Anthony J. Masys   *Editor*

Security by Design

Innovative Perspectives on Complex Problems

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Contents

Introduction

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1 Introduction

The current and future security landscape is diverse and complex. It is characterized by such issues as: mass migration and refugee crisis; economic slowdowns in emerging markets; ever-rising numbers of terrorist and cyberattacks; pandemics; active shooters; climate related disasters; global water shortages; energy security; the proliferation of the Internet of Things and its impact on the security of our homes, cities and critical infrastructure. These global risks have been in the headlines in the last year (Global Risks Report) and pose significant security challenges both nationally and globally. In fact, national security is no longer just national. Non-state actors, cyber NGOs, rising powers, pandemics and hybrid wars and crimes in strategic areas pose complex challenges to global security.

Designing security solutions requires understanding the complex interdependencies that reside within the threat landscape to create a plan or action such that '*…if implemented-is intended to bring about a situation with specific desired characteristics without creating unforeseen and undesired side and after effects*' Rittel (1968).

This edited book captures salient global, regional and national security challenges and leveraging key design thinking principles, presents 'design' solutions to address them.

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2   Designing Security

As part of the Springer book series: Advanced Sciences and Technologies for Security Applications, this edited volume: **Security by Design,** introduces novel perspectives and innovative approaches to how we can design security interventions.

The 17 chapters in this book reflect contributions from various experts and through case studies and research reveal the many perspectives, tools and approaches to support security design. Security design can support risk and threat analysis, risk communication, problem framing and development of intervention strategies.

3   Content

Rama Gheerawo in his chapter '**Design Thinking and Design Doing: describing a process of people-centred innovation**' outlines the benefits of Design Thinking as a creative framework for innovation that can be applied to projects and organisations across government, business and the public sector. This chapter includes a short history of the Design Thinking approach to set context and define the concept. At the heart of the approach is a people-centered focus, and the chapter discusses the role of Inclusive Design and design ethnography in underpinning Design Thinking. It outlines five principles: Involve People, Translate Design Thinking into Design Doing, Create Value and Capture Value, Follow the Arc of Design Thinking and Navigate Complexity. It aims to give an overarching view of Design Thinking, demonstrating the value that it can bring to diverse areas of research and application. Challenges and observations for progressing the approach are also noted.

Craig Perry and Andy Hines in their chapter '**An Integral Futures lens on the future security issues**' argues that conventional analysis of security issues tends to take a disjointed approach through tightly focused tactical lenses. Increasingly, however, security issues are embedded in a wider and diverse range of factors that may escape conventional analysis. An integral futures perspective to exploring security issues is proposed that provides a wider lens by taking an integrated holistic approach that explores individual and collective aspects of emerging issues from both an interior (e.g., motivation, culture) and exterior (e.g., behavior, systems, and infrastructures) perspective. We believe the approach may provide a fresh approach to issue identification as well as more holistic explanatory framework.

Bradley Keating and Anthony Masys in their chapter '**Innovations in Active Shooting Emergency Medical Response and Triage**' argue that with the rise in prevalence of mass shootings, Emergency Medical providers may now find themselves responding to an active shooter event. Traditional triage and victim management techniques leveraged from military experiences are being

re-examined. As noted by Smith et al. [15], 'A recent analysis of mass shooting events noted a wounding pattern different from military experience with very few cases of life-threatening extremity hemorrhage; therefore, extrication and transfer to definitive care needs to be a priority in addition to any in-place care provided'. As noted in van Rein et al. [18: 329] 'prehospital trauma triage is essential in providing appropriate care for patients at risk from severe injury to improve their chance of survival'.

This chapter will discuss the requirements for a more 'tactically oriented' medical response in an active shooter incident, and presents novel triage and scene management techniques to facilitate a more rapid and effective response to maximize victim survivability.

Miriam Kaundert and Anthony Masys in their chapter '**Mass Migration, Humanitarian Assistance and Crisis Management: Embracing Social Innovation and Organizational Learning**' argue that the current surge in migration to the European Union (EU) is rapidly becoming the largest and most complex facing Europe since the Second World War. Between January 2015 and February 2016, over 1.1 million people made their way to the EU, escaping conflict and poverty in their countries.

Moore and Westley [8] argue that 'urgent calls for "innovation" have become increasingly frequent as people begin to recognize both the need for fundamental change in human beings' relationships with each other and their environment, and the catastrophic ramifications of inaction or ill-informed decisions as to how such change might be effected'.

This chapter examines the complex causality regarding mass migration of refugees and leverages social innovation and organizational learning as theoretical frameworks to support the design of humanitarian assistance and crisis management.

Ivan Taylor and Anthony Masys in their chapter '**Complexity and Unintended Consequences in a Human Security Crisis: A System Dynamic Model of the Refugee Migration to Europe**' examine the mass migration crisis in Europe. As described by UNHCR [17], 'Europe is living through a maritime refugee crisis of historic proportions. Its evolving response has become one of the continent's defining challenges of the early 21st century, with long-lasting implications for humanitarian practice, regional stability and international public opinion'. UNHCR's figures show that over one million people had reached Europe across the Mediterranean, mainly to Greece and Italy, in 2015. Of these, over 3700 were missing, believed drowned. This represents a regional human security crisis. Sagan [13: 12] argues that 'Things that have never happened before happen all the time'. The mass migration of refugees should not have come as a complete surprise. The mass migration in Europe, North Africa and Middle East derives from a wicked problem space and is linked to humanitarian challenges elsewhere. Thus, the flight to European shores reflected not only the pull of greater long-term security in Europe, but also the failure of the international humanitarian community to meet basic needs in other places [10].

This chapter explores the complexity of the refugee and humanitarian crisis in Europe and North Africa through the application of a system dynamics model. Given the unintended consequences associated with policies and intervention strategies, the system dynamics model examines the volatility of such interventions on migration.

Polinpapilinho F. Katina and Charles B. Keating in their chapter '**Cyber-Physical Systems Governance: A framework for (meta) CyberSecurity Design**' presents a framework for improving security of cyber-physical systems through purposeful design, execution, and evolution of metasystem functions. State actors (i.e., government agencies), non-state actors (i.e., for-profit and non-profit organizations), and their systems operate under highly emergent and complex conditions. Under these conditions, system performance is not always deducible from the constituent systems. Moreover, such systems are often interdependent and dynamically interacting with other systems such that the state of each system is influenced by and is influencing states of the interconnected systems. In these conditions, leaving a system to develop through processes of 'accretion' (ad hoc evolution of a system) or 'self-organization' (totally unconstrained evolution of a system) might increase the probability of missing performance expectations. In contrast, 'purposeful design' is an invitation for a more determined engagement in system development to increase the probability of producing expected and desired performance. In this chapter, emerging research in *Complex System Governance* (CSG) is suggested as an emerging field to direct more purposeful design for systems. Specifically, a CSG enabled framework for security design focused on Cyber-Physical Systems (CPS) is provided. The framework, grounded in Systems Theory and Management Cybernetics, emphasizes more holistic design for integration, coordination, communication, and control for development of CPS.

Erik Hollnagel in his chapter, '**To feel secure or to be secure, that is the question**' focuses on the title of this volume 'Security by design' as an expression of confidence that it is possible to be secure by design. In that case the obvious next step is to think about possible ways of ensuring security by design, starting, for instance, with the solutions that have been developed to solve the seemingly analogous problems of safety or prevention by design. But what if the title had been "Security by design?" or in other words a question rather than a statement? In that case the title would not be taken as an expression of confidence but rather as an admission of uncertainty or even of impotence, a possible doubt of whether security can be ensured by design. The obvious next step would then be to take a closer look at the two central concepts, namely "security" and "design". The current chapter will do just that.

D.B. Skillcorn and C. Leuprecht in their chapter '**Clustering Heterogeneous Semi-Structured Social Science Datasets for Security Applications**' argues that social scientists have begun to collect large datasets that are heterogeneous and semi-structured, but the ability to analyze such data has lagged behind its collection. They design a process to map such datasets to a numerical form, apply singular value decomposition clustering, and explore the impact of individual attributes or fields by overlaying visualizations of the clusters. This provides a new path for

understanding such datasets, which we illustrate with three real-world examples: the Global Terrorism Database, which records details of every terrorist attack since 1970; a Chicago police dataset, which records details of every drug-related incident over a period of approximately a month; and a dataset describing members of a Hezbollah crime/terror network in the U.S.

Frederic Petit, Duane Verner, Julia Phillips, and Lawrence Paul Lewis in their chapter '**Critical Infrastructure Protection and Resilience—Integrating Interdependencies**' argues that enhancing the protection and resilience of critical infrastructure has emerged as an urgent goal—a goal made more challenging by the complexity of these systems and their inherent interdependencies. Consideration of critical infrastructure interdependencies, as well as their integration into risk management and business continuity processes, is an important element of *U.S Presidential Policy Directive 21 on Critical Infrastructure Security and Resilience* (PPD–21), the *Canada-United States Action Plan for Critical Infrastructure*, and the *European Program for Critical Infrastructure Protection*. Several international standards also require the consideration of interdependencies between organizations and the effect on their risk management and business continuity practices. All of these documents, from the strategic level through the operational standards, involve the consideration of interdependencies that can exist among infrastructure, how they are managed, and how they affect business continuity, security, and resilience management. A "system of systems" approach can help establish the appropriate scope of an interdependency analysis, as well as the specific assets and/or subsystems for which resilience-related information should be collected.

David Wood in his chapter '**The Application of Warden's Concentric Ring Theory to Applegate's Offensive Cyber Manoeuvre Strategy in Modern Conflicts**' argues that Cyber has become an essential element for governments, militaries and societies. This importance makes it a target when planning a military campaign. The targeting model developed by Colonel John Warden has demonstrated flexibility in that it can be applied to any entity that can be analyzed as a system. Scott Applegate has accurately described three different strategies that can be employed when waging offensive cyber warfare. The targeting model developed by Colonel John Warden can be applied to each of these cyber maneuver strategies to analyse and attack an opponent's cyber capabilities. There is anecdotal evidence that these different cyber strategies have been employed in recent world conflicts. Real world examples accessed from open source literature have been analysed using Warden's theory, to demonstrate that countries have already started basing their attacks against their opponent's cyber capabilities using this model.

Corey Tsang and Anthony Masys in their chapter '**Fentanyl Crisis: a National Security matter**' describe how amongst the global security challenges, synthetic drugs constitute one of the most significant drug problems worldwide [16]. Fentanyl and non-pharmaceutical fentanyls (NPFs) have moved beyond being a concern to emerging as a national and global security matter. In 2015, more than 52,000 Americans (144/day) died from drug overdose. As reported by Chester [4], 63% of overdoses involved opioids whereby they are having '…a considerable impact on public health and public safety in communities across the United States'.

In Canada, the Fentanyl-related deaths has markedly increased across British Columbia, Alberta, Ontario and Quebec, ranging from a doubling to 20-fold increase from 2009 to 2014 [3]. This increasing trend is noted internationally with increasing mortality noted in Australia [12] and the Nordic countries (Denmark, Finland, Iceland, Norway, Sweden) [14].

Richmond (2001:3) argues that 'The way we think is outdated. As a result, the way we act creates problems, and then we are ill-equipped to address them because of the way we think'. His argument stems from the '…fact that we have been applying the same set of non-solutions to the crucial social problems such as drugs, poverty and crime for most of the last fifty years without any positive results'.

This chapter examines the national and global fentanyl crisis and introduces a holistic perspective of the problem space that leverages social innovation and macro-social analysis [2, 7] to examine the public health and criminal dimensions.

Simon Bennett in his chapter '**Risk-based aviation security- designing out terror**' reviews the pros and cons of risk-based aviation security. Advantages include the opportunity to use scarce resources to best affect and—for most airline customers—a speedier passage. Disadvantages include greater operational complexity and additional capital and revenue cost. There is also the matter of political sensitivity: a risk-based aviation security system that is perceived to be discriminatory risks losing the support of those it is designed to protect—with unpredictable consequences. Finally, if the assumptions that inform the computerised vetting algorithms are wrong, the innocent may be inconvenienced, and the malevolent waved through. Referencing the Israeli experience, the author concludes that realising the benefits of risk-based aviation security requires planning, intelligent design and the will and ability to deliver a professional vetting service *in perpetuity*.

Ross Prizzia and Jason Levy in their chapter '**Customizing Web-EOC Crisis Management Software to Facilitate Collaboration and Increase Situational Awareness: Advances in Business Resource Center (BRC) Design for Business Continuity Management**' examines the best design and use of a Business Resource Center (BRC) to increase the disaster management collaboration among the public, private and non-governmental sectors. The visitor industry was identified as the first sector that will be engaged. The project includes five major tasks: creation of a BRC Annex and Standard Operating Guide; the development of a BRC WebEOC portal; the design of small businesses preparedness materials; the identification of emergency communications requirements; and emergency management outreach, training and exercises. This paper focuses on the second task listed above: development of a BRC WebEOC portal for effective disaster management collaboration, information sharing and situational awareness. This involves the design of data fields for the WebEOC crisis management system. Finally, focus groups in Hawaii are examined to learn more about current levels of disaster engagement, gaps in disaster information or services, and opportunities for increased success with disaster management through a central BRC. In general, there was a strong sense of support for the development of a collaborative BRC space for the public and private sectors. Investigations pertaining to business disruptions are undertaken with an emphasis on modeling, understanding and

characterizing the complex causality that defines these incidents. In so doing this chapter uncovers creative, timely and important strategies improving business continuity management and disaster resilience in Hawaii.

JiYoung Park, Jason Levy, Minsu Son, Changkeun Park, and Ha Hwang in their chapter '**Advances in Cybersecurity Design: An Integrated Framework to Quantify the Economic Impacts of Cyber-terrorist Behavior**' put forth an integrated framework to quantify the economic impacts of cyber-attacks on the U.S. airport security systems. A cyber-attack on the United States would involve complex strategic behavior by terrorists, who could invade an airport electronic system without any U.S. border or entry point. At the same time, defending entities must consider the complex processes that may cause any turmoil. The possibility of simultaneous threats from cyber-attacks makes it more difficult for defending entities to secure their airports, highlighting the need for improved and integrated inter-governmental collaboration. Collaborative networking requires close inter-governmental coordination to overcome such cyber-terrorism to protect critical infrastructure systems. Constructing a new model for strategic cyber-terror security requires a combination of competitive and cooperative game situations to develop specific strategies against cyber-terrorism. In addition, an airport shutdown would have ripple effects throughout domestic and international economies; these effects must be analyzed with a spatially disaggregate economic model. Combining competitive and cooperative game situations with an economic impact model, this study proposes the Game Theoretic National Interstate Economic Model (G-NIEMO) framework. G-NIEMO identifies which airport may be most vulnerable in the event that an airport electronic system is shut down. Using the probabilistic costs of airport closures, the model identifies the economic importance of cyber security by event location and industry type. From G-NIEMO, equilibrium strategies to protect U.S. airport systems can be developed and a general guideline for the evaluation of resource allocation can be provided to U.S. government agencies.

Anthony Masys in his chapter '**Operationalizing 'Deliverology' for Humanitarian Aid and Disaster Risk Reduction: Accelerating improvement in delivery**' examines recent disasters and humanitarian aid efforts in the Asia/Pacific Region through the lens of the Sendai Framework and 'Deliverology'. Deliverology is a 'systematic process for driving progress and delivering results in government and the public sector' [1]. The key principles of Deliverology, rooted in design thinking and reflective practices can help organizations (humanitarian aid) define and execute their highest-priority objectives so that they have the greatest possible impact. In so doing, the chapter walks the reader through 'operationalizing deliverology and design' to accelerate improvements in delivery of humanitarian aid in support of the 'New Ways of Working (NWOW)' [9]. Deliverology combined with design is more than a process model but is a **mindset** for truly impacting communities through disaster risk reduction.

Suzanne Waldman and Anthony Masys in their chapter '**Nuclear Waste Management: Security and Safety Implications**' argue that given the significant nuclear footprint throughout the Asia/Pacific, issues pertaining to nuclear waste

management resonate with Beck's risk discourse on how distinctively modern manufactured risks are both temporally and spatially displaced. Many Asia/Pacific countries, including Japan and South Korea are facing increasingly large nuclear fuel stocks, with safe space for surface storage growing tight. A key event complicating nuclear power waste storage in the region was the Fukushima nuclear accident, which increased the nuclear waste profile while complicating storage siting by elevating public concern and diminishing trust in nuclear industries and regulators [11]. At the same time, equally salient manufactured risks from global climate change due to fossil fuel consumption are contending with nuclear risks, adding urgency to the optimization of cradle-to-grave energy life cycle decisions. All in all, the manufactured risk landscape calls for "reflective practices" that leverage the theoretical frameworks of risk perception and risk communication to shed light on issues challenging the Asia/Pacific region. In this chapter, the authors draw upon theoretical orientations of cultural cognition of risk [6], responsible innovation [5], and design thinking as a lens for reflection and guidance to enable more constructive and conciliatory nuclear waste decision-making within the Asia/ Pacific region.

Jason Levy and Ross Prizzia in their chapter 'Building Effective Emergency Management Public-Private Partnerships (PPP) for Information Sharing' describe how recent disasters have highlighted the need for effective and proactive partnerships between public emergency responders and the "Whole Community" to assist in all phases of disaster management. This paper examines the importance of reliable, credible, and accessible information that can support the private sector and the "Whole Community" in times of disaster It is shown that community resilience is enhanced through a shared, real-time "common operating picture", explicit linkages, and enhanced information sharing. Business Emergency Operations Center (BEOC) designs are compared and contrasted and recommendations are put forth. Optimal Public Private Partnerships for information sharing identified. It is shown that achieving disaster resilience involves government and businesses sharing potential risks, as well as identifying disaster consequences, priorities, information, and capabilities. The conclusions provide guidance that can be used as dual-use roadmap for improving information sharing: on the one hand governments can use the insights of this paper to build new public-private sector programs (or to improve existing programs); on the other hand, the private sector can better understand how to become connected with the information sharing processes of governments.

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Design Thinking and Design Doing: Describing a Process of People-Centred Innovation

Rama Gheerawo

Abstract This chapter outlines the benefits of Design Thinking as a creative framework for innovation that can be applied to projects and organisations across government, business and the public sector. It includes a short history of the Design Thinking approach to set context and define the concept. However, much of the ensuing discussion and evaluation of ideas and methods is based on recent publications, papers and journal articles to give a current view of academic and practitioner activities. At the heart of the approach is a people-centred focus, and the chapter discusses the role of Inclusive Design and design ethnography in underpinning Design Thinking. It outlines five principles: Involve People, Translate Design Thinking into Design Doing, Create Value and Capture Value, Follow the Arc of Design Thinking and Navigate Complexity. It aims to give an overarching view of Design Thinking, demonstrating the value that it can bring to diverse areas of research and application. Challenges and observations for progressing the approach are also noted.

Keywords Design thinking · Inclusive design · Empathy · Innovation
People-centred

1 Design Thinking

Design Thinking (DT) has gained significance and importance in using the principles and practice of design to address issues, problems and challenges across a variety of sectors and situations—from healthcare to education, from urban to rural, from local to global. It has proven to be an effective method for harnessing the creative, innovative, and a people-centred approaches enshrined in the design process and applying them across organisations drawn from the private sector,

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public sector, government and education. However, DT has had a wider impact and is not simply limited to these organisations, reaching beyond them to impact entrepreneurs, small and medium enterprises as well as social institutions. DT harnesses ideas that have been developed within the design disciplines but makes a unique contribution by presenting disparate concepts and notions in a way that is digestible and implementable to designers and non-designers alike. It has allowed the ideas and creative endeavours of design to be democratised, co-opted and applied to creatively solve critical problems and issues in an innovative, holistic and human-centred way.

The practice of DT predates its modern nomenclature, with some scholars arguing that its ideas and ideals resonate across the centuries and even reach back to the achievements of ancient civilisations. Human history is thought to be full of design thinkers, long before the term was defined and popularised. Leonardo Da Vinci, Isambard Kingdom Brunel and Richard Buckminster Fuller all used or created processes that resonate with a DT approach that modern practitioners would recognise, from a desire to better the human condition using a cross-disciplinary approach, to taking advantage of technological advances to invent and innovate in a way that tackles complex or challenging situations.

Numerous definitions of DT currently exist, with many new ideas being researched, discovered and articulated as the value has spread. However, a widely-accepted positioning was articulated by Tim Brown, Chief Executive Officer of IDEO, a global design and innovation company. Published in Harvard Business Review, this primarily denoted DT as a tool for business. The article described DT as a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity [4]. It signified an aspiration to shift design from simply being viewed as an aesthetic endeavour to moving upstream in the innovation process and upstairs to the boardroom. Importantly, it put the value of a people-centred approach at the heart of the idea through consultation with users and consumers. The simple strapline of *Thinking like a designer can transform the way you develop products, services, processes—and even strategy*, represented a bold statement of intent, positioning the discipline of design within the 'cut and thrust' of the business environment.

There are several suggestions as to other modern origins of DT as a phrase or a concept, with Mootee [53] and Chae [9] suggesting Herbert Simon's 1969 book *The Sciences of the Artificial* as the initial point at which design was suggested as a way of thinking, highlighting the definition of design in this publication as 'the transformation of existing conditions into preferred ones'. The book proposes seven steps which still relate to current processes of DT as follows: Define, Research, Ideate, Prototype, Choose, Implement, and Learn. Szczepanska [66] talks about the Design Science movement that originated in the US in the 1960s where Buckminster Fuller created multidisciplinary design teams to address complex systemic challenges. He described this as "the effective application of the principles of science to the conscious design of our total environment in order to help make

the Earth's finite resources meet the needs of all humanity", a definition that parallels some of the aspirations within the field of DT today.

Peter Rowe's 1987 book titled *Design Thinking* is also notable, though its focus was on delineating a detailed account of the process of designing in architecture and urban planning rather than DT as it is known today. Kleinsmann et al. [42] cite another early use of the term from Bruce Archer in his 1979 article *Whatever became of Design Methodology*, stating that DT originated within the design research community. Archer helped found the Design Research Society in 1967 and established the Department of Design Research at London's Royal College of Art (RCA) where he tackled one of the urgent healthcare issues of the time—the standardisation of the hospital bed. He used the newly established principles of design research to effect widespread consultation, evidence gathering through direct observations, and extensive field trials using mock-ups and prototypes to create a successful design that was written into a British Standard and ultimately taken up by a commercial bed manufacturer [44]. Archer's philosophy shifted the focus of design from being an individual process that could be framed as ego-driven, to one that is more collaborative and observant, noting over 40 years ago that:

> You cannot ignore the nurturing of the material culture and still expect to enjoy its fruits. That is why I invented design research as a back-up to design practice. I don't think it is because I happen to be standing here instead of somewhere else that the world seems to be revolving around this point.

In today's context, DT has become a living, evolving idea that is being adopted by a range of individuals and organisations. It is also being defined and redefined and means different things to different people [39]. Importantly, at the centre of DT is the idea that everyone can access and activate the creative value of design. Cross [13] states that "everyone can—and does—design", noting that humans have had a long history of DT as evidenced by the artefacts and inventions of previous civilisations and the "continuing tradition of vernacular design and traditional craftwork".

Exact definitions of DT vary but there are some commonalities and convergences that emerging published literature and practitioners see developing within the theory and practice. As a starting point, Beverland et al. [2] describe the following characteristics of a DT approach: 'abductive reasoning, iterative thinking, experimentation and human-centeredness', and these are often widely accepted as some distinct benefits of DT. Dorst [21] talks about DT as a 'real alternative to conventional problem-solving strategies', something which DT case studies attest to, whether drawn from industry, public sector or academia. The move to address systemic challenges through DT [47] or create organisational change by establishing a DT culture within an institution or company [6] are ideas that have gained visibility in the last decade.

The link between DT and innovation, whether described as an attitude, a process or a result, is also widely understood within the general understanding of the work. It has even been noted to *promise* innovation inspired by the way designers work [7], hinting that DT when used as a strategy, can actually guarantee results.

The people-centred aspect of DT is also prevalent, with the terms human-centred and user-centred used unilaterally within the field. Fraser [24] talks about 'deep human understanding' based on work at the Rotman School of Management. Curedale [14] notes that design has moved from being a marketing tool to answering human need. This people-centred aspect of DT is further discussed later on in this chapter.

In recent years, academic literature has focused on progressing the application of DT in different contexts and looking at the different aspects and influences. As DT becomes increasingly global, one area that would benefit from further investigation would be how different cultural influences affect DT practice and process. Small-scale pilot studies also indicate the need for further research in this space, with Clemmensen et al. [11] noting that 'the core DT methods of induction, deduction …. are affected by the ongoing appearance and disappearance of cultural difference among design team members'. They viewed their study as a starting point for additional research in this area. This represents one of many areas of further study that will need to be conducted over the coming years including the important aspect of delineating and implementing tools for evaluation that capture the outcomes effects and performance of DT in a variety of contexts, sectors and situations. This will need to be done in a manner that is both qualitative and quantitative to ensure a true representation of DT value-adds as well as challenges. As Kimbell [41] simply notes, more research needs to be done into critical understanding and evaluation of DT.

1.1 Creating a Bridge Between Business and Design

DT has enabled design to enter the business sector with a sense of purpose and legitimacy. Design Councils across the globe urge businesses to work with design to ensure a heightened level of creativity and to ensure longevity through a better understanding of their customers and through value creation. Antonelli [1] goes even further, urging business people to become designers, not just aim to understand them better. Recent financial trauma across the globe has fuelled a need for alternative thinking, and a drive for business to think differently, and this is where DT, with its ability to create and co-create non-traditional and alternative outputs has gained traction.

DT can influence innovation management within a business context, replacing outdated ideas such as strategic planning powers strategic innovation. Applied DT is strategic innovation with management of the process being more about imagination, creativity and mobilising as opposed to planning, reducing risk or control [53]. The limitations of current management and organising paradigms can be improved with the integrative practice of DT and the value-based approach that it affords [65]. Professional guidance on project management remains rooted in a mechanistic paradigm of control and cannot therefore address changes in environment or business needs [48]. They go on to delineate three areas that DT can help with in evolving management approaches: managing the explorative phase,

managing stakeholder involvement, and managing the project in relation to the strategizing process of the organisation. Together these make for an important addition to innovative outcomes that may be achieved by DT as they point to impact on process, management and strategy.

A definitive move that strengthens the relationship between DT and business is the development of DT methods, tools, teaching curricula and practice at business schools, a notable example being the d.school at Stanford University founded in 2005 and recognised as one thought leader in human-centred design, and a leading teaching institute for design and experiential learning [15]. Drawing on different design capabilities and a focus on addressing complexity rather than ignoring it, the d.school outlines eight 'core abilities' [16]:

1. Navigate Ambiguity
2. Learn from Others (People and Contexts)
3. Synthesize Information
4. Experiment Rapidly
5. Move Between Concrete and Abstract
6. Build and Craft Intentionally
7. Communicate Deliberately
8. Design your Design Work.

As large business organisations adopt DT methods and begin to train staff in the theory and application of these ideas, a number of books have appeared that describe and capture best practice. A popular publication is *Design Thinking Pocket Guide* by Curedale [14], a DT practitioner and professor who presents a brief introduction to DT and a collection of methods and tools used in the process, from insight generation, synthesis, ideation and prototyping. The book champions DT as the reason for intelligent business change, defining DT as "a human-centred approach which is driven by creative and analytical thinking, customer empathy and iterative learning".

Curedale suggests that DT is most applicable when you have a poorly defined problem, a lack of information and a changing context or environment, something many business organisations face. The book presents a selection of methods and tools collected over a number of years from a range of disciplines such as the social sciences, business, engineering and design. These are commonly used throughout the DT process, and are outlined as:

1. Define intent
2. Through ethnographic research develop empathy for the point of view of the user
3. Synthesise the research
4. Frame insights
5. Explore Concepts
6. Synthesize the concepts generated
7. Prototype the favoured ideas

8. Test the prototypes with users
9. Incorporate changes
10. Iterate prototype and testing till a workable design is reached
11. Implement
12. Deliver Offering.

An empirical interview study of six large organisations by Carlgren et al. [7] lead to five themes that characterise DT. These are: User focus, Problem framing, Visualisation, Experimentation and Diversity. *User focus* is about 'deep empathy building' as well as understanding and involving people in the generation and making of ideas. *Problem framing* looks at 'widening, challenging and reframing' a problem statement instead of simply trying to solve it, and avoiding the trap of narrowing down to a solution too quickly. *Visualisation* aims to use 'visual representations' to show ideas in either two or three dimensions to gain consensus and share ideas rather than simply being about prototyping and delivering a solution. *Experimentation* refers to iteratively developing and testing ideas in ways that are convergent and divergent, working on multiple solutions to maximise the creative value of process and outcome. *Diversity* was seen as a cross-cutting theme applicable to ensuring a range of opinions and perspectives as well as a diversity of team members. This type of detailed study is essential in establishing an evidence-base of the benefits and challenges of DT practice within business organisations and can lead to more empirical measures of the value that it can bring. Understanding this within a business context can lead to insights applicable to other areas and sectors where DT is being implemented, particularly the public sector.

1.2 Developing Focus Beyond Business

Although DT has been articulated primarily with a business focus, the ideology and application has developed to accommodate and impact a more social context. It has been described as an iterative and co-creative approach that can support innovation in both the economy but also importantly within society [17]. This effectively reflects the three aspects of sustainability namely, environmental, economic and social [61]. All three have to be considered in order to create truly sustainable solutions and DT can be instrumental in achieving social, as well as economic sustainability.

DT builds on a number of different movements and practices that take a socially-focused attitude to design. In Scandinavia, Co-operative Design emerged as a powerful antidote to 'top-down' problem-solving, by involving everyone in decisions and processes that the designer facilitated [22]. Participatory Design has also risen in popularity and prominence, involving people as authors, instigators and designers of their own solutions, and ideas [63]. Far from devolving or diminishing the role of the designer, this is being seen as a powerful tool for engaging non-designers within the design process in a way that parallels the

ambitions of DT. People-centered design encourages attention to, and consideration of the individual as a central part of any creative process and terms such as 'co-design' [64] and 'co-creation' are now actively being used across education, business and government. Professional designers have also co-opted these terms with most understanding that engagement with their end users can provide innovation benefits across the design process.

A recent publication of significance in the field, *Design Thinking for the Greater Good* [46], explores and emphasises how DT has moved from a business focus and into the social space. It outlines how DT is being used by organisations as diverse as charitable foundations, social innovation start-ups, national governments, and elementary schools to solve difficult social challenges. This builds on the inherent business focus that influenced DT at its inception and helps to evolve the ideas. DT is presented in this book as the perfect tool to tackle increasingly complex problems such as:

– Stakeholders who cannot even agree on the problem, much less the solution;
– Employees who are reluctant to change behaviours and take risks, who are often rewarded for compliance rather than performance;
– Decision makers who have too much data, but little of the kind they need;
– Leaders who are more likely to have short tenures and whose every move is scrutinised by funders, politicians, bureaucrats and the media; and
– Users of their services such as students, patients, customers, citizens—whose expectations are sometimes rising as fast as resources to meet them are declining.

The publication argues that DT can tackle these issues as it is a unique problem-solving approach; one that is human-centered, possibility driven, option focused, and iterative. It has developed as a new democratized form of innovation, moving away from designers as experts and external stakeholders, to participatory design with strategic partnerships. As with other DT definitions, they emphasise the importance of reframing the problem as a key evolution from traditional approaches to innovation. "*The definition of a problem is a hypothesis to be tested, as are its solutions… breakthroughs come with the redefinition of the problem itself*". DT moves away from the traditional 'one big solution' approach, towards multiple solutions quickly tested because numerous answers are both possible and desirable. Whilst the definitions of DT provide a useful background, the novelty of the publication is in how DT can advance from the business world to be applied to the social sector, where issues can be more challenging, and solving them can matter even more.

The idea of 'designing for' people, which gained prominence in the last century is now evolving towards 'designing with' people and subsequently incorporating processes around 'designing by' people [26]. DT reflects these movements helping organisations to understand and relate to their customers and users. This democratization of design practice enables a move towards more people-centered and equitable processes that are increasingly relevant today.

DT is being applied in progressively diverse areas and with typically high levels of success. A few instances are mentioned in this chapter, but the list is by no means exhaustive. Healthcare has seen an influx of DT approaches partially driven by the

rise of technology applications and 'health tech'. As economist Peter Drucker noted, healthcare institutions are amongst the most complex in human history, and DT is seen as a competent tool for addressing this type of complexity. Even in critical emerging areas such as e-pharmacy, DT has a role on defining and supporting the collection of software requirements [8], and Peterson et al. [59] found in their study that "DT processes used in the development and implementation of the mobile heath app were crucial to creating value for user".

Education has also benefitted from DT consideration. Hernández-Leo et al. [36] noted that when dealing with the complexities of designing learning experiences for students, DT supported the range of activities from "designing stimulating and engaging tasks, selecting and creating appropriate resources, and deciding how best to support students to successfully complete the tasks". Even at primary school level, DT education interventions lead to a "paradigm shift" [57] and that it would be beneficial to expose children to the values of design and DT. When looking at higher education, Leonard et al. [45] argue that DT can enable sustainable curriculum development "through processes of rapid reconnaissance, mapping the territory and emergent modelling", signalling the value that can result when addressing urgent, emerging issues.

DT can also work in areas such as public services, engineering and urban planning but has seen significant results when applied in technological contexts which often lack people-centred consideration [30]. Merging traditional HCI methods with DT can lead to a seamless co-existence of methodologies such as user-centered design and rapid prototyping [54]. Even in a focussed technology context such as data storage, DT can have an effect. During a process to apply DT to an innovative data storage service, the methods were felt to be vague, blurry and very broad [28], however, the collaborative and people-centered emphasis of the method was appreciated, even by the technical participants.

DT processes can be used to 'design' creative forms of research in scientific and clinical areas. They were co-opted to create a framework of methods to study cognitive biases that can appear within teams involved in strategic decision-making [43], though the actual DT tool did not have the expected influence on mitigating confirmation bias, signalling that more research needs to be done in translating DT approaches from a primarily creative arena into more technical, technological and scientific areas. Other fields of study could also benefit from a DT approach. Ideas around social entrepreneurship and social business are on the rise, but whilst DT has established itself in business practice, it has received scant attention in entrepreneurship pedagogy [38].

2   Principles of Design Thinking

There are numerous frameworks that aim to codify and summarise DT intention and activity that are delineated by academics and practitioners alike. This section outlines five principles drawn from the Helen Hamlyn Centre for Design (HHCD) at

the RCA. This design centre, lead by the author, has completed over 260 projects with organisations, corporations and communities at an international level. Much of the work is based on DT methodologies developed and applied in the field and tested by academics and practitioners alike. The HHCD's approach is inclusive and interdisciplinary and work is organised in three research spaces:

- Age & Diversity, focusing on design for a more inclusive society irrespective of a person's age or ability

- Healthcare, looking creating safer and better products and services in the hospital and home
- Social & Global using people-centred design methods to deliver research projects that have social and global impact for marginalised communities.

The five DT principles developed at HHCD and outlined on the following pages are: Involve People, Translate Design Thinking into Design Doing, Create Value and Capture Value, Follow the Arc of Design Thinking and Navigate Complexity.

2.1 Involve People

Human-centeredness and empathy are widely accepted components of DT as noted by several researchers and practitioners [2, 46, 53, 56], sometimes framed as meeting customer latent needs [62] or an empathic look at users or consumers [31]. The discipline of design, which DT draws its processes from, is also changing, becoming less about making people want things, and more about answering human need [14]. DT can enhance co-creation and facilitate respectful, creative interaction, thereby ensuring that both a project output and the process are people-centred, and providing benefit for the recipients of a product, service or system as well as the creators.

Empathy is fundamental to DT and can range from an observational stance to complete immersion. Immersive techniques draw on some radical sociological experiments. In 1979, aged twenty-six, designer Patricia Moore dressed up as different eighty-year old women and travelled across the US to document society's treatment of older people firsthand [52]. Nearly two decades earlier, John Howard Griffin, a journalist living in Dallas darkened his face using medication to immerse himself in African American communities and experience the difficulties they encountered in some Southern US states at that time [33]. Although these types of approaches were viewed negatively by designers and social scientists at the time, they are now seen as positive and pioneering in creating empathy within the research process.

However, whilst they change the perspective of the designer or researcher by moving them closer to that of the user, recent methods in DT look to empower participants themselves, giving them visibility and a platform for self-expression. It is not enough to simply advocate on behalf of another person, as the ideal is to

empower and enable people in order to bring higher level of authenticity and a directness of the 'lived experience' into the ethnographic process.

Methods that involve people are at the core of DT. At the HHCD, 'design ethnography' is used to empower and involve people. This term is being increasingly used to cover the description of a process by which designers conduct research with people using tools and methods drawn from social science [10]. As designers typically have to operate in much shorter timescales than traditional social science, many of the ethnographic methods employed by them have come to be known as 'rapid ethnography' [58]. As a result, designers often evolve existing tools, some of which address the opposing time demands of design and ethnography [37]. The process of design ethnography has been embedded in the HHCD's work over the last 26 years.

Practitioners within research, DT and ethnography, should avoid relationships that promote them as 'so-called' experts, and participants in a project as 'non-experts'. People are often termed 'users' or 'consumers', but this can reduce their contribution to that of a 'research subject' simply responding to questions set by the designer, and following the lines of inquiry as dictated by the process. This removes the human perspective that can so often lead to hidden insight, innovation and design opportunities. Participants should be seen as human beings with a context, lifestyle, attitudes and desires. The terms 'user' or 'consumer' can remove the human perspective which runs the risk of missing deeper connections with an individual. Users just use, consumers only consume, but people live, and the aim of DT is to capture different dimensions of a person's life.

There is a tendency to objectify the people that designers choose to work with, seeing them as 'test subjects' rather than human beings with a context, lifestyle and desires that go beyond their physical representation and as a person with needs, aspirations and ambitions. Design thinkers should shift towards an attitude of peer-to-peer exchange, treating a person as a valued contributor and partner. Only then can contributions go beyond a viewpoint of assumption (Fig. 1).

People are typically seen within the context of their lives, whether at home, at work, in the city, the hospital or whilst travelling. Every person has a context that informs and surrounds them, and a richer ethnographic picture can be formed when people are seen against the background of their connections, their family or even just the architecture of their surroundings. Nothing can replace this type of direct contact [68]. This is especially important when a design thinker aims to empathise with a person who can be radically different from them.

Interaction between a person and their space can also be significantly informative allowing the designer to access contextual issues rather than simply studying the individual, and opening up a wider channel of inquiry. Context also becomes important when dealing with different types of exclusion such as cultural or emotional, or looking at multi-faceted or less tangible issues. The relationship between designers and users of their designs can be historically described as one of producer-consumer, or expert and non-expert. However, co-creative and collaborative viewpoints have begun to engender a more equitable stance in these relationships, moving from a perspective that is empirically objective to one that is

Fig. 1 When researching issues of safety and security with migrant workers in the Middle East, it took days before trust could be built with the project researchers. Dressing in the same clothes was part of a suite of activities to gain trust and build acceptance

more connected. This can result in a heightened level of inventiveness as design thinkers are challenged to seek new, novel or non-conventional solutions. An empathic stance is essential for designers developing their own ethnographic practice in this area [50] (Fig. 2).

Fig. 2 HHCD researchers conduct conversations and interviews with a project participant in their home to gain contextual insights and ensure that they are on an equal footing

2.2   Translate Design Thinking into Design Doing

Some critique of DT exists around actioning frameworks and translating the 'thinking' into 'practice. Although insights have real value, they need to be implemented in order to bring maximum benefit and impact. The traditional processes of design have to be evolved to support the delivery of DT and one prominent approach is called Inclusive Design (ID). This was defined in 2000 by the UK Government as products, services and environments that include the needs of the widest number of consumers [18]. This consumer focus marked it as a business strategy, bringing ideas of people-centred design and a social attitude into the corporate innovation space.

Since 2000, ID has developed in a number of different directions whilst maintaining relevance to the private sector. It has been characterised as a practice, methodology, philosophy and technique, but a key achievement is that it is internationally recognised and used by governments, industry, designers, policymakers, and social and creative organisations. The idea was articulated in a paper delivered at the International Ergonomics Association's 12th Triennial Congress [12] and is the primary focus of the HHCD at the RCA.

ID is very close in its ideology to two other people-centred design practices, namely Universal Design (UD) and Design for All (DfA). All three began by focusing on issues of accessibility, the needs of older people or those with disabilities, but a variety of different cultural, historical and political factors have affected the exact manner in which these ideals have been interpreted, developed and expressed [67].

ID has progressed to meet a wider range of emerging social challenges that go beyond a focus on age or ability. Today, the people-centred design tools enshrined in ID can be used to address other instances of exclusion such as by gender, socio-economic circumstance, geography, race or locality, amongst many others. Whilst ID has traditionally focused on product design or the built environment, emerging design disciplines such as digital design, service design or experience design are becoming increasingly prominent and more relevant to the innovation landscape today. There is a shift from historical approaches, to defining new theories, practices and experiences within the teaching, research and practice of design. A notion within ID is that design should sit within a multi-disciplinary context, often forming the platform discipline for other departments or sectors to engage with. Within commercial development processes, design has real value when added into the 'mix', and DT is key in enabling this.

At the HHCD, designers draw down from research techniques including co-creation approaches, expert consultation, interviews, observation 'in situ', testing with prototypes, research kits and more design-specific practices such as cultural probes [27]. If the designer cannot be present to conduct face-to-face research with participants, methods such as diaries or video logging are also used to record material in absentia [60]. Designers are encouraged to derive their own methods and build on existing ones so ensure appropriate engagement throughout the process.

Sometimes design ethnography methods are developed at the HHCD to suit shorter-term, DT-focused applications. *Creative Bridging* has been extensively used in work redesigning the London taxi. This uses a combination of words, user quotes and images associated with modern London to inspire creative designs for the vehicle exterior. *Design Provocation* is another example where props, visuals or sketch ideas are shown to people to stimulate feedback and provoke discussion [23]. This originated in a technology project conducted at the HHCD in 2006 that asked older people to discuss digital technology, something they were unfamiliar with and even fearful of. Creating a set of 'mocked-up' ideas around managing health or money, such as digital medicine bottles and piggy banks, allowed them to step over their apprehension and take ownership of the ideas, even drawing over and modifying them (Fig. 3).

The search is for creative insights rather than a detailed understanding of every aspect of a person's life. The aim is to achieve a diversity of needs, points of view and life positions. It is essential to look at new practice as well as evaluating limitations from existing approaches. Creative speculation within design where the designer as the key protagonist is often at odds with the move to engage users. Facilitating peer-to-peer exchange and community engagement demand deeply different thinking from traditional people-centred methods.

The co-creative stance of ID can raise some questions, such as whether users can be equal partners with designers when they are typically placed in a less powerful position. Or can they be seen as co-inventors with rights to the Intellectual Property within a business context? This all points to the idea that in DT, the practitioner is

Fig. 3 A Design Provocation consisting on an image of a piggy bank with a USB tail that reads out bank information when a credit card was inserted into the slot on its back. This was used to prompt response from older people

ethically bound and responsible for the people they work with, something that needs careful consideration when applied in practice. In summary, ID can be considered as a delivery tool for DT, taking it from the realm of insight, framing and thinking, and into the realm of practice, development and delivery,

2.3 Create Value and Capture Value

DT can create value in a number of different ways. It can enable organisations to go beyond the limits of their imagination and overcome innovation barriers [5]. Figure 4 shows a research activity conducted with eight older people as part of a workshop held at the HHCD looking at attitudes to technology and health for a large Japanese company. Initial responses to questionnaires were of limited value, but employing a visual research method allowed researchers to access people's inventiveness. It asked participants to describe what an imaginary fourth hand on a watch would measure about their health and well-being. As well as functional ideas such as steps, heart rate or calories, this inspired aspirational responses such as happiness of family members, proximity of authority figures, or level of stress in the people around them. These ideas enabled a deeper level of communication and insight into what was important and of value to the workshop attendees.
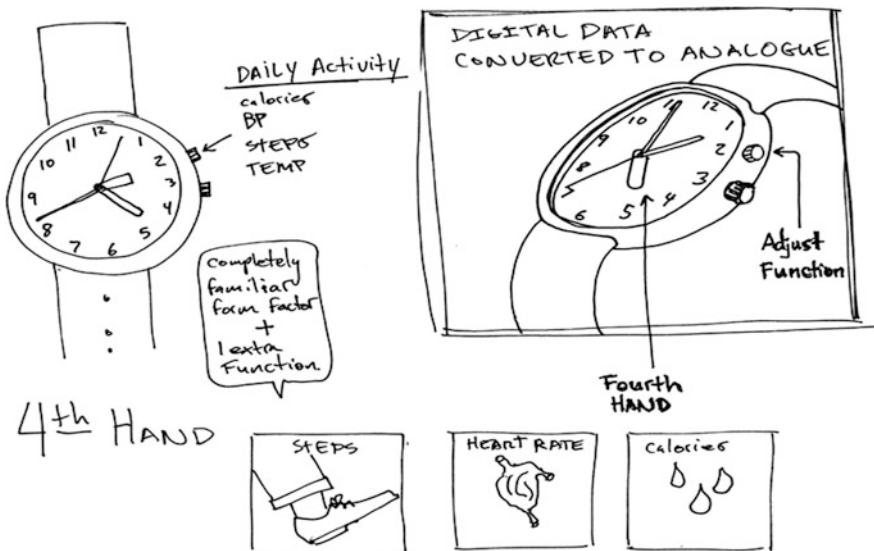

Fig. 4 A DT imagination exercise asking participants to imagine what the fourth hand on a watch would tell them about their health