding high income)	63.86155	80.40163
Latin America & the Caribbean (IDA & IBRD countries)	64.37302	80.60141
Latvia	67.095	68.142
Least developed countries: UN classification	17.15725	33.56806
Lebanon	73.672	88.593
Lesotho	11.45	28.153
Liberia	35.167	51.151
Libya	70.094	80.102
Liechtenstein	18.274	14.338
Lithuania	61.158	67.679
Low & middle income	30.71832	50.32784
Lower middle income	26.01568	40.50789
Low income	19.77946	32.5722
Luxembourg	80.042	90.981
Macao SAR, China	98.519	100
Madagascar	18.524	37.191
Malawi	9.05	16.937
Malaysia	42.044	76.036
Maldives	22.25	39.808
Mali	18.484	42.356
Malta	89.785	94.612
Marshall Islands	58.298	77.031
Mauritania	27.371	53.672
Mauritius	42.351	40.793
Mexico	66.339	80.156
Micronesia, Fed. Sts.	26.445	22.703
Middle East & North Africa	49.60953	65.37197
Middle East & North Africa (excluding high income)	47.00149	61.59055
Middle East & North Africa (IDA & IBRD countries)	47.00149	61.41454
Middle income	31.58836	52.53426
Moldova	40.387	42.629
Monaco	100	100
Mongolia	52.083	68.445
Montenegro	36.813	66.813
Morocco	41.21	62.453
Mozambique	13.158	35.988
Myanmar	23.973	30.579
Namibia	25.066	50.032
Nauru	100	100
Nepal	6.091	19.74
Netherlands	64.745	91.49
New Caledonia	57.426	70.683

Country Name	1980	2018
New Zealand	83.428	86.538
Nicaragua	50.292	58.522
Niger	13.443	16.425
Nigeria	21.97	50.344
North America	73.93113	82.17315
Northern Mariana Islands	86.784	91.618
North Macedonia	53.469	57.963
Norway	70.545	82.248
OECD members	70.5149	80.59331
Oman	47.562	84.539
Other small states	38.80041	62.11804
Pacific island small states	28.71618	38.78134
Pakistan	28.066	36.666
Palau	62.542	79.93
Panama	50.447	67.709
Papua New Guinea	13.047	13.169
Paraguay	41.688	61.585
Peru	64.574	77.907
Philippines	37.456	46.907
Poland	58.086	60.058
Portugal	42.785	65.211
Post-demographic dividend	71.73781	81.28069
Pre-demographic dividend	22.79021	41.22695
Puerto Rico	67.835	93.578
Qatar	89.363	99.135
Romania	46.07	53.998
Russian Federation	69.751	74.433
Rwanda	4.721	17.211
St. Kits & Nevis	35.882	30.776
St. Lucia	26.54	18.678
St. Martin (French part)	–	–
St. Vincent & the Grenadines	35.87	52.198
Samoa	21.173	18.243
San Marino	81.231	97.226
Sao Tome & Principe	33.482	72.803
Saudi Arabia	65.86	83.844
Senegal	35.769	47.192
Serbia	–	56.092
Seychelles	49.366	56.691
Sierra Leone	29.819	42.055
Singapore	100	100
Sin Maarten (Dutch part)	100	100
Slovak Republic	51.638	53.726
Slovenia	48.045	54.541
Small states	40.13794	58.72442
Solomon Islands	10.576	23.749
Somalia	26.763	44.971
South Africa	48.425	66.355
South Asia	22.32941	33.99236

Country Name	1980	2018
South Asia (IDA & IBRD countries)	22.32941	33.99236
South Sudan	8.519	19.615
Spain	72.789	80.321
Sri Lanka	18.607	18.476
Sub-Saharan Africa	22.33942	40.17682
Sub-Saharan Africa (excluding high income)	22.33496	40.17534
Sub-Saharan Africa (IDA & IBRD countries)	22.33942	40.17682
Sudan	19.959	34.642
Suriname	64.96	66.06
Sweden	83.087	87.431
Switzerland	74.477	73.797
Syrian Arab Republic	46.708	54.162
Tajikistan	34.289	27.134
Tanzania	14.555	33.776
Thailand	26.791	49.949
Timor-Leste	16.483	30.578
Togo	24.663	41.702
Tongo	21.154	23.131
Trinidad & Tobago	52.284	53.184
Tunisia	50.569	68.945
Turkey	43.78	75.143
Turkmenistan	47.078	51.593
Turks & Caicos Islands	55.259	93.098
Tuvalu	29.822	62.387
Uganda	7.534	23.774
Ukraine	61.693	69.352
United Arab Emirates	80.71	86.522
United Kingdom	78.481	83.398
United States	73.738	82.256
Upper middle income	36.28337	66.23337
Uruguay	85.394	95.334
Uzbekistan	40.782	50.478
Vanuatu	14.74	25.274
Venezuela, RB	79.185	88.208
Vietnam	19.247	35.919
Virgin Islands (U.S.)	80.147	95.721
West Bank & Gaza	–	76.164
World	39.34943	55.27058
Yemen, Rep.	16.534	36.642
Zambia	39.815	43.521
Zimbabwe	22.371	32.209

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** Denotes a mandatory field*

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