discribe
IMAGINING SECURE DIGITAL FUTURES

Futures

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SUMMARY

Futures thinking, anticipation, and imagination play a central role in the research agenda of the DiScriBe Hub+. The core purpose of the DSbD Futures programme within the DiScriBe Hub+ was therefore to connect with stakeholders to help imagine the possibilities involved in the adoption of new secure technologies such as CHERI/Morello and the challenges likely to be faced in a (VUCA) volatile, uncertain, complex, and ambiguous future, including:

- what the hardware enables
- what the core proposition for DSbD involves
- how DSbD might potentially be used in VUCA future(s)
- what future use cases DSbD might have
- how DSbD might relate to a continuation of today's business-as-usual (BAU) in digital security, or contribute to utopian and/or dystopian sociotechnical futures

To achieve this, the DSbD Futures programme used creative engagement techniques to bring together different stakeholder groups and develop novel methods for stimulating dialogue between them. In the first 12 months of the programme it co-designed and co-delivered a portfolio of interviews and participatory engagements that innovate upon 'futures literacy' practice, adapted to suit the specific context of DSbD Futures, in order to:

- garner data to support a better understanding and a richer description of the possible, plausible, probable, and preferred futures that each group in the technical community anticipates and imagines for DSbD and for the next generation of security hardware technologies;
- identify multi-order consequences and DSbD use cases in VUCA futures;
- develop a stronger sociotechnical capability in 'futures literacy' across the Discribe Hub+ team and its various expert stakeholder partners;
- interrogate a range of different types of 'desired' futures;
- explore futures scenarios that present both desirable (utopian) opportunities for some communities alongside undesirable (dystopian) risks or compromises for others;
- provide a safe and creative space to surface and discuss different viewpoints (including disagreements) concerning the core proposition for DSbD.

INTRODUCTION

This report presents the preliminary work and findings of an ongoing investigative programme examining stakeholder insights into the speculative future(s) of Digital Security by Design (DSbD). It forms part of a wider portfolio of work funded by the ESRC-funded Digital Security by Design Social Science Hub+ (Discribe).

The core mission of the Discribe Hub+ is to provide interdisciplinary leadership to realise Digital Security by Design through a focus on three overarching goals:

1) Bridging divides within and between STEM and social science approaches to digital security, with a particular focus on connecting those technologists and engineers working on the hardware architectures with software engineers, social scientists, end-users, industry, and policy makers.
2) Capacity building, with the inclusion of established world-leading experts and emerging early career researchers (ECRs) from across the social sciences, many of whom have not previously applied their work to digital security; and
3) Generating new insights on the adoption of new secure technologies, the readiness of diverse communities for such adoption, and the regulatory challenges likely to be faced in an uncertain future.

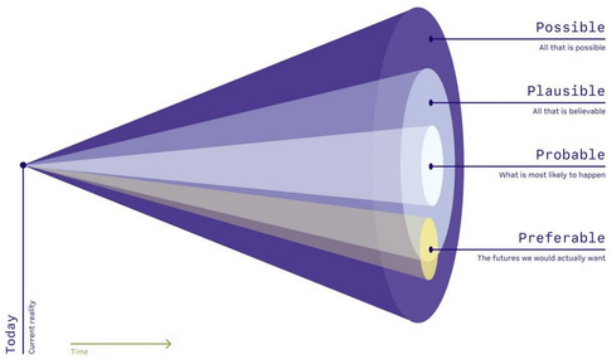
Aims and Objectives

The Discribe Digital Security by Design Social Science Hub+ supports these goals and the wider DSbD challenge by applying social and economic science to core questions around the adoption of new secure technologies, the readiness of different sectors (and roles) to adopt new secure hardware, the regulatory and policy environment and how that might influence the adoption of DSbD, and the social and cultural factors that might influence the success of the wider DSbD programme. Futures thinking, anticipation and imagining, therefore, play a central role in the research agenda of the Discribe Hub+. The core purpose of the DSbD Futures programme within the Discribe Hub+ is to connect with stakeholders to help generate new insights into the possibilities involved in the adoption of new secure technologies such as CHERI/Morello and the challenges likely to be faced in a volatile, uncertain, complex, and ambiguous future.

The Futures work strand of Discribe Hub+ sets out to identify these possibilities and to address these challenges by working with stakeholders from across the DSbD ecosystem to develop shared visions of digital security by design futures that particularly address:

- what the hardware enables
- what the core proposition for DSbD involves
- how DSbD might potentially be used in the future(s)
- what future use cases DSbD might have
- how DSbD might relate to a continuation of today's business-as-usual (BAU) in digital security, or contribute to utopian and/or dystopian sociotechnical futures

To achieve this, the DSbD Futures Programme has used creative engagement techniques grounded in the arts and humanities to bring together different stakeholder groups and develop novel methods for stimulating dialogue and promoting stronger understanding of the DSbD proposition between hardware developers, digital service providers, software developers, social scientists, policy makers and regulators. In the first 12 months of the programme it has co-designed and co-delivered a portfolio of interviews and participatory engagements that particularly draw upon and develop 'futures literacy' practice, adapted to suit the specific context of DSbD Futures, and building upon the creative engagement and elicitation methods more typically encountered in design practices (Zimmerman, Forlizzi, and Evenson 2007) and in creative anticipation practice (Miller 2018; Liveley, Spiers, and Slocombe 2021). The specific aim of each engagement was to garner data to support a better understanding and a richer description of the possible, plausible, probable, and preferred futures (Poli 2017) that each group in the technical community anticipates and imagines for DSbD and the next generation of security hardware technologies. The subsequent challenge was then to further interrogate these data with stakeholder groups in order to identify multi-order consequences and use cases in futures that might represent (a) a continuation of today's business-as-usual (BAU), (b) utopian, or (c) dystopian imaginings of the DSbD/CHERI proposition.



Source: Futurice, 'The Lean Futures Creation Handbook 2.0' https://futurice.com/lean-futures-creation-toolkit

Co-Production Workshop Partners

To support this work we commissioned three internationally renowned partners to collaborate with us in developing and implementing innovative creative approaches to enhance our engagement with DSbD stakeholders through workshop activities: StoryFutures, Punchdrunk, and the School of International Futures (SOIF). StoryFutures brought their unique skills in storytelling in immersive spaces across disciplines and formats, with particular experience in designing and running interdisciplinary Writers' Labs, bringing together diverse participants to help understand one another's practices and to collaborate in solving problems and developing new prototypes. StoryFutures' research interests in world-building and point-of-view combines a robust theoretical understanding of narrative with practical experience of making stories in a range of media, making them ideal partners to support the activities undertaken as part of the Futures programme: https://www.storyfutures.com. Their research collaborators Punchdrunk are one of the world's leading immersive theatre practitioners – making them also ideally situated to help DSbD stakeholders explore and understand differences in imagination and anticipation of the DSbD proposition https://www.punchdrunk.org.uk/. While SOIF (The School of International Futures) is an approved provider of foresight and futures to UK Government under the 'Futures Framework' (1902/05/2019) run by GO-Science within the Department of Business, Energy and Industrial Strategy (BEIS). SOIF's futures practitioners are experts in qualitative and data-driven research into future trends, uncertainties and emerging issues, and in integrating foresight into strategy, policy, risk management, with particular expertise in transformation initiatives:

https://soif.org.uk/about-us/foresight-with-impact/. Their work for the Futures programme was further informed by the 'Seeds of Change' (https://goodanthropocenes.net/) and 'Futures Wheel' frameworks for futuring (https://www.jisc.ac.uk/guides/vision-and-strategy-toolkit/futures-wheel). Both frameworks are described and illustrated in the Appendix, and full details of the programme's co-designed work with these partners are set out in the Methodology section.

We also commissioned a graphic artist to work with us in capturing, interpreting, and encapsulating the study data in comics form: http://www.littlecreature.org/. These images were used to socialize the Future programme's preliminary findings with the wider Discribe Hub+ team, and with stakeholders across the broader DSbD ecosystem.

The findings detailed below represent a synthesis of the data collated across the Future programme's three key research activities, and include a selection of the illustrations produced to help condense this data (and the key stakeholder insights it represents) into image form.

BACKGROUND:THE RELEVANCE OF 'FUTURES LITERACY' FOR DSBD

The prospect of DSbD presents a unique set of challenges for the DiScriBe Hub+ team, for the wider DSbD programme, and for the broader community of DSbD stakeholders, because the full potential of DSbD, its future use cases, its multi-faceted sociotechnical impacts and effects, and the regulatory issues likely to frame its adoption are all situated in a volatile, uncertain, complex, and ambiguous (VUCA) future. It was essential, then, that the Futures programme should initiate the DiScriBe Hub+ wider research agenda, to help the core team as well as stakeholders across the DSbD ecosystem better understand the anticipatory futures thinking required to tackle these challenges. Indeed, one of the supplementary aims of the Futures programme was to develop a stronger sociotechnical capability in 'futures literacy' across the DiScriBe Hub+ team and its various expert stakeholder partners.

For Miller (2006, 27), one of the pioneers of this capability, futures literacy (FL) describes the ability to identify, analyse, and communicate data about the future. This means using:

- 'rigorous imagining' to develop and question the theories and models that define the variables and relationships, metrics and definitions being used to make sense of the present (note: pattern recognition/data mining is insufficient). The point of FL is to become more adept at inventing imaginary futures: to use these futures to discern system boundaries, relationships and emergence; to invent and detect changes in the conditions of change; to rethink the assumptions we use to understand the present.'

This emphatically does not mean attempting to predict, prophesy, or divine the future of DSbD. It means knowing how to use the right tools and methods to understand and manage futures data rigorously in order to make robust 'futures literate' decisions in the present.

The value of this approach to futures thinking is championed by UNECSO, which is currently leading the development of a global 'futures literacy' capability[1].

[1]https://en.unesco.org/themes/futures-literacy#:~:text=Futures%20Literacy%20is%20a%20capability,present%20(Miller%2C%202015)

The Head of Futures Literacy at UNESCO, suggests that (Miller 2011, 26-27):

- There is no way to outsmart the complexity of reality; unforeseeable novelty is a certainty. Instead, the approach should be to try and develop the capacity to use the future in a range of different ways, and not be limited by prediction or by narrow conceptions of a desired future. It is about being Futures Literate.

Being 'futures literate' in the context of the DSbD programme requires its stakeholders to avoid placing undue emphasis upon the predictability, certainty, unity, or clarity of the future of DSbD. It requires the interrogation of a range of different types of 'desired' future. This involves resisting the assumption that present and historic trends are inevitable and will continue (chronocentrism), and includes taking steps to avoid simplifying or restricting the range of possible futures by focusing only on those that are deemed plausible, probable or preferable. This means looking beyond the future as a continuation of the recent past and present (avoiding presentism or BAU – 'business-as-usual' thinking) as well as interrogating binary distinctions between apparently 'utopian' or 'dystopian' futures – recognizing that a futures scenario that presents desirable (utopian) opportunities for one community may represent undesirable (dystopian) risks or compromises for others.

For example, when we imagine possible, probable, plausible, and preferred futures, we necessarily imagine them from our present situation. Future projections and imaginations are typically 'extensions of the present' and 'linked to known trends' (Poli 2017, 69). Through a failure of imagination, therefore, we risk populating the future with present priorities and with present concerns: 'being able to think about the future … is perpetually spoilt by our present incapacity to be sufficiently imaginative, to think the unexpected, to factor in surprise…' (Bode and Dietrich 2013, 100). Communities, organizations, and individuals typically make sense of the new and unfamiliar by assessing its resemblance to the old and familiar – testing its relation to so-called 'knowledge frames' or 'knowledge scripts' and making predictions of future patterns based upon templates shaped by prior knowledge and experience (Tait and Norris 2011, 20). The history of technology offers plenty of salient illustrations of the blind-spots produced by such 'presentism' or 'chronocentrism':

"I think there's a world market for maybe five computers." (Thomas Watson, Chairman of IBM, 1943)

"There is no reason why anyone would want to have a computer in their home." (Ken Olson, president, chairman and founder of Digital Equipment Corp, 1977)

“That’s an amazing invention, but who would ever want to use one of them?” (President Rutherford B. Hayes to Alexander Graham Bell in 1876 regarding the new telephone)

Futures literacy helps to expose the mechanisms and heuristics which stakeholders use in making sense of the plurality and complexity of the possible, plausible, probable and preferable worlds that DSbD has the potential to realise.

This is especially important if the wider DSbD programme is to imagine and to deliver futures (plural) which do not merely re-present (that is, continue or make ‘present’ again) the priorities and concerns of the now in a futures mode of ‘business-as-usual’ (BAU).

Futures literacy in this context, therefore, requires some acknowledgement and understanding of the heuristics and knowledge shields that inevitably shape the imagination and anticipation of DSbD futures. Some of the biases which assert particular influence in futures thinking and are of particular relevance to the DSbD challenge are given in the table below:

Futures Cognitive Bias or Heuristic	Description
confirmation bias	where we struggle to detect and make sense of novel phenomena that do not relate to pre-existing models
anchoring bias (and availability bias)	where focus and attention is captured by current concerns and significant events in recent memory, resulting in the over-estimation of the likelihood that these will recur
clustering	extrapolating future patterns from small runs, streaks, or clusters in data
declinism	viewing the past nostalgically and the future negatively
negativity/optimism bias	where we remember and anticipate unpleasant experiences more vividly than pleasant ones – or *vice versa*
projection bias/the 'end of history' bias	where we overestimate the similarities between our past, present, and future selves and organisations
narrative bias	where we view past, present, and future as chapters in a coherent (hi)story

These cognitive biases or heuristics affect all stakeholders when it comes to anticipation and futures thinking and being futures literate means recognizing both personal and collective limitations when it comes to 'rigorous imagining' about the future(s) of DSbD. For, as Ward, et al. (2018, 39) describe, these heuristics readily transfer into 'knowledge shields':

- "These are denial or defense mechanisms of a sort. Shields include down-playing the importance or relevance of contradictory data, arguing from authority, resorting to bad analogies, ignoring secondary effects, arguing from special cases, and arguing that a principle has restricted applicability. Although these findings emerged in the domain of medicine, similar observations have been made in other domains and applications, including ... the design of complex sociotechnical systems."

Creative and imagination-led processes have been identified by UNESCO and others as particularly useful tools to help surface these heuristics (Miller 2018; Liveley, Spiers and Slocombe 2021) and to challenge and break through these 'knowledge shields' (Ward, et al 2018). The Futures programme therefore adopted a creative story-based approach to its futuring activities with stakeholders – albeit remaining alert to the effects and affects of 'narrative bias'. To support this, throughout the Futures programme we worked closely with images – not only those produced to illustrate the interview study data, but those used as imagination prompts in the workshops. These images and illustrations helped to 'disrupt' participants' view of the futuring process as a (chrono)linear system in which DSbD futures are clearly tied to the status quo – that is, to the past and present of digital security and its technologies. Examples of such story 'snapshots' encapsulating key findings from the Futures programme are included in the report's 'Findings'.

METHODOLOGY

Design

Key DSbD stakeholders (including those involved in the development of CHERI and Morello as well as DSbD advisory panel members) were identified by the DiScriBe Hub+ team and its Challenge Fellows and invited to participate in the Futures programme. Using one-to-one semi-structured interviews (most lasting up to one hour, some up to ninety minutes) and follow-up focus groups convened as workshops (lasting up to three hours), participants were asked to share their particular insights into the possible, plausible, probable, and preferable futures offered by the adoption of DSbD and the challenges likely to be faced in this adoption in the context of a VUCA (volatile, uncertain, complex, and ambiguous) world. All interviews, follow-up focus group workshops were conducted using video conferencing platforms (Microsoft Teams and Zoom). No interview conversations or follow-up focus group workshops were recorded (in order to encourage participants to speak candidly) but in each case a set of anonymized notes were written-up, confirmed as an accurate record, and considered for analysis and illustration. No participants are identified as a named individual in any output arising from this research.

Following 11 initial interviews with core DSbD stakeholders in the period November 2020 to January 2021, we then worked with the same group of stakeholders/interviewees plus an additional pool of stakeholders drawn from the wider DSbD ecosystem (as identified during the interviews) in two follow-up workshops. The first of these was co-designed and run in collaboration with StoryFutures and the Punchdrunk Theatre Company; the second was co-designed and run in collaboration with the School of International Futures (SOIF). The broad aim of both workshops was to further elicit stakeholder insights and anticipations of the DSbD proposition through shared narrative-based interventions and activities – focusing in particular upon consequential futures thinking through storytelling. The particular aim of the StoryFutures/Punchdrunk workshop was to surface some of the heuristics and knowledge shields that were framing (and potentially limiting) futures thinking in the context of DSbD, and to begin to focus in a futures literate way upon the complex 'cascade' of effects that might ensue from introducing a disruptive technology such as DSbD into the digital security ecosystem.

The workshop was structured to help participants think through the experiential effects of this innovation by imaginatively 'immersing' themselves and the technology within a fictive storyworld. The design of the second workshop was closely informed by the findings of the first, and its particular aim was to explore and unpack the wider political, economic, social, technological, legal, and environmental (PESTLE) implications of the future DSbD storyworlds identified in the first workshop.

Participants in both workshops were carefully selected to ensure a good mix of expertise and an equal gender balance, and breakout groups were similarly configured to ensure that in each sub-group there was at least:

- one DSbD academic stakeholder with expertise in digital/cyber security
- one DSbD sociotechnical academic stakeholder with expertise in sociology/criminology/etc
- one member of the DiScriBe Hub+ or DSbD programme
- one stakeholder from the National Centre for Cyber Security (NCSC)
- one business/industry stakeholder
- one stakeholder with deep technical knowledge of DSbD

Interview Questions and Focus Group Workshop Provocations

A suite of questions to prompt and structure discussion about what DSbD is and what its future use cases might include were asked during the semi-structured interviews and used as thought-provocations for the follow-up focus group workshop activities. Each question formed the basis for a deeper discussion with the participants; not every interview covered every question; and questions were not necessarily posed in the order they appear in the table below.

What recognised or anticipated problems does DSbD have the potential to solve?
What is our best use vision for this technology? What could go wrong in realizing that vision?
Do any historical parallels for DSbD come to mind?
Can we learn anything from past innovations and their consequences in this space?
What futurist parallels (from sci-fi, speculative fiction, etc) come to mind for DSbD?
How could DSbD be deliberately, accidentally and/or unwittingly misused to cause harm?
What is the UK Industrial futures narrative on DSbD? (i.e., how might it shape or reimagine the future here?)
What is the UK 3rd sector futures narrative on DSbD?
What is the UK SME futures narrative on DSbD?
What global developments/incidents could accelerate or decelerate the development and use of DSbD?
What are the critical uncertainties of DSbD? What are the known unknowns?
Who might end up 'winning' and 'losing'? (e.g., (how) could DSbD deepen inequalities?)
In what ways could DSbD constrain or benefit future generations?
What existing technologies or processes or jobs could it enhance – and make obsolete?
How could a 4-year-old, a 14 year old, a 74 year old, an asylum-seeker, benefit from DSbD technology?
Suggest a future news headline for DSbD.
Suggest a future TV crime show story for DSbD.
Suggest a film poster headline' for DSbD.
If DSbD were a superhero, what would its power be? (e.g., invisibility, super strength, super speed).
If DSbD were available to an evil villain what could they do with it?
What other key stakeholders do you think we should be talking to?

Workshop 1 (with StoryFutures and Punchdrunk): Methodology

The goal of this creative elicitation workshop was to socialize and interrogate some of the data from the initial interview phase of the Futures programme and to widen the pool of participants involved in the Futures research by connecting with a broader variety of stakeholders. This three hour online workshop, co-designed and delivered with Punchdrunk and StoryFutures, facilitated this investigation and socialization by 'thinking fantastically and metaphorically' – at the same time as experimenting with innovative ways of working with diverse stakeholders on this topic and building 'futures literacy' skills into the DSbD programme.

The creative and immersive activities delivered as part of this workshop were carefully designed to create a rupture in participants' futures thinking and so break stakeholders out of story 'lock-in' whereby the imagined future(s) of DSbD is unconsciously biased to develop along familiar trajectories and plotlines: that is, to break away from presentist or chronocentric futures thinking and so avoid limited, generic thinking about DSbD capabilities and possibilities; to imagine what a future DSbD world could do differently; and how it could transform the digital/online ecosystem. To facilitate this rupture, the example of the USA's Yellowstone Park Ecosystem transformation was used as a hook to help participants imagine a similar transformation in the digital security ecosystem (in which the introduction of DSbD to the cyber security ecosystem is imagined to be broadly analogous to the re-introduction of wolves to the Yellowstone National Park).

A workshop session plan with further details and links is provided in the Appendix.

Workshop 2 (with the School of International Futures): Methodology

The aim of this workshop was to further socialize and interrogate some of the data from the initial interviews and Workshop 1 and to further widen the pool of participants involved by connecting with a broader variety of stakeholders. This 2.5 hour online workshop, co-designed and delivered with the School of International Futures, facilitated this investigation and socialization – at the same time as experimenting with innovative ways of working with diverse stakeholders on this topic and introducing new futures tools and methods to the DSbD programme. Participants worked in three breakout groups, each led by a member of the SOIF team to:

- choose and analyse a selection of 12 'seeds of change' (informed by the findings and data elicited in the initial interviews and in Workshop 1) – story headlines written as if the use cases and future 'seeds' of DSbD we see today have become mainstream 10 years or so into the future;
- imagine the broader consequences of these seeds, including the 1st as well as the 2nd and 3rd order consequences – organized on the spokes of a 'Futures Wheel';

- build out these consequences into vignettes of the future, by imagining newspaper headlines and products and services that would exist in this future world of DSbD;
- compare the vignettes created in each of the three sub-groups, discussing the insights and challenges of using this model for thinking about how change could happen.

The purpose of this activity was to derive a variety of potential worlds from these vignettes, which take us beyond the obvious futures that are a continuation of today's business-as-usual (BAU) towards both utopian and dystopian imaginings of the DSbD proposition. However, one of the values of the 'Futures Wheel' design is that does not constrain or silo participants' futures thinking into binary either/or choices or anticipations but, rather, helps stakeholders to think through richer descriptions of the possible, plausible, probable, and preferred futures potentially offered by DSbD.

A workshop session plan with further details and links, and a list of the 12 'seeds of change', is provided in the Appendix.

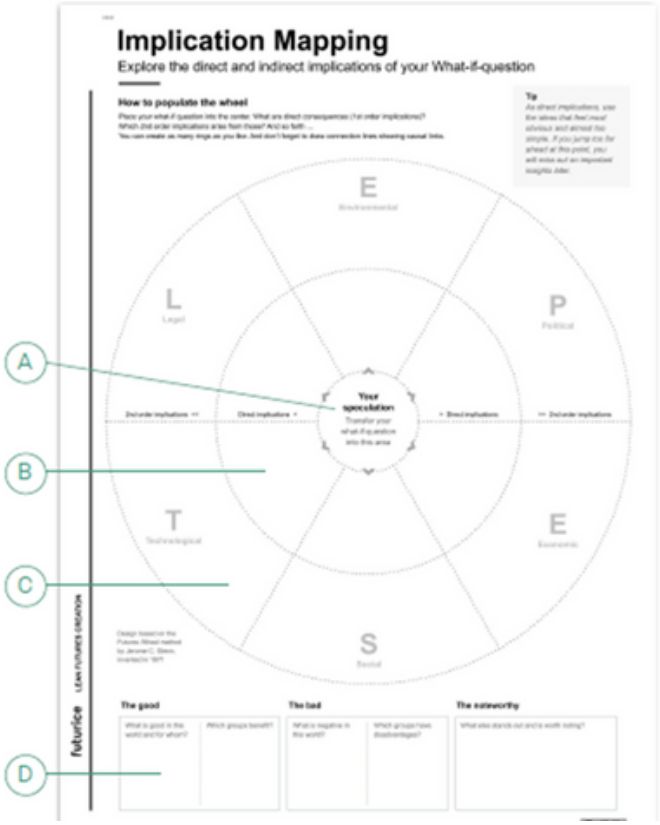
The **'Seeds of Change'** were informed by data collected in the interview phase of the research and co-designed by the Futures programme team and SOIF according to the 'Seeds of Change' futuring framework devised by the 'Seeds of Good Anthropocenes' Project (https://goodanthropocenes.net/).[1] The project defines seeds as 'initiatives which hold potential to shape the future … They can be social initiatives, new technologies, economic tools, or social-ecological projects, or organisations, movements or new ways of acting that appear to be contributing to the creation of a future that is just, prosperous, and sustainable.' The project advises 'that not everyone will agree on the importance or value of every seed' (as was, indeed, the case with the 12 DSbD seeds designed for this workshop) but disagreement in this context is welcomed as a productive aspect of the rigorous imagining involved in such futures thinking. The seeds provide the initial proposition from which the spokes of the Futures Wheel exercise radiate.

The **Futures Wheel** is a popular tool in futures research and practice, and is particularly useful for 'implication mapping' and exploring the multi-order ramifications of a given futures scenario.

[1]See Pereira, L. 2021 "Imagining Better Futures Using the Seeds Approach". 2021. Social Innovations Journal, vol. 5, https://socialinnovationsjournal.com/index.php/sij/article/view/694.

It provides a collaborative map of the possible, plausible, probable, and preferred consequences that ensue from an initial proposition, 'what if?' question, or future 'seed':

1. Groups choose a 'seed' to explore and place this at the central hub of the wheel;
2. Using PESTLE or PESTLE+CO categories, groups imagine the basic (1st order) consequences of this proposition Politically, Economically, Socially, Technologically,
3. Legally, Environmentally (and, optionally, imagine the effects upon their own Culture and Organization);[1]
4. Groups imagine and explore the causal consequences that might follow from these (because of x … ; because of y …; until …);
5. Groups consider these consequential outcomes, reflecting upon their negative (dystopian) and positive (utopian) implications for different communities, and considering which of the possible consequences lead – in their estimation – to plausible, probable, and preferred future scenarios.



Source: Futurice, 'The Lean Futures Creation Handbook 2.0' https://futurice.com/lean-futures-creation-toolkit

[1] See Perera, R. (2017). The PESTLE analysis. Nerdynaut.

Data analysis

Once anonymized interview notes had been produced, these were sent back to interviewees for confirmation and/or clarification of data and collection of any further thoughts. These anonymized notes were then assigned a thematic identification tag according to the dominant metaphor for DSbD that each interview had suggested. Narratological and thematic analysis was then used to identify key sub-themes within and across the interview data. Themes were grouped into the following categories:

- Defining the core proposition of DSbD
- Describing the architecture of DSbD
- Identifying future use cases of DSbD
- Ascribing analogies, myths and metaphors to DSbD
- Anticipating BAU (Business-as-usual), Dystopian, or Utopian consequences for DSbD

The interview data were then interpreted and summarized in comics form by an illustrator, and these images used to socialize the Future programme's preliminary findings – (1) within the follow-up focus group workshops, (2) across the wider DiScriBe Hub+ team, and (3) across the broader DSbD programme. Significantly, the lack of consensus among stakeholder interviewees as to the core proposition and future use cases for DSbD was amplified at each cascading tier. For example, at a macro level, interviewees, workshop participants, and members of the wider DSbD ecosystem disagreed as to whether CHERI represented a transformative step-change in digital security or whether it represented a refashioning of RISCS-V architecture and a continuation of BAU in this space. At a micro level, interviewees, workshop participants, and members of the wider DSbD ecosystem disagreed on the extent to which software designers and end users would experience any tangible differences as a result of DSbD/CHERI. Further details and examples are given in the following section on 'Findings'.

Workshops were used as vehicles to bring together follow-up focus groups comprising some members of the original interview set plus stakeholders from the wider DSbD ecosystem (in industry, business, policy, government, and academia).

Some stakeholders who were unable to attend the workshops provided additional input on the topics via email correspondence and by adding comments to Miro Boards after the event. Workshops were run under 'Chatham House Rules' and all views and opinions expressed therein (including those raised using a Teams or Zoom 'chat' function) were recorded in written note form and fully anonymized. Some workshop data were collated using Miro Boards and again, the data were fully anonymized before analysis – employing the same narratological and thematic analysis process to identify key sub-themes as used for the interview data set.

Limitations

The study was based on 11 preliminary interviews with core stakeholders, widened to include a larger group of participants from the DSbD ecosystem in follow-up workshops (20 at the StoryFutures/Punchdrunk event in March 2021; and 15 at the SOIF Workshop in May 2021). Although limited in number and drawn from a relatively 'closed' community of digital security stakeholders, participants were invited on the basis of their pre-existing expertise and knowledge of the DSbD programme to ensure good familiarity with the technical and sociotechnical ramifications of implementing DSbD. The open and semi-structured nature of the interviews, and the story-based explorations conducted in the follow-up focus group workshop activities, enabled a broad and deep examination of the topic.

Ethical Governance

The study was approved by the by the Faculty of Arts Research Ethics Committee at the University of Bristol and complied fully with University of Bristol Research Governance and Ethics protocols: http://www.bristol.ac.uk/red/research-governance/ethics/uni-ethics/. In accordance with this ethical approval, all data were managed in full compliance with guidance on information security provided by the University of Bristol (http://www.bris.ac.uk/infosec/uobdata/research/) and the University of Bath (https://www.bath.ac.uk/guides/data-protection-guidance/).

All data – which consisted of anonymised written research notes capturing the key points of interviews and focus group discussions – were fully anonymized; no personal information was attached to or included in the notes and transcripts (such as participant names, names of locations, companies, or places of employment, or any other potentially identifiable information). Thematic tags were used instead of actual names to label notes and transcripts. All informed consent forms were collected digitally and stored securely under password protection. Copies of the anonymized transcripts and notes were approved by the participants before being shared with the wider programme team for subsequent analysis. Informed consent forms and anonymised transcripts and notes will be retained digitally until the end of the DiScriBe Hub+ research project (February 2024).

FINDINGS

Narratological and thematic analysis of (a) the interview data; (b) workshop 1 data; and (c) workshop 2 data were used to identify key sub-themes which were grouped into the following categories:

- Defining the core proposition of DSbD
- Describing the architecture of DSbD
- Identifying future use cases of DSbD
- Ascribing analogies, myths and metaphors to DSbD
- Anticipating BAU (Business as usual), Dystopian, or Utopian consequences for DSbD

The surfacing of both individual and collective stakeholder heuristics and the challenging of 'knowledge shields' as part of the programme's creative futuring activities accordingly produced a set of findings that: (a) explicitly play-up (rather than down-playing) the importance of contradictory data; (b) include a diversity of viewpoints and opinions (rather than privileging any one kind of authority); (c) actively elaborate, illustrate, and interrogate analogies, myths, and metaphors (rather than passively accepting 'bad analogies'); and (d) explicitly recognize multi-order consequences and implications (rather than discounting or ignoring secondary effects). Indeed, we found that the cartoon images produced by our illustrator to help encapsulate and socialize key messages from the interview phase, proved a highly effective vehicle for conveying this complex 'mosaic' of futures literate insights into the DSbD proposition.

The findings detailed below represent a synthesis of the data collected and collated across the Future programme's three key research activities, and include a selection of the illustrations produced to help condense this data (and the key stakeholder insights it represents) into image form, used as illustrations in the relevant categories below.

1. Defining the core proposition of DSbD

1.1 To ensure the security of safety critical services in order to:
(a) protect better home-life/personal security;

(b) achieve secure delivery of social challenges such as a preventative integrated healthcare system;
(c) realise the full benefits of new tech innovations, such as 5G ;
(d) provide security and safety solutions (for both violations of safety cases and cyber attacks) in the context of extremely high levels of automation, large/complex data, and real time monitoring of emergent properties (but equally applicable to use cases involving IoT, smart buildings, cities, healthcare, defence, aerospace, etc.);

1.2 To 'change the perceptible norms' of cyber security;

1.3 To achieve Trust and Trustworthiness in online/digital services (but note that it is difficult to express DSbD in terms of concrete benefits to end users and easy to get bogged down in the detail; DSbD concerns the art of the not possible, i.e., the harms that it is no longer possible to inflict; the risks it is no longer possible to take);

1.4 To translate Trusted into Trustworthy systems and devices by replacing both the basic building blocks and the traditional construction techniques of legacy systems;

1.5 To give greater control to users (taking control away from programmers and tech companies);

1.6 To offer better ways to manage permissions, privileges, capabilities, access control;

1.7 To reduce the risk of error and flawed code – and when things do go wrong, reduce the opportunity for a cascading/exponential spread of the problem (although any fundamental design flaw which goes unnoticed could be very expensive to fix later on and patching may not be an option; hardware attacks such as Meltdown and Spectre could still pose threats);

1.8 To rebuild transparency and trust in online activity;

1.9 There isn't a binary 'possible with CHERI / impossible today' divide, there's a security cost trade-off space that looks different in the with- and without-CHERI worlds.

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2. Describing the architecture of DSbD/CHERI/Morello

2.1 A transparent 'box' containing a series of smaller boxes;

2.2 CHERI/Morello compartmentalization is akin to nesting Russian dolls;

2.3 Dry-stone-walling: DSbD/CHERI compartmentalization and isolation allows for individual stones to crumble and fail without risking the overall integrity of the structure; each stone interconnects with others to work as a mutually reinforcing system but maintains its own independent solidity;

2.4 DSbD/CHERI compartmentalized architecture can be imaged as safes within safes within strong boxes within a locked house on a gated estate;

2.5 DSbD/CHERI is like a prison or house with locked rooms/cells;

2.6 DSbD/CHERI architecture is like a house with 'walled garden';

2.7 Compartmentalization has proven to be effective but expensive in terms of RAM/resource; DSbD/CHERI promises to make compartmentalization significantly cheaper and faster (and in theory, CHERI compartmentalization offers better protection than ACLs) but the value for its core security proposition is still up for debate;

2.8 There's a difference between what CHERI-the-hardware-platform provides in terms of security guarantees and CHERI-as-used-with-a-specific-OS/compiler/language provides (i.e., misunderstandings in relation to evaluations of what CHERI/MIPS on FreeBSD with a specific compiler mode provides vs the space of what it could provide if we had tweaks to the way we translate C ideas into machine code);

2.9 CHERI does not require changes in the languages and so supports C/C++ in mostly unmodified forms (around 0.02% of code requires changes so far in a typical program). It also enables new programming language abstractions and gives an efficient way of mixing safe languages and unsafe languages to give us a way of slowly and incrementally migrating to safe languages and getting the benefits now,

rather than in 30-50 (optimistically) years – once we've rewritten all of the legacy code in the world.

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3. Identifying future use cases of DSbD

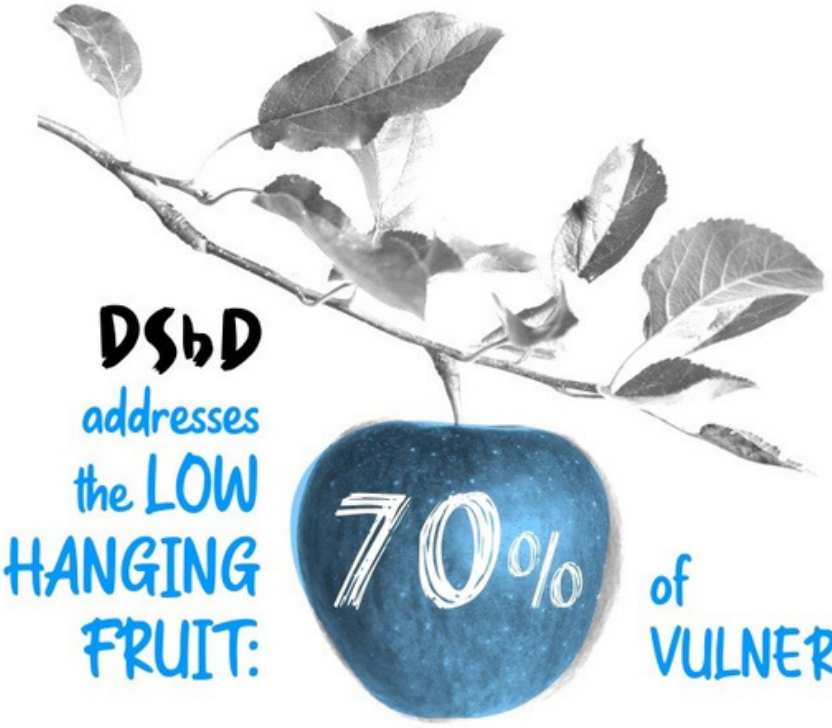
3.1 It's possible that the first product will be out to market by 2023/24 – but volume in solution will probably take until 2030/40 when DSbD tech 'will be everywhere in economy and society';

3.2 To get the full value of DSbD/CHERI will require a lot of change, but there are also possible quick wins – e.g., compartmentalization schemes such as Google Chrome;

3.3 The probable big win is trust online through DSbD; people won't worry about online activity but may be forced to engage with online services (with, e.g., healthcare, finances, phone service, home services, etc);

3.4 Other long-term use cases possibly and plausibly include:

a) 5G and mobile telecoms
b) automotive (especially in autonomous and electric vehicles, AV infrastructure)
c) integrated and anticipatory healthcare (managing data across the NHS)
d) aircraft
e) smart cities and digital twins
f) e-commerce
g) social media
h) biomed and biotech
i) fintech (especially benefits and pensions)
j) Brexit mitigation (especially in management of imports/exports; immigration, etc), post-pandemic rebuilding/levelling up
k) surveillance and security (including CCTV; recycling, farming, military, employers monitoring home or gig working)
l) IoT



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4. Ascribing analogies, myths and metaphors to DSbD

4.1 A cyber security hug (wearing boxing gloves);

4.2 Our current national digital security is a Jenga-tower and it will fall at some point;

4.3 DSbD/CHERI isn't a bandage – it fixes the wound;

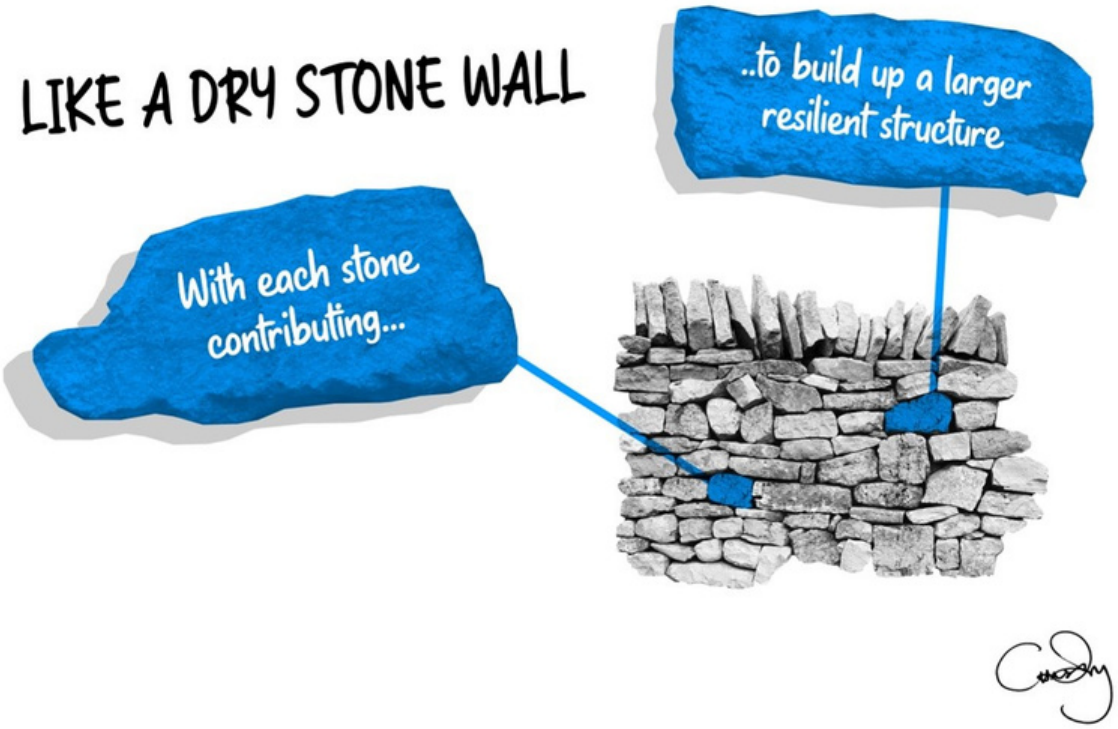
4.4 DSbD/CHERI is like the IT Crowd internet 'box' made transparent and containing a series of smaller boxes;

4.5 DSbD/CHERI is like a concrete house in an earthquake zone; its strength in some aspects makes it weak in others (potentially too brittle to withstand tremors);
4.6 DSbD/CHERI offers some protection from external viruses but may be more vulnerable to 'auto-immune' attacks from failure within (amplified by machine learning recursion and corroboration);

4.7 A DSbD/CHERI-world is a Brave New World (rather than 1984);

4.8 DSbD/CHERI is a poker game (where some players are showing their hand to others; some players are in teams; some are playing against certain opponents only; some are unable to see or reach across the table);

4.9 DSbD/CHERI is like a wildlife/safari park: where some enclosures are more heavily protected than others; where entry/exit permissions are (flexibly) controlled; where the 'user' has a map and clear expectations as to access and control, permissions, etc; and where the 'user' knows where things live and what to feed them.



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The StoryFutures and Punchdrunk workshop expanded upon some of the metaphors and analogies suggested in the initial interview phase, and invited stakeholders to imagine the DSbD challenge through a series of allegorical narratives. Those prompting particularly rich discussion included the analogies of the **wildlife park** and the **house.**

The Wildlife Park: Introduced as an example of 'trophic cascades', participants were asked to view and discuss a short video telling the story of 'The Wolves who changed the rivers': https://www.youtube.com/watch?v=ysa5OBhXz-Q. Wolves were reintroduced to the USA's Yellowstone National Park in 1995 to help manage the over-population of deer. Not only did these wolves kill and eat the deer, thus managing over-population, but their reintroduction changed the deer's habits, allowing other forms of flora and fauna in the park to flourish. Thus the wolves became effectively 'ecosystem engineers', transforming not only the behaviours of other animals but even the geography of the park – changing the flow of rivers by changing the chosen watering places used by different species within this ecosystem.

Stakeholders found the analogy particularly useful in illustrating the potential for unintended multi-order consequences to ensue over time from a single point of intervention into a complex system. They also noted that 'change', 'transformation', and 'difference' do not necessarily equate in 'better' for every part of that system. As one participated observed: 'The deer weren't better off as a result of the wolves being reintroduced, even if other elements of the ecosystem benefitted. Likewise in cyber security, benefits for one party may very well equal losses for another. We need to be conscious of different outcomes for different parties.' One crucial difference further complicating the wolves analogy is the 'invisibility' of DSbD/CHERI to most other inhabitants in the security ecosystem. Both DSbD/CHERI and the wolves 'disallow' certain behaviours and actions: wolves prevent deer drinking at accessible waterholes; CHERI prevents some classes of bugs from introducing security vulnerabilities. However, DSbD/CHERI does this unnoticed by most other actants in the system.

As one stakeholder put it: 'the vulnerability that allowed the WannaCry ransomware to propagate itself would have been prevented by CHERI but the end user (excluding malware authors from that category) would not have noticed anything different: their system would have functioned in exactly the same way.'

The Crooked House: Introduced as an illustration of an ecosystem on a smaller scale, the 'crooked house' story asked participants to imagine what you do when you inherit a property that is fundamentally and structurally flawed. The crooked house was at some point in time safe and sound but now it is structurally unsound and poses a risk to its inhabitants. Participants expanded upon this as a parallel for most cyber security infrastructures. As one participated observed: 'You could continue to patch it up, but wouldn't it be better to start again and build a new house with better foundations?'

5.Anticipating BAU (Business as usual), Dystopian, and Utopian visions and consequences for DSbD

Across each phase of the Futures programme, participants were asked to imagine both positive (utopian) and negative (dystopian) future consequences of introducing DSbD to the digital security ecosystem – as well as the middle ground (BAU or Business-as-usual). The following table collates insights from the interview phase:

Utopian Anticipations
The transformation should ideally be radical yet quiet, a disruption that nobody notices; the transition story must manage expectations carefully yet incentivize and excite
A patchless world is unrealistic but CHERI should result in fewer patches and updates, fewer reboots, and allow the use of chips in places they cannot be used now
DSbD is not about delivery of products but new ways of doing
BAU (Business-as-usual)
The core challenge to this remains a 'chicken and egg problem' (the hardware versus software prioritization) or the 'Catch 22' of legacy systems where you can't change the hardware chips and boards before you change the software
We can't stop the world and start again so the transformative potential of DSbD is unlikely to be widely transformative
DSbD will only protect against certain low-level attacks (e.g., social-engineering cyber-attacks will continue); DSbD/CHERI is only part of a (complex) system – not a solution in itself
DSbD/CHERI will not fix everything in cyber security or remove online risk – it will resist some attacks but attackers will shift their attention elsewhere and go after softer (human) targets
It remains unclear who is to blame when things go wrong with DSbD/CHERI
DSbD involves an absence of action, the suppression and negation of threat; when it works well there is no drama, nothing to see (the curse – or the blessing – of DSbD/CHERI success will be to make life boring but safe)
User consent will remain a fiction (it will be impossible to get 'informed consent' because issues are too complex; users won't fully understand the consent and permissions they grant; and it is impossible to consent anyway to a feature that is 'hard-baked' into a device)
No products as such are deliverable as part of this current imaginary and proposition – we are 'promising promises'
Dystopian Anticipations
We currently have a global cyber security market built on insecurity and DSbD/CHERI threatens that financially and commercially lucrative status quo
The carbon footprint of DSbD/CHERI (as cars, etc, become computers) and the tech

waste through obsolescence could be huge
There is a risk that the CHERI Morello boards will fail to achieve their promised impact and become obsolete and expensive paperweights in the near future
Other Anticipations
DSbD/CHERI must demonstrate and communicate a tangible improvement in terms which are accessible to different audiences – journalists, business leaders, policy makers, etc
DSbD/CHERI is emerging into an 'arms race' (business and government don't want to get locked out of the market; don't want to lose market share; don't want to proceed in the dark; but also don't want to get locked in to something too far in advance)

Across this programme of initial futures activities, one significant challenge was flagged by stakeholders when trying to imagine different futures in which DSbD is embedded in the digital security ecosystem: the prospect that one of the ambitions for DSbD in general and CHERI in particular is for there to be zero experiential impact on any of the higher tiers of the technology stack – and therefore zero impact on programmers and end users. We found the expectation among some stakeholders that software developers (designing apps in Java/ Kotlin or Windows apps in C#, for example) will not automatically notice CHERI architecture in the hardware. As one participant put it: 'People should not have to think about CHERI at all if we've done our jobs well. As a result, anything that considers folks even further removed from the details of the implementation is going to be difficult to get right.' Anticipating the future consequences and use cases for DSbD/CHERI which stakeholders can agree as representing possible, plausible, probable, or preferred futures is particularly challenging, therefore.

Mindful of these challenges, the SOIF workshop sought to expand further upon some of the use cases suggested in the initial interview phase alongside some of the issues identified in the Punchdrunk/StoryFutures activities in the first workshop. We adopted a futures methodology explicitly designed to promote 'rigorous imaging' and forward facing conversation in contexts where there is such disagreement: the 'Seeds of Change' futuring framework, which takes the idea 'that not everyone will agree on the importance or value of every seed' as a positive and productive aspect of futures thinking.

Stakeholders were asked to imagine the potential consequences of various DSbD 'enabled' scenarios from the year 2030, presented as a selection of 12 'seeds'. Not every seed was considered in detail at the workshop, but further feedback on each of them was solicited from participants after the event, allowing for a more expansive and nuanced analysis. The findings from this activity are synthesized and summarized as a narrative data set below:

DSbD Seeds of Change

1. Supported by DSbD and 5G, Highways England restricts the public use of Motorways and A roads to "autonomous electric vehicles only" between the hours of 6am and 9pm

This seed was considered plausible and possible (although not probable) and stakeholders suggested it might even be preferred by some groups (e.g., in support of net zero targets). However, some stakeholders observed that DSbD and 5G are not necessarily the enabling technologies in this scenario. The difficult technical problems required for this are related to autonomous vehicle navigation, large-scale deployment of charging infrastructure, and so on. If this system is predicated on real-time tracking of all vehicles, then there are privacy concerns there. DSbD/CHERI, by itself, does not solve these or enable this use case.

2. Supported by DSbD systems and a partnership between NHS Scotland and Biffa Waste, Glasgow City Council launches a 'smart' recycling scheme monitoring household consumption of food and alcohol.

This seed was considered possible but participants disagreed as to whether or not it was also plausible or probable – or desirable. First order consequences (positive, negative, and neutral – utopian, dystopian, and BAU) suggested by the focus groups included: waste efficiency increases; household data sets are leaked; health and other problems are identified and mitigated; data subcontracting; external agencies (and insurers) start building risk profiles based on these data; police issue court orders requesting data to confirm individual household alcohol consumption levels.

Second and third order consequences suggested included: wide resistance to joining the scheme (in a replay of the smart meters debate); fly tipping increases; a burger bar boom ensues (eating out to avoid putting out certain types of waste); a grey market in clearing waste emerges; households are enabled to make more informed choices about eating and drinking habits; a secondary market for data within the supermarket sector emerges; data are used to support community level bids for levelling-up funding; leads to improved regional and local health and recycling outcomes; leads to wider socio-economic divides ('when does this initiative get rolled-out in Chelsea?'); scandal as 'councils evict burger eaters from social housing'; mission creep emerges as councils move from 'nudging' to 'shoving' households towards greater recycling and healthier lifestyles; jobs in the waste industry fall but new data analysis jobs are created. Participants also noted that such a system could already be deployed today, although it was not clear what the incentive would be for anyone to participate. Some also noted that this kind of dystopian pervasive surveillance system is not necessarily related to or enabled by DSbD.

3. DSbD makes the newly integrated GOV.UK portal (now processing all passport, pensions, universal credit, driving, immigration services, etc, online) and NHS UK systems 'unhackable'.

This seed was considered possible and plausible and as likely to represent a preferred future for some people – but it was considered significant and appropriate that the 'unhackable' claim is in quotes here.

Participants pointed out that CHERI would not prevent, for example, someone leaving the administrator interface for such a system exposed with weak passwords. It would prevent a lot of attacks on the infrastructure and potentially make these systems more trustworthy. CHERI gives building blocks for assembling trustworthy systems but it doesn't eliminate human error.

First order consequences (positive, negative, and neutral – utopian, dystopian, and BAU) suggested by the focus groups included: greater automation, speed and efficiency of these services; objections arise to an increased carbon footprint of GOV.UK and NHS services (akin to the bitcoin backlash);

lack of access to services by those physically as well as digitally challenged; UKRI's research agenda sets out to prove the 'unhackable' claim is wrong; increased uptake of DSbD tech in other areas of GOV.UK and NHS services; inter-operability issues and problems with data sharing with legacy systems in these and other GOV.UK and NHS departments; a backlash against GOV.UK and NHS services for enforcing a technocratic governance model upon citizens; increased costs of access to services (to fund the new tech).

Second and third order consequences suggested included: enhanced trust of users in the reliability of GOV.UK and NHS services and systems; job losses; the need for human-tech teaming to challenge and contest and check automated systems; citizens opt-out and become adversarial; the unintended consequence of discrimination against those without digital access or skills; the cost benefits of the system do not materialize; the need emerges for stronger, different, or complementary controls to cover authorized access; hesitancy in using the system (akin to vaccine hesitancy); a risk that any bad news story results in the public losing trust in the whole DSbD system; the need for new measures and mechanisms to control ethical hacking; a reputational and legal risk when problems do occur; to be a full citizen with full rights you need to have digital access and skills to navigate the new system; risk of exclusion from democracy (and other basic rights) and exclusion from the benefits system for those without digital access; the creation of an indelible digital footprint for every citizen.

4. DSbD and 5G systems enable Kent farmers to supply UK supermarkets with 86% of their fresh fruit and vegetables.

This seed was considered to represent a purely market and logistics problem and DSbD and 5G were not in themselves identified as the enabling technologies here.

5. DSbD compartmentalisation secures personal data for the next generation of integrated IoT, personal care/healthcare robotics, and home surveillance.

This seed was considered probable, possible, plausible, and preferable – but participants noted that CHERI only helps protect data from unauthorized use by attackers, not from malicious use by authorized individuals.

CHERI will (if deployed properly) make it harder for attackers to compromise devices but CHERI doesn't impose any controls on authorized use: for example, CHERI by itself wouldn't prevent an administrator in an NHS hospital from downloading the medical records of every patient to a USB flash drive.

6. The Financial Services Authority (FSA) supports insurers in their refusal to cover households and businesses who continue to use non-DSbD devices – leaving vulnerable individuals unable to insure buildings, contents, pets, cars, holidays, and health; and forcing millions of small businesses to cease trading.

This seed was considered possible, plausible, probable, and likely to be a preferred future for some – although the negative consequences for the 'vulnerable individuals' and SMEs imagined in the seed highlight the fact that such a preference will be 'dystopian' for others. Participants noted that normally insurance rules and similar (e.g. PCI compliance) require 'best practices' for security and using a less-secure CPU is probably not going to be 'best practice' for long.

7. There are still 69.17 million hand-me-down smartphones, laptops, and tablets in use in the UK running 'legacy' operating systems.

This seed was considered plausible, possible, probable – and really interesting. Participants observed that we saw something similar with the 32 -> 64-bit switch in PCs then in mobile devices, where the cost of supporting the older ones was increasingly expensive. In terms of longer term multi-order consequences, such devices tend to be owned and used (and shared) by people in disadvantaged socio-economic households and communities and there's less financial incentive to support such devices (i.e., when they're owned by people who don't have the disposable income to buy products). The social implications of expecting or requiring people to access government services and benefits raised concern, as did the environmental implications of taking these older devices offline.

First order consequences (positive, negative, and neutral – utopian, dystopian, and BAU) suggested by the focus groups included: problems as the ongoing running of dual systems undermines or complicates access to key services; the UK adopts new EU legislation for labelling of IoT with a security 'best before' date; environmental benefits emerge as more devices are recycled and reused; a continuation and possible

exacerbation of today's existing digital divide emerges as new inequalities are introduced because the poorer in society are unable to access new services enabled by the new DSbD tech; new legislation (and regulations from the fintech and insurance sectors) could increase the digital divide by offering different levels of protection.

Second and third order consequences suggested included: DSbD makes security invisible so there's a risk of damagegoing unnoticed when it fails or there are breaches; the hacking risk remains (through authorized access points); a shift in liability puts onus onto users of older devices in case of loss/attack; the implications for abuse of personal data remain; the lifecycle of DSbD products is longer because devices need fewer updates; new DCMS consultation and legislation on IoT has a positive impact on support lifetimes; millions of devices end up in landfill; a global divide increases as developing countries using older devices have less security; older people and those in lower socio-economic groups are disadvantaged by using older devices – especially without fair use policy interventions; legacy systems will still need (expensive) support from tech firms; lessons will need to be learned and carried over from the government's 'universal credit' implementation; HMG forces banks to support non-DSbD customers; the existing open-source hardware ethos is challenged; new global verification programmes and certification processes emerge; incomplete and/or buggy implementation damages trust in DSbD; this seed and its multi-order consequences could lead to micro-tampering in closed chips that would be hard to detect; secure devices from overseas become a major import market into the UK – and the UK loses its key export market stake in DSbD.

8. The offices of UKRI are picketed and an online social media campaign goes viral claiming that DSbD has increased digital insecurity by making security a premium product that is unaffordable for many.

This seed was considered plausible – although it was noted that there is no reason currently to anticipate that the cost differential between a CHERI and non-CHERI phone in 2027 (or whenever we get them into mainstream production) would be more than that between a 32- and 64-bit phone back in 2014.

9. Which? takes DSbD to court over its advertising claims that computer systems are now "unhackable" because this has led consumers to believe that they have greater protection on-line than they actually do.

This seed was considered plausible and possible (though likely not probable and obviously not desirable) – if people make claims about DSbD technology that can't be supported by evidence. The consequences of this seed seem relatively simple to pre-empt by managing expectations (and the DSbD/CHERI 'narrative') about what the technology can and cannot do.

10. Refuge gives evidence to the All Party Parliamentary Group on Violence Against Women that despite government pressure on mobile phone operators to adopt DSbD for privacy assured and secured health services, many vulnerable women find these services too difficult to access, because they have not been designed with digital inclusion in mind.

This seed was considered possible (though likely not plausible or probable, and obviously not preferred) – and highlights similar concerns and consequences to those flagged in seeds #8 and #9 that the digital security ecosystem is complex (even chaotic) and that there will be both winners and losers (analogous to the Yellowstone Park's wolves and deer) in this future.

11. Supported by DSbD, England and Wales fully automate all operations at 9,000 water/sewage treatment plants.

This seed was considered possible, plausible, probable, and preferred. Automation is more plausible when it can be built on a trustworthy (versus a simple 'trusted' foundation) – but DSbD/CHERI needn't be the enabling technology for this, and something like a water-treatment plant could protect the control system by other means (e.g., it could be air gapped).

12. Following a change of UK government in the 2024 elections, DSbD is mothballed and Morello boards are recalled, while Russia gifts 851 million Sputnik' smartphones featuring a CHERI architecture/software package to Nigeria, Pakistan, Bangladesh, and Iraq.

If we substitute China or India for Russia (perhaps substituting Xinik for Sputnik) then this seed was considered possible, plausible, and probable, with consequences that some stakeholders preferred. Both China and India have home-grown RISC-V CPUs and it would be quite feasible for them to adopt CHERI extensions in these and flood the market with them. The core CHERI functionality ('capability essential IP') is already public and unprotected to encourage adoption. From the perspective of the wider ecosystem, having China and India's home-grown CPUs adopt CHERI is a win. From the perspective of UK PLC, losing our first-mover advantage and technical leadership position is clearly an undesirable future consequence for this seed. Again, there will be both winners and losers (analogous to the Yellowstone Park's wolves and deer) in this future.

Participant Feedback on the Creative Futuring Process

The creative elicitation and innovative futures storytelling activities trialed under the auspices of the Futures programme were novel to most participants but were undertaken with great generosity and imagination. The activities were designed to be gently disruptive in their framings of different futures for DSbD as a means of clarifying what is and is not possible and plausible in this space, helping to clarify the core proposition further at each stage in the process. Feedback from stakeholders who took part in the futuring workshops included the following responses that add further important 'futures literate' insights into understanding the wider DSbD challenge:

- This is a really exciting departure from standard protocol and ways of thinking about things.
- I've found it really useful to watch the wolves video and then pull this back through what we are asking [of DSbD]. What might the ripple effect be?
- Everything is usually examined through the wonders of hindsight – but this isn't the best method for predicting the future.
- In fiction you can travel into the future to review the effects, we need to try to do this [with DSbD]. Is DSbD a continuation of the past or are we switching gear?
- Is there a difference between unpredicted and unpredictable?
- Benefits for someone may well be at the cost of others.
- How do you build trust in the unknown/novel? In stories who to trust… who not to trust… it's unpredictable. This is not usually applied in a major corporate context, but who to trust is about who really controls/runs things. What dark forces lie behind?
- We need to think about epilogues … the longer term effects, what happens after the story, the story outside the story. We need to consider policy making and legislation … Likewise, how does DsBD fit in with environmental concerns? Focus on 'epilogue time' needs rigorous investigation. And we should be thinking about that now, not later.
- I found the futures narratives very useful to make us think of the barriers and prepare for the 'what ifs'.

- The question I was left with was: what would the villains be doing in the futures we were discussing and how would that affect the scenarios we were discussing?
- I thought the Futures Wheel was a really useful structure to think in as it didn't devolve into a binary of utopia versus dystopia.
- It was great to see a methodology that considered second- and third-order effects.

This feedback will help inform and shape the next phase of our futures engagement with stakeholders in the DSbD ecosystem.

CONCLUSIONS AND RECOMMENDATIONS

Futures literacy, anticipation, and rigorous imagination have a critical (and ongoing) part to play in informing the research agenda of the multifaceted DSbD challenge. Creative engagement techniques offer innovative opportunities to bring together different stakeholder groups and to stimulate dialogue between them. Such activities provide a safe and creative space to surface and discuss different viewpoints (especially disagreements) concerning the core proposition for DSbD/CHERI. This matters because different stakeholders from across the digital security ecosystem currently anticipate very different possibilities for the future of DSbD – including details of what the hardware enables and what future use cases DSbD might enable. One of the key conclusions to emerge from this research is that the DSbD community is presently fragmented in terms of what it anticipates as the possible, plausible, probable, and preferred futures attending the next generation of security hardware technologies in general – and attending the value proposition of DSbD/CHERI in particular.

For example, DSbD/CHERI promises to make compartmentalization significantly cheaper and faster (and its compartmentalization architecture promises better protection than ACLs) but stakeholders regarded the value of its core security proposition as something still up for debate. We also identified different understandings of the core 'chicken and egg problem' in terms of hardware vs software prioritization in DSbD implementation – i.e., the Catch 22 of legacy systems where we can't change the hardware chips and boards before we change the software. Many participants saw this as a barrier to adoption but a few stressed that CHERI does not in fact require changes in the languages and so supports C/C++ in mostly unmodified forms; CHERI also enables new programming language abstractions and gives an efficient way of mixing safe languages and unsafe languages to give us a way of slowly and incrementally migrating to safe languages and getting the benefits now, rather than in a much longer term future, 30-50 years hence.

We found further disagreement as to the likely impacts and use cases of DSbD/CHERI – complicated by the prospect that one of the ambitions for DSbD in general and CHERI in particular is for there to be zero experiential impact on any of the higher levels of the technology stack, and therefore zero experiential impact either on programmers or end users. Imagining future consequences and use cases for DSbD/CHERI upon which stakeholders might agree as representing possible, plausible, probable, or preferred futures (or future products) for specific use cases and users proved particularly challenging, therefore.

We did find greater unanimity across the stakeholders involved in the Futures programme in the broad agreement that DSbD/CHERI futures scenarios will necessarily present both desirable (utopian) opportunities for some communities alongside undesirable (dystopian) risks or compromises for others – and we recommend that the multi-order 'trophic cascade' effects of DSbD/CHERI across the wider socio-digital ecosystem are further tested and analysed.

We also found agreement that DSbD/CHERI is likely only to protect against certain low-level attacks; DSbD/CHERI will not fix everything in cyber security nor remove risks entirely. It will resist some attacks but attackers will shift their attention elsewhere and likely go after softer (human) targets; and it will not protect against breaches and damage (criminal or accidental) committed by authorized administrators. We recommend that the limitations of DSbD/CHERI are socialized along with its potential benefits (as part a transparent DSbD/CHERI narrative) to avoid unrealistic expectations damaging future perceptions.

Finally, we found agreement that the carbon footprint of DSbD/CHERI and the environmental impact of future tech waste through device obsolescence could be significant – and potentially compromise COP targets and net zero ambitions. We recommend that an environmental impact study on the future digital security ecosystem be commissioned as part of the wider DSbD programme.

FUTURE FUTURES WORK

In the next phase of the Futures Programme we will commission a range of small projects to help us flesh out these findings and translate this understanding into shareable narratives (e.g. in an anthology of short stories, and in a museum exhibit – provisionally titled 'The Secret Life of Data'). We will continue to socialize the data from the first phase with participants in the broader DSbD programme and across the wider digital security ecosystem (e.g., through conference presentations and journal publications).

REFERENCES

- Bode, C. and Dietrich, R. (2013) Future Narratives. Berlin: W. de Gruyter.
- Liveley, G., Slocombe, W., & Spiers, E. (2021). Futures literacy through narrative. Futures, 125, 102663.Miller, R. (2006). From trends to futures literacy. Reclaiming the future. Centre for Strategic Education. Seminar Series Paper (No. 160). CSE Publications, Victoria.
- Miller, R. (2011). Futures literacy: embracing complexity and using the future. Ethos, 10(10), (pp.23-28).
- Miller, R. (2018). Transforming the future: anticipation in the 21st century. UNESCO Publishing. Available from: http://library.oapen.org/handle/20.500.12657/30271
- Pereira, L. (2021). Imagining Better Futures Using the Seeds Approach. Social Innovations Journal, vol. 5, https://socialinnovationsjournal.com/index.php/sij/article/view/694.
- Perera, R. (2017). The PESTLE Analysis. Nerdynaut.
- Poli, R. (2017). Introduction to Anticipation Studies (Vol. 1). Abingdon: Routledge.
- Poli, R. (2018). Introducing Anticipation. In R. Poli (Ed), Handbook of Anticipation: Theoretical and Applied Aspects of the Use of Future in Decision Making (pp. 1-14). Abingdon: Routledge.
- Tait, A. and Norris, L. (2011). Narrative and the Origins of Law. Law and Humanities, 11-22.
- Zimmerman, J., Forlizzi, J., and Evenson, S. (2007). Research through design as a method for interaction design research in HCI. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 493-502).
- Ward, P., Gore, J., Hutton, R., Conway, G., and Hoffman, R. (2018). Adaptive skill as the conditio sine qua non of expertise. Journal of Applied Research in Memory and Cognition, 7(1) (pp. 35-50).

REFERENCES

- 'Future Seeds': https://goodanthropocenes.net/
- 'Futures Wheel' framework: https://www.jisc.ac.uk/guides/vision-and-strategy-toolkit/futures-wheel
- Futurice, 'The Lean Futures Creation Handbook 2.0' https://futurice.com/lean-futures-creation-toolkit
- 'The Wolves who changed the rivers': https://www.youtube.com/watch?v=ysa5OBhXz-Q
- UNESCO Futures Literacy: https://en.unesco.org/themes/futures-literacy#:~:text=Futures%20Literacy%20is%20a%20capability,present%20(Miller%2C%202015)

APPENDIX

This appendix provides details of the materials used to structure the creative elicitation and engagement workshop activities carried out with the Future programme's focus groups.

Workshop 1 Materials: Punchdrunk and StoryFutures Workshop Plan

Timing (total in brackets)	Activity
Waiting room open 9:50	
10:00-**10:10** Intro & housekeeping 10 min	Housekeeping. Tech issues. Breakout rooms. Chat function. All participants introduce themselves. Frame the approach with PD and Story Futures. Why are we working together especially in relation to DSBD/CHERI; our approach to the workshop.
10:10-**10:15** Intro to SF 5 min	StoryFutures work
10:15-**10:20** Intro to PD 5 min	Punchdrunk work. A couple of examples of projects and unpack a focus on experiential and audience centred work. Creation of storyworlds. This will become a focus for our approach today.
10:20-**10:30** DSBD/Cheri challenges and opportunities 10 min	Challenges, opportunities and solutions that are prominent in current discussions. These are collated and we purposefully park these momentarily.
10:30-**10:40** Sound exercise and reflection 10 min	All participants listen to meditative creative exercise Reflections following this. Acknowledge it is a good way of understanding both how we create work and also give a sense of how we aim to make an audience feel
10:40-10:50 Magic Object exercise 10 min	All participants use the object that they focused on in the sound exercise and imagine that this becomes a magic object. Thinking about it having the ability to do something magically and beyond the current realms of possibility. Eg- A pen that can dares things that immediately come into

	being. Think about what problem this solves. Focus on a couple of examples and encourage participants to put ideas in chat.
10:50-**10:55** Transmigration of DSBD/Cheri challenges and opportunities 5 min	Reimagine DSbD in a film or story. Give examples.
10:55-**11:05** Transmigration of DSBD/Cheri challenges and opportunities 10 min	Thinking fantastically and metaphorically translate challenges, problems and opportunities noted earlier into story metaphors. Eg- Chicken or egg problem : Each group is given one or two to work on. Group splits into breakout rooms come back together and feedback and these are noted down on shared doc.
11:05-**11:10** Break 5 min	
11:10-**11:20** The Wolves Changed the Rivers 10 min	Watch this video together. https://www.youtube.com/watch?v=ysa5OBhXz-Q (watch the whole video 4:33 in total) Frame the reasons for the choice of the video in relation to the subject matter. Predator versus prey. Shift of assumptions of what is good and bad and what you imagine might happen versus reality what happens. Link to safari park analogy from interviews. Responses from participants. Via chat and through joining the discussion. In the next section of the workshop we'll look at constructing narratives and shifting perspectives. Reveal unintended consequences and unseen or surprising reveal and under told epilogues.
11:20-**11:25** Faces and Places Intro 5 min	Introduction to session and timings
	CREATIVE EXERCISE IN BREAKOUT SESSION 11:25-12:10 (activity timings as a guide)
Faces and Places	Faces and Places exercise.

10 min explanation and model	First, Places. Work through this together as a group with a shared image: - Is this a public or a private space - What does it feel like to be here - What is going on here - What kind of people inhabit this space - What is beyond the space - What secret is held here - Something surprising you wouldn't expect
Faces 10 min	Faces - What is their name - What do they do - What are they doing in this picture - What type of person are they Marry the face and the place, how are the two connected, how does the character add and fit into your narrative and vice versa.
	Shifting perspectives
Shifting perspectives 15min	Now shift the perspective eg if your space was nice make it more sinister. How is the character a force for good or a force for bad? Now introduce a magic object. How does the magic object change this scenario? Now introduce a transmigrated DSBD element - How does the transmigration the story, how do we make sense of it? - How does the object change this story?
	BREAKOUT SESSION ENDS- RETURN TO MAIN ZOOM ROOM
12:10-**12:25** Feedback session 15 min	Both groups feedback on the task. Presenting the first iteration saying how it changed with the shifting perspective exercise and the introduction of the magic object and the DSBD transmigrated story.

12:25-**12:35** Little known epilogues 10min	Quick thoughts to the next part of the story. What is the mundane or the every person epilogue? The story that isn't front the main narrative but is impacted as a result of the main story. Eg- Godzilla story: the city is saved but what about the shop owner who's lost their livelihood and worldly possessions or the soup kitchen owner who has an unlimited supply of Godzilla burgers. Put answers into the chat
12:35-**12:45** Sum up and goodbyes 10 min	Wrap Up
12:45-13:00 Debrief 15 min	

Workshop 2 Materials: SOIF Pre-read for DSbD Futures Wheels workshop 19 May 2021, 10 am - 12:30 pm

During this 2.5 hour workshop, you will work in groups led by a member of the SOIF team to

- choose one of 12 seeds of change (listed below), which have been written as if the seeds we see today have become mainstream 10 years or so into the future.
- Imagine the broader consequences of this seed, including the 1st as well as the 2nd and 3rd order consequences – organised on a wheel.
- build out this vignette of the future, by imagining newspaper headlines and products and services that would exist there.

We will then compare the vignettes created in each of the three groups, discussing the insights and challenges of using this model for thinking about how change could happen.

Through further work, we could derive a variety of potential worlds from these vignettes, which take us beyond the obvious futures that are a continuation of today's business-as-usual.

Preparation for the workshop

We'd like to hear in advance if you'd particularly like to work on any of the 12 seeds listed below: what would your top 3 choices be? You will decide which to work on collectively as a group, but if we know your preferences in advance that will give you more time to do the exercise. If you are interested in the background to the techniques we'll be using in the workshop, here are links to relevant materials for each of the steps.

Background materials

- Using seeds of change as an approach to imagining different futures: https://socialinnovationsjournal.com/index.php/sij/article/view/694
- History and theory of the futures wheel, one of the first formalised foresight tools, from its creator Jerome Glenn: http://www.millennium-project.org/wp-content/uploads/2020/02/06-Futures-Wheel.pdf
- Details of the VERGE method, which we will use to build detailed vignettes of the future: https://ddtconference.files.wordpress.com/2017/07/lum-verge-apfcompass-april14.pdf
- https://www.jisc.ac.uk/guides/vision-and-strategy-toolkit/futures-wheel

Seeds of change matured over 10 years

DSbD/CHERI innovations and implementations could lead to:

1. Supported by DSbD and 5G, Highways England restricts the public use of Motorways and A roads to "autonomous electric vehicles only" between the hours of 6am and 9pm.

2. Supported by DSbD systems and a partnership between NHS Scotland and Biffa Waste, Glasgow City Council launches a 'smart' recycling scheme monitoring household consumption of food and alcohol.

3. DSbD makes the newly integrated GOV.UK portal (now processing all passport, pensions, universal credit, driving, immigration services, etc, online) and NHS UK systems 'unhackable'.

4. DSbD and 5G systems enable Kent farmers to supply UK supermarkets with 86% of their fresh fruit and vegetables.

5. DSbD compartmentalisation secures personal data for the next generation of integrated IoT, personal care/healthcare robotics, and home surveillance.

6. The Financial Services Authority (FSA) supports insurers in their refusal to cover households and businesses who continue to use non-DSbD devices – leaving vulnerable individuals unable to insure buildings, contents, pets, cars, holidays, and health; and forcing millions of small businesses to cease trading.

7. There are still 69.17 million hand-me-down smartphones, laptops, and tablets in use in the UK running 'legacy' operating systems.

8. The offices of UKRI are picketed and an online social media campaign goes viral claiming that DSbD has increased digital insecurity by making security a premium product that is unaffordable for many.

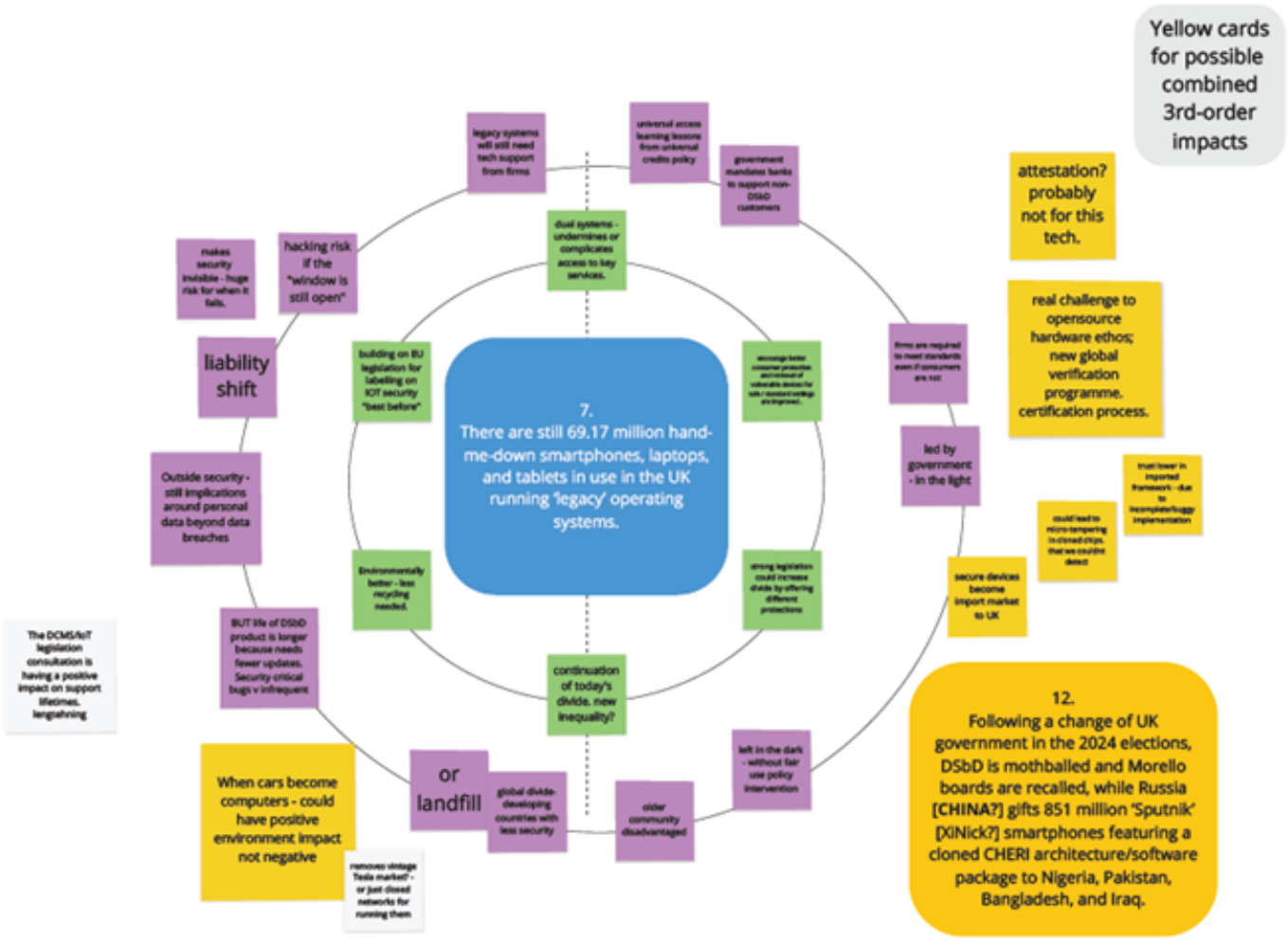
9. Which? takes DSbD to court over its advertising claims that computer systems are now "unhackable" because this has led consumers to believe that they have greater protection on-line than they actually do.

10. Refuge gives evidence to the All Party Parliamentary Group on Violence Against Women that despite government pressure on mobile phone operators to adopt DSbD for privacy-assured and secured health services, many vulnerable women findthese services too difficult to access, because they have not been designed with digital inclusion in mind.

11. Supported by DSbD, England and Wales fully automate all operations at 9,000 water/sewage treatment plants.

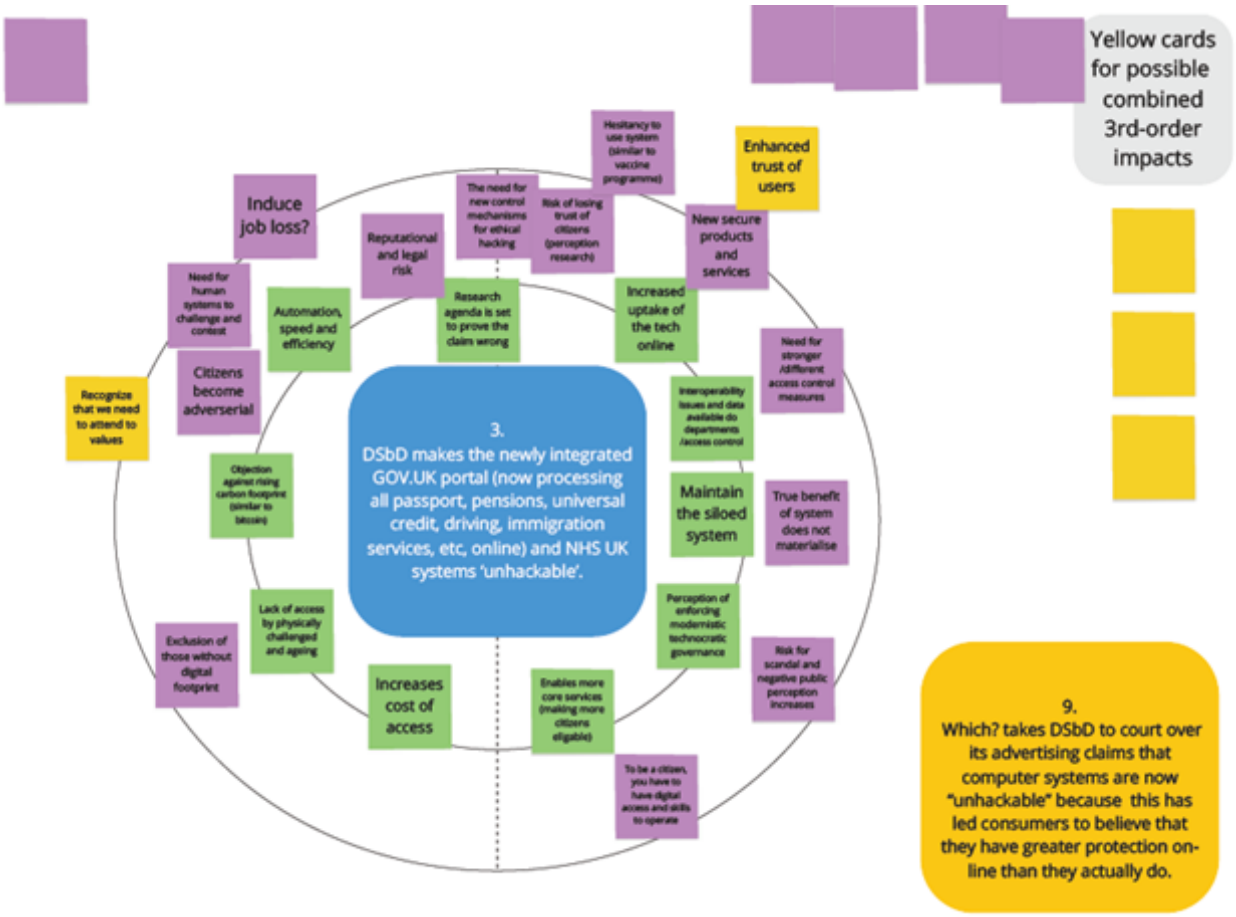
12. Following a change of UK government in the 2024 elections, DSbD is mothballed and Morello boards are recalled, while Russia gifts 851 million 'Sputnik' smartphones featuring a cloned CHERI architecture/software package to Nigeria, Pakistan, Bangladesh, and Iraq.

Workshop 2: Futures Wheel Miro Board #1 snapshot



Workshop 2: Futures Wheel Miro Board #2 snapshot

Workshop 2: Futures Wheel Miro Board #3 snapshot



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IMAGINING SECURE DIGITAL FUTURES

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