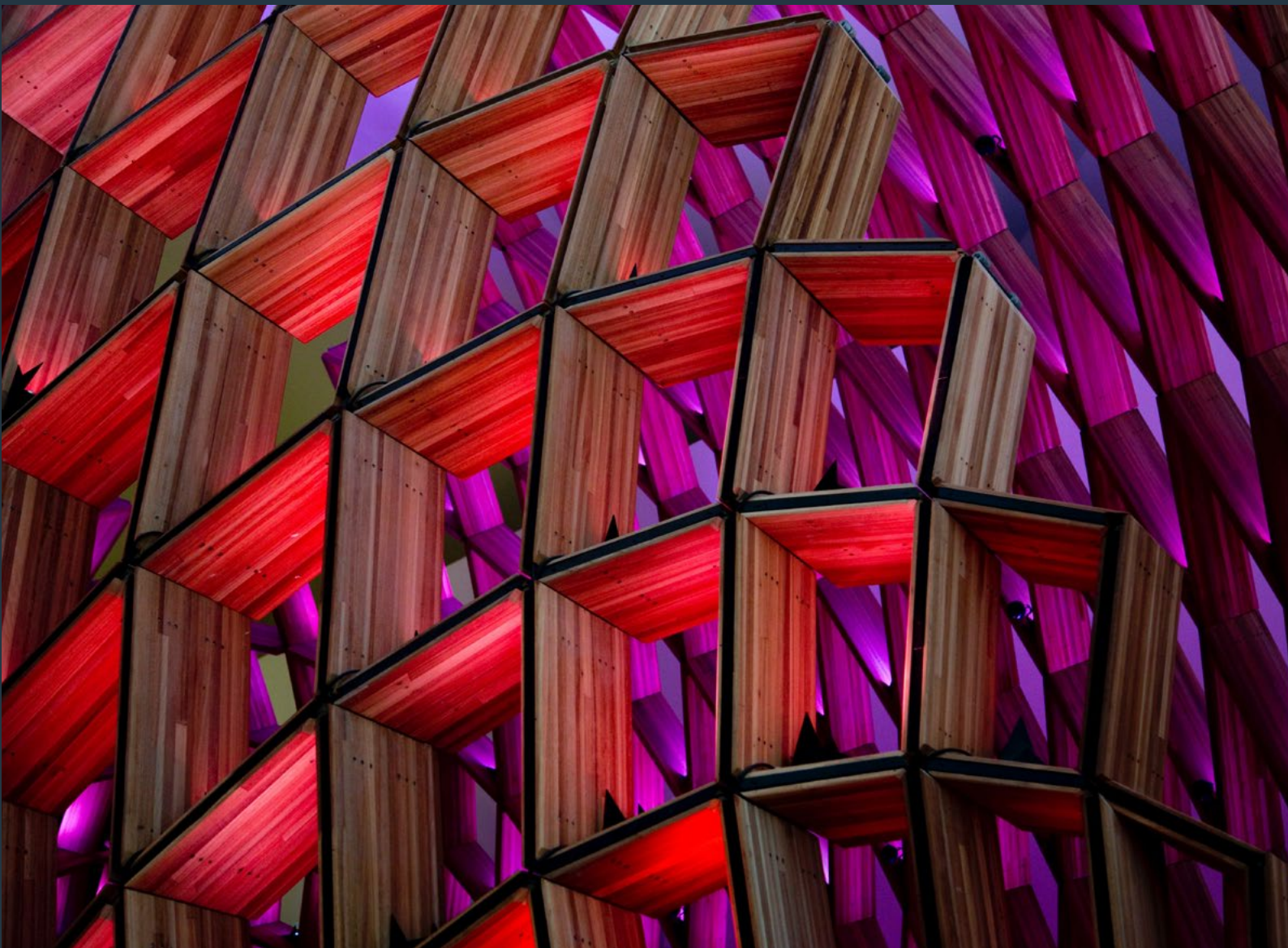# DIGITISATION OF REQUIREMENTS, REGULATIONS, STANDARDS AND COMPLIANCE CHECKING IN THE BUILT ENVIRONMENT

D-COM briefing note

D-COM

CONTENTS

FOREWORD

As an industry we have begun to recognize the magnitude of accurate and reliable information to support decision making and evidence better and safer service provision by those who will use the completed asset, from residential accommodation to a new rail system.

The last decade has positively seen a sharp increase in the production of structured data and information models to support this agenda.

As information modelling and management become central planks in our built environment, we must now examine how we can better automate our workflows.

So where do we start? Arguably there can be no better opening than with the digitisation of our regulatory processes and compliance checking in relation to same.

D-COM plan to set out a logical and achievable plan, help prioritise compliance on the agenda and create a nexus for neighbouring communities to integrate within.

The D-COM network in their initial findings have shown the need for this work to happen and indeed the positive response to compliance checking shifting from a manual endeavour to once that is supported by computer driven automation allowing a swifter and more integrated process.

I would encourage you to take time to read this report and consider the need for the D-COM 2025 road map, and ultimately the policy recommendations to be made.

There is a mutualism between compliance checking and digital workflows and now is the time to make it happen.

David Philp

MSc BSc FICE FRICS FCIOB FCInstES FGBC

CDBB's Home Nations Working Group BIM Level 2 Communication Manager

Global MIC Consultancy Director – AECOM

CIOB Trustee and Chair of CIOB Digital Technologies Specialist Interest Group

INTRODUCTION

WHO IS D-COM?

The Digital Compliance (D-COM) Network was formed to meet the clear need for research, insight and leadership in the digitisation of regulatory processes and automated compliance checking.

D-COM is highly rated in its ability to help create the landscape and agenda around digital transformation of the regulations and compliance processes.

D-COM's network and research is formed of a balance of industrial and academic capabilities.

It has a multi-institutional and multi themed approach with transparency, which it considers as significant factors in this journey.

D-COM was inaugurated as part of **Centre for Digital Britain (CDBB)** capabilities and research agenda.

D-COM
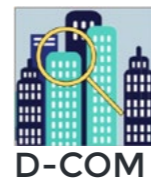
WHO IS CDBB?

The Centre for Digital Built Britain (CDBB) is a partnership between the Department of Business, Energy & Industrial Strategy (BIES) and the University of Cambridge to understand how the construction and infrastructure sectors could use a digital approach to better design, build, operate, and integrate the built environment.

CDBB's mission is to support the digitally enabled transformation of the full lifecycle of the built environment to increase productivity and improve economic and social outcomes in the UK and, where appropriate, internationally.

CDBB will achieve this by developing and demonstrating policy and practical insights, leading to standards and guidance that will enable the exploitation of new and emerging technologies, data and analytics to enhance the natural and built environment.

cdbb
Centre for Digital Built Britain

WHY DID WE DO THIS WORK?

The concept of automated compliance checking can bring tangible advantages including increased efficiency and a reduction in the costs of compliance checking.

The entire lifecycle of the built environment is governed by a variety of regulations, requirements and standards. The checking of compliance against these is a complex task, which is currently performed manually, thus becoming highly resource intensive.

So far there has been no meaningful adoption of either the digitisation of regulations or compliance systems.

D-COM has shown that the concerns raised in the Hackitt review of responsibility and departures from regulations is a systemic problem.

There has been a significant rise in the formation of government expert groups to address some of these failings.

D-COM is proposing not simply 'plugging the leaks', but a transformation of the regulatory compliance system. Digitising and automating this system will instil transparency and inherently build in the 'Golden Thread'.

This is an opportunity to start overhauling the system. Why? Because the current system is extremely difficult to police. It lacks resource, there are too many compliance departures and ambiguous regulations and statements, as well as untethered and unauditable decision making processes. The list is relentless.

The recent increase in information and data maturity owing to the adoption of processes such as Building Information Modelling (BIM) and supporting standards, means automation of compliance checking is becoming feasible.

HOW DID WE ALIGN WITH CDBB'S IDEAS AND FRAMEWORK?

In delivering this body of work, D-COM aligned with CDBB's framework which focusses on the understanding of the following classes:

- the trends and drivers
- complex integrated systems
- outcomes and outputs sought by stakeholders
- implication of social constructs around regulations & legislation
- governance, management and optimisation of built assets

- acquire create and manage data about built assets
- analyse and interpret this data to exploit it.

The key dynamic in the framework is to consider the impact or changes and how these are managed over time.

Click here for further reference to CDBB's research framework. Youtu.be/irpadEHOkaU

Exhibit 1 - Proposed Operating Model for Automated Compliance Checking

WHAT WERE OUR ULTIMATE GOALS?

The ultimate goals of D-COM were:

- develop a 6 year plan to bring UK to the verge of automated compliance checking by 2025 for Building Regulations

- pave the way to realising the concept of a 'Living brief' with requirements spanning the entire life cycle of the asset. This is based on technologies to enable site-based monitoring of compliance and monitoring of compliance of assets once they move into the operation phase of their life cycle after handover

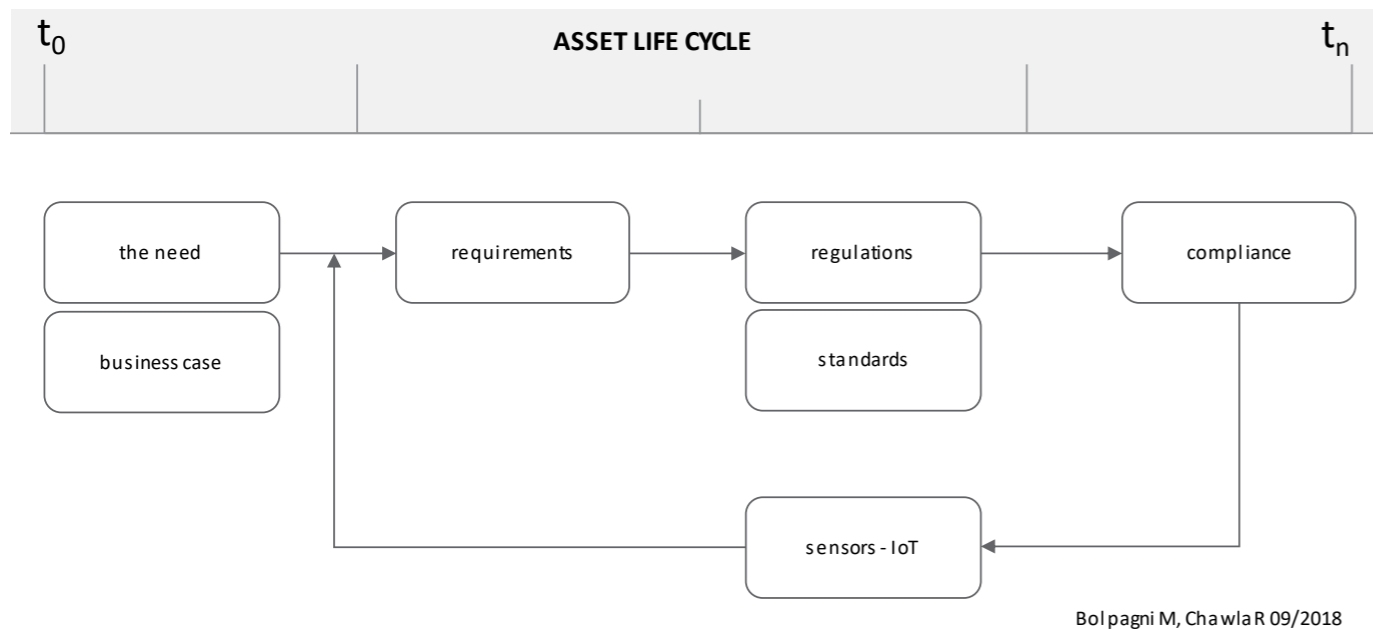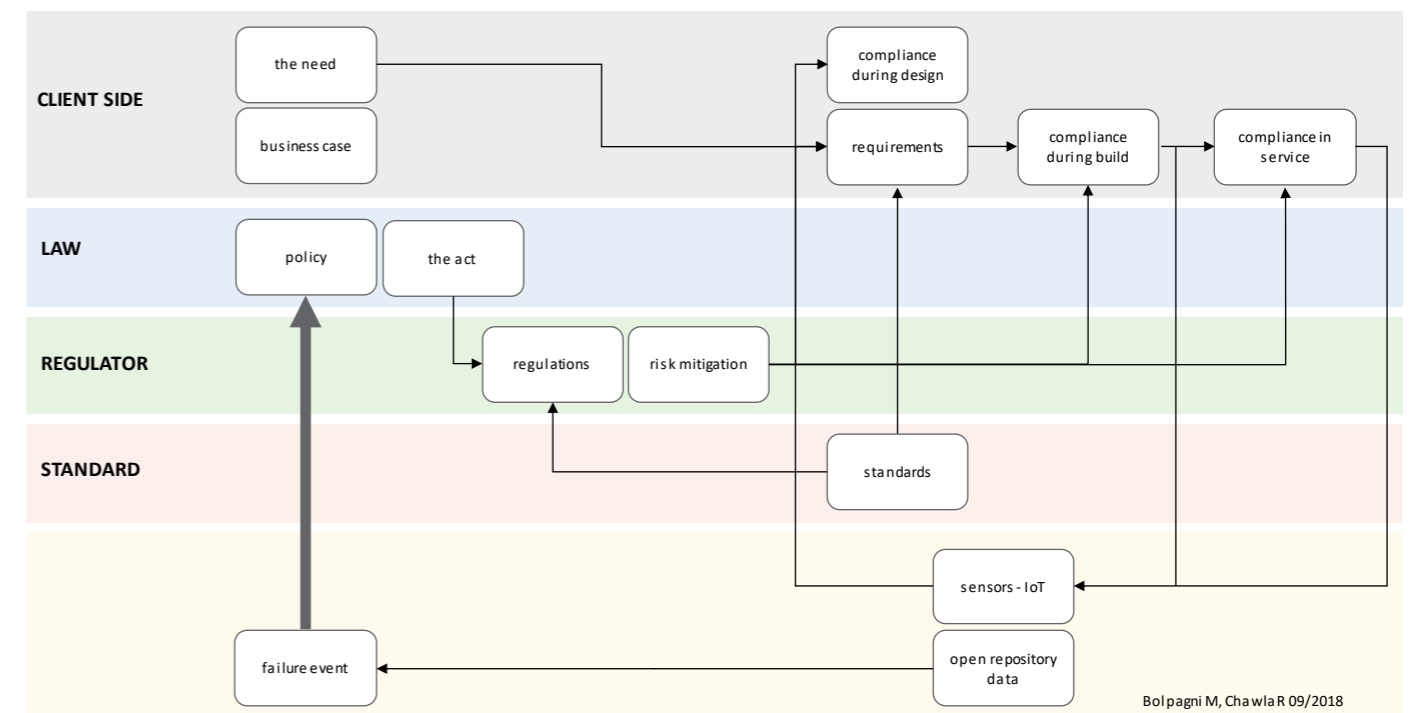- build a community around the concept of automating compliance checking.

Exhibit 2 - Proposed Stakeholder Operating Model for Automated Compliance Checking

APPROACH

Our approach to this initial work followed two pathways:

- firstly, to determine the State of the Nation and its views of automated compliance checking
- secondly, to engage with key stakeholders who inform and drive regulatory policy.

In following these pathways, our key outputs were to:

- grow a community
- define the capabilities required to deliver automated compliance checking
- develop a roadmap to deliver a working and operating model.

Our work focused around three key themes and their impact on digitisation and automation of compliance checking. These themes were:

- **technology**
- **commercial**
- **political.**

HOW DID WE ASSESS THE STATE OF THE NATION?

To understand the 'state of the nation' of regulatory compliance, D-COM devised a methodology, which looked at what capabilities were required to achieve our goals and what market forces were acting around achieving these goals.

D-COM's overarching themes of **Technology, Commercial** and **Political** were all to be tested for capabilities and market forces acting within each theme.

D-COM understood that these themes have strong dependency on each other and took this into consideration.

PATHWAY 1

Determine the state of the nation on the digitisation of regulations, stands and requirements

PATHWAY 2

Engage with key stakeholders in delivering the regulatory policy

DEVELOP ROADMAP TO DELIVER

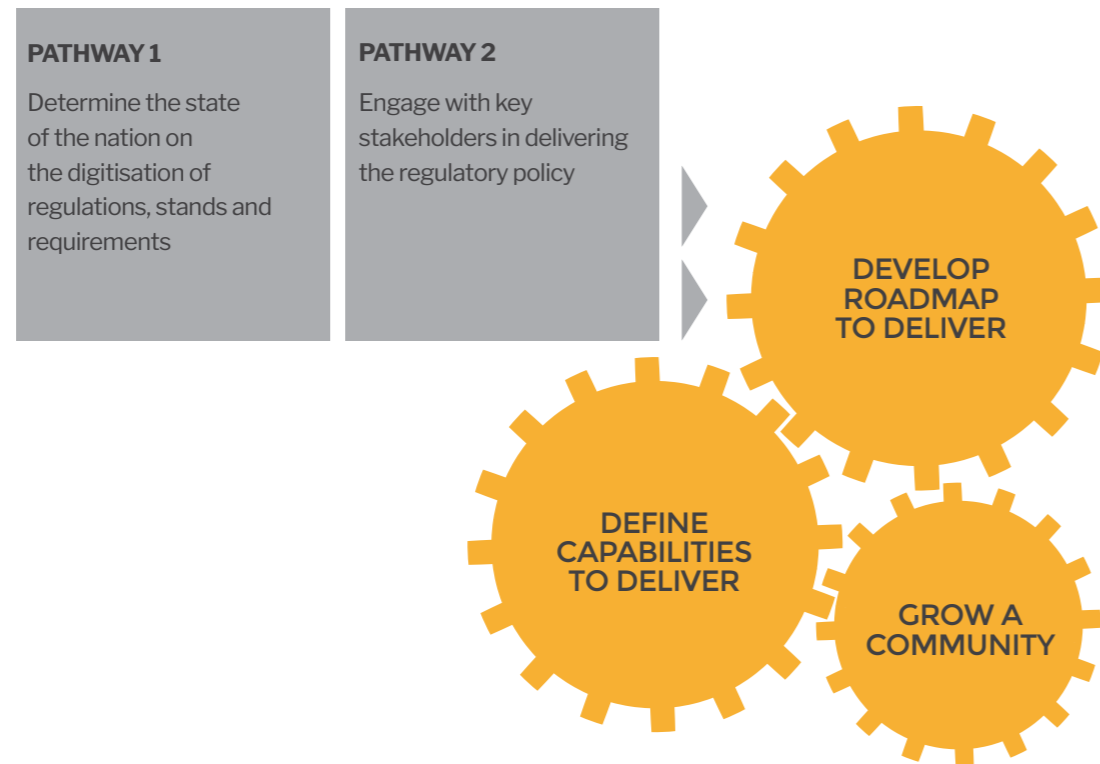**DEFINE CAPABILITIES TO DELIVER**

GROW A COMMUNITY

Exhibit 3 - D-COM Vision

WHAT TERMINOLOGY DID WE USE?

To ensure consistency in understanding, D-COM declared definition of key words in a common language. The key words of focus were defined as follows:

- **capabilities** - the power or ability to do something. i.e. new abilities that the industry must possess in order to achieve automated checking

- **market forces** - changes in the direction/attitudes within the built environment sector that must be achieved in order to achieve automated checking

- **regulation** - a rule or directive made and maintained by an authority i.e. compliance with legislation

- **requirement** - necessary conditions, i.e. compliance with requirements set as part of a project brief

- **recommendation** - a suggestion or proposal as to the best course of action, especially one put forward by an authoritative body

- **standard** - something used as a measure, norm, or model in comparative evaluations. In the UK British Standards (BSI) are the national standards body.

HOW DID WE GATHER INDUSTRY'S VIEWS?

D-COM published a survey that consisted of 19 questions and was designed to fulfil two requirements:

1. to test the 'state of the nation' with regards to the acceptance of the automated checking against regulations/requirements/standards

2. elicit a set of initial required capabilities and market forces.

The survey consisted of a mix of open and closed questions to allow quantitative data to be collected regarding the state of the nation, but still allowing respondents to express their views.

The closed questions would follow a quantative analyses and open text questions would be analysed using semantic analyses.

HOW DID WE CONSULT ON A FUTURE ROADMAP?

The objective of this exercise was for D-COM to present the survey findings to the audience and to start to develop a 'strawman' of the roadmap. The objective was to reach a consensus on:

- the acceptance or rejection of digitised regulations and automated checking
- test, confirm and broaden the validity of required capabilities and market forces to achieve D-COM's goals.
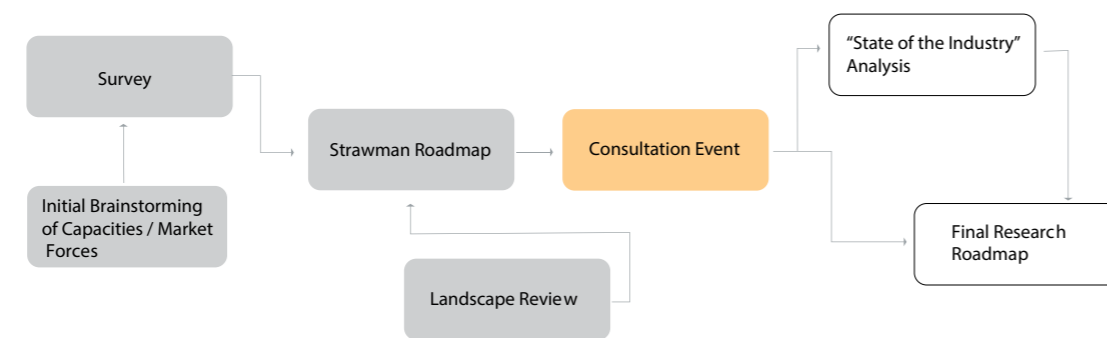

Exhibit 4 –D-COM methodology

HOW DID WE ENGAGE WITH KEY STAKEHOLDERS?

To supplement the consultation event, and to capture the views of important industry experts that were unable to attend the consultation event, interviews were held.

The objective of the interview was to discuss the results of the consultation and take on board other considerations.

FINDINGS

In each of these activities we maintained **technology, commercial** and **political** themes.

The closed questions results were overwhelmingly positive, with the vast majority of respondents believing that adoption of automation was both feasible and desirable.

The open text questions were analysed using semantic analyses to provide affirmation of capabilities and market forces. The patterns in the analyses started to confirm the influencing factors and the limiting factors.

These findings were further confirmed through the consultations and the industry expert interviews.

WHAT ARE THE OVERARCHING INSIGHTS?

The overarching insights are:

- There is an appetite for automation.
- There were caveats and suggestions, that automation should have human oversight. D-COM recognise that until trust is established, automation, in near future will include Human Aided Design Policies

- current research landscape revealed that there are ad hoc solutions that have many limitations:
  - these are not able to scale from small to larger buildings or to district/city levels
  - these cannot be adjusted to support different requirements, or to translate from one project to another and they often need significant technical expertise to implement.

DIRECTOR
30.00%
25.00%
20.00%
REGULATION PROFESSIONALS
15.00%
HEAD MANAGER LEAD
10.00%
5.00%
0.00%
Low regulation professional participation
ACADEMIC
BIM
CONSULTANT

0 - No Automation: The current document and drawing based procedures are adequate
50.00%
45.00%
40.00%
35.00%
5 - Full Automation: Fully automated compliance checking.
30.00%
1 - Automated Information Exchange: Automating submission of project information for regulatory compliance
25.00%
20.00%
15.00%
10.00%
appetite for automation
5.00%
0.00%
Venn represents automation but with human intervention
4 – Automated Assessment: Fully Automated assessment, but requiring final human approval.
2 - Automated Validation: Automating the checking of information for completeness prior to compliance checking.
3 - Partial Automated Assessment: Automatic assessment of some key regulations.

Classification

|		
DIRECTOR	11	18.97%
HEAD MANAGER LEAD	16	27.59%
BIM	13	22.41%
CONSULTANT	4	6.90%
ACADEMIC	8	13.79%
REGULATION PROFESSIONALS	6	10.34%
# 58 respondents declared their roles and responsibilities	58	

Which Target is possible by 2025?

● 1 From a technology perspective, which target is possible by 2025?

● 3 From a commercial perspective, how far is this process viable by 2025?

● 5 From a political perspective, what is level of appetite required that will allow policy makers to affect

In your opinion, what are the technological limitations today?
If there are limitations, what work is required to overcome these?
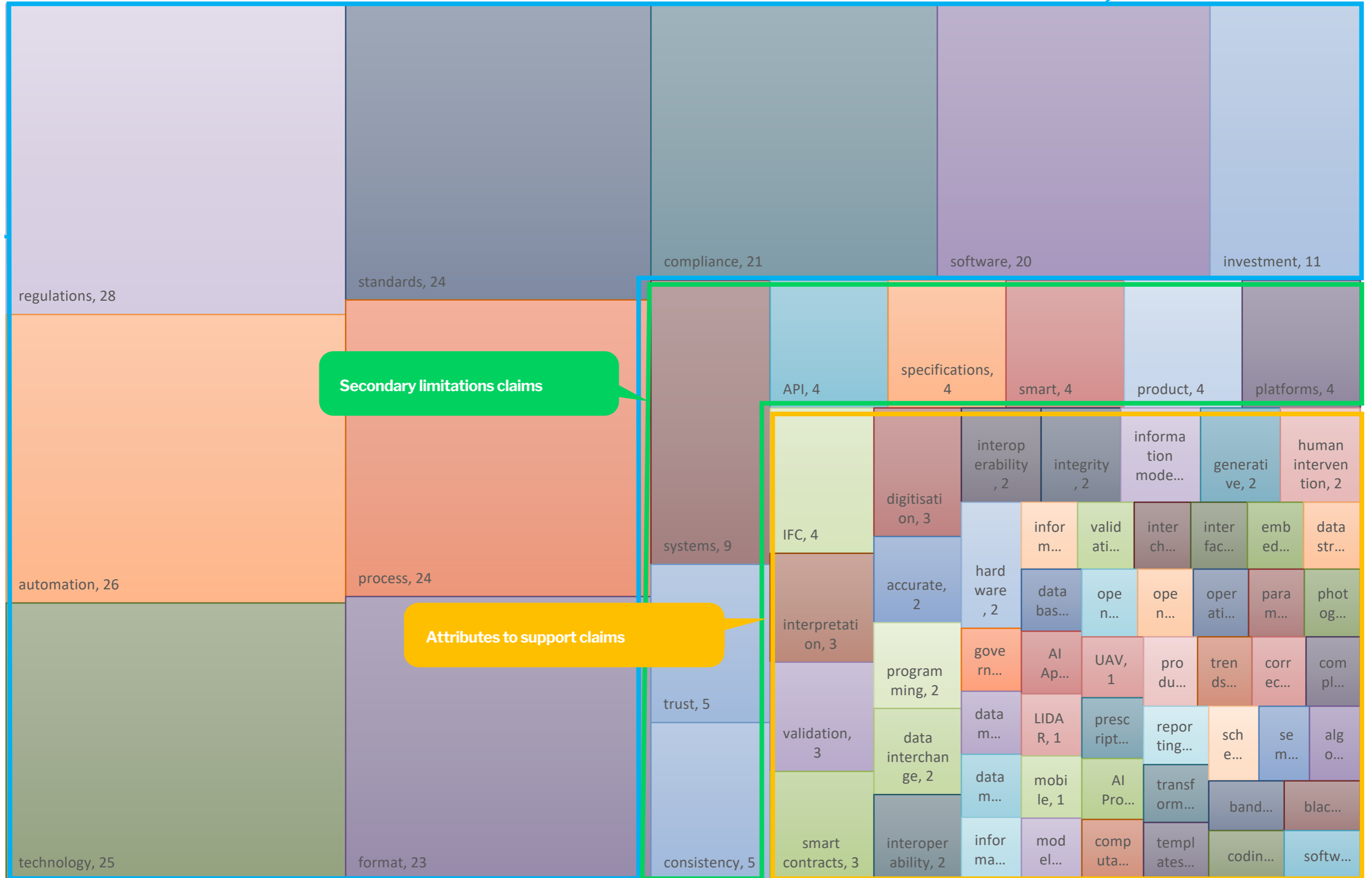
WHAT CAPABILITIES ARE NEEDED FOR DELIVERY?

The capabilities needed for delivery are:

- definition of precise digitisable regulations
- standardised data models for regulatory compliance data defining required properties
- standardised APIs for compliance checking tools
- improved compliance checking process definition, standardisation and management
- generative design based on regulations/requirements
- linkage between requirements, designers and product suppliers and their data
- shared open standards for regulation clauses
- clear government direction towards automated compliance checking
- checking on as-built assets using calibrated instrumentation
- new business models factoring in: reduced costs for assessment

- faster turnaround for assessment
- ability to pre-check prior to formal submission
- artificial intelligence to interpret between regulations and requirements
- rule processes to track decisions, feedback, and uncertainty
- standard data and criteria for social, environment and economic impact assessments
- ability for software to be certified as performing 'correct' checking
- implementation of data's 'chain of custody'
- implementation of smart contracts
- achieving wider awareness of the meaning automation of regulations, requirements and standards and its benefits
- checking software validation and certification
- structured product data standards.

WHAT MARKET FORCES ARE ACTING ON DELIVERY?

The market forces acting on delivery are:

- increased investment in automated compliance checking
- as proposed/designed and as built structured asset information to be required for all projects
- primacy of structured asset information over documentation and drawings for the purposes of compliance submission
- increase professional development and training in compliance checking
- phasing out of negotiated regulations increasing the transparence of regulations
- cultural change to accept automated compliance checking
- establishment of a public right to see compliance assessments

- brief and regulatory requirements to be contractually enforceable
- implementation of a strict legal responsibility for compliance
- direct engagement to Ministry of Housing, Communities and Local Government building regulation policy unit
- direct engagement with Building Regulation Advisory Committee
- developed green and white papers for presentation to government and establish funding pathways
- establishment of dual paths automated checking and engineered checking
- policy for standard data and criteria for social, environment and economic impact assessments.

CONCLUSION

This briefing paper describes the outcomes from of this work.

The key output of the work is the D-COM 2025 roadmap, which offers a comprehensive and methodical list of next steps.
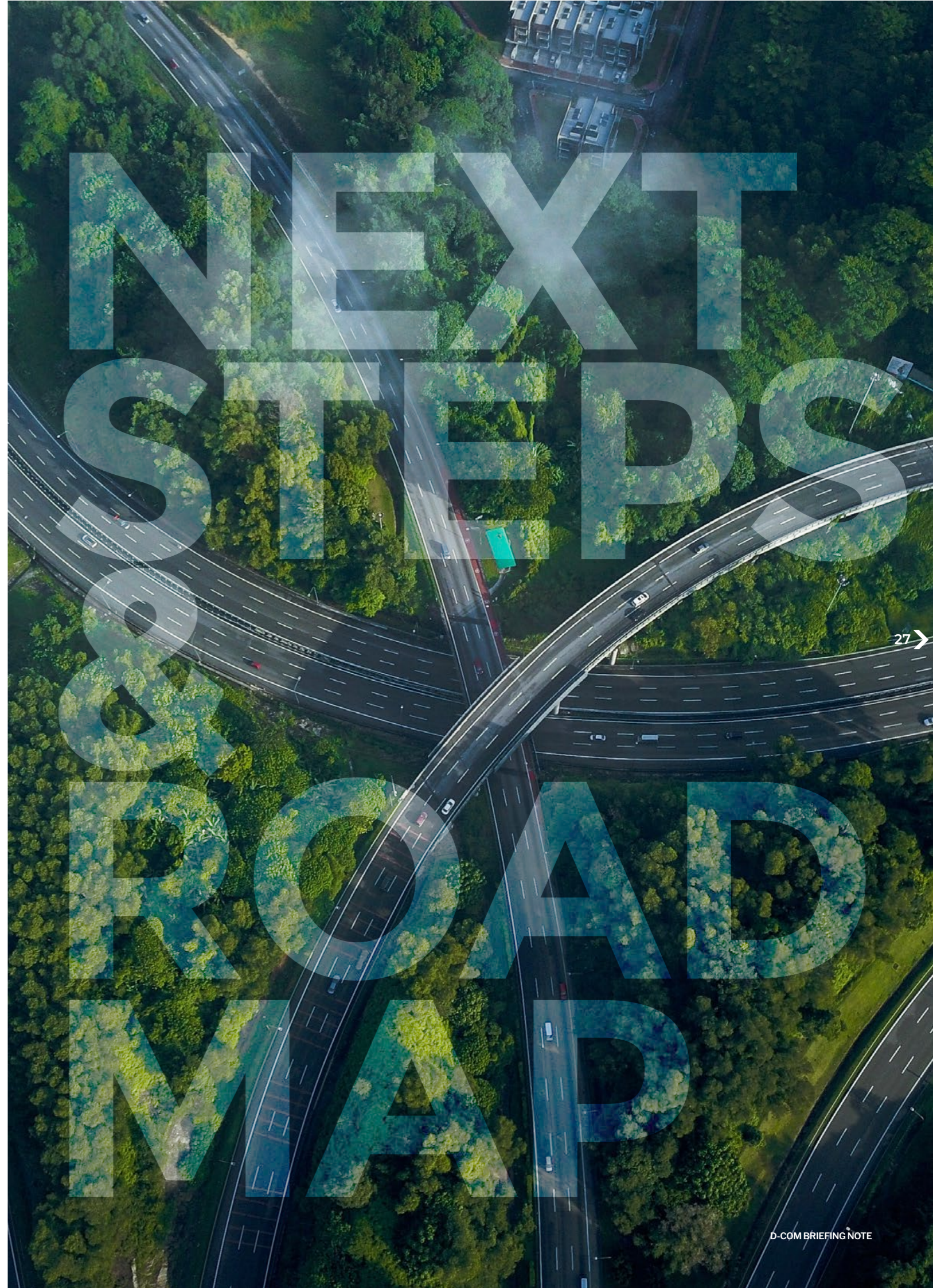
This is a plan for the next 6 years that brings the UK to the verge of mass industrialisation of automated compliance checking by 2025.

This is aligned with the long-term UK Government industrial strategy targets set in Construction 2025, as well as providing a solution to support recommendations in the Hackitt review, which UK Government has committed to implement.

NEXT STEPS & ROADMAP

The D-COM roadmap is organised into four phases. These include a phase of research, a pilot or proof of concept, a phase of industrialisation, where technologies developed for the pilot are matured and designed for scalability, and finally, commercial adoption.

The digitisation of regulatory compliance checking is critical to the delivery of a safer and more efficient Digital Built Britain.
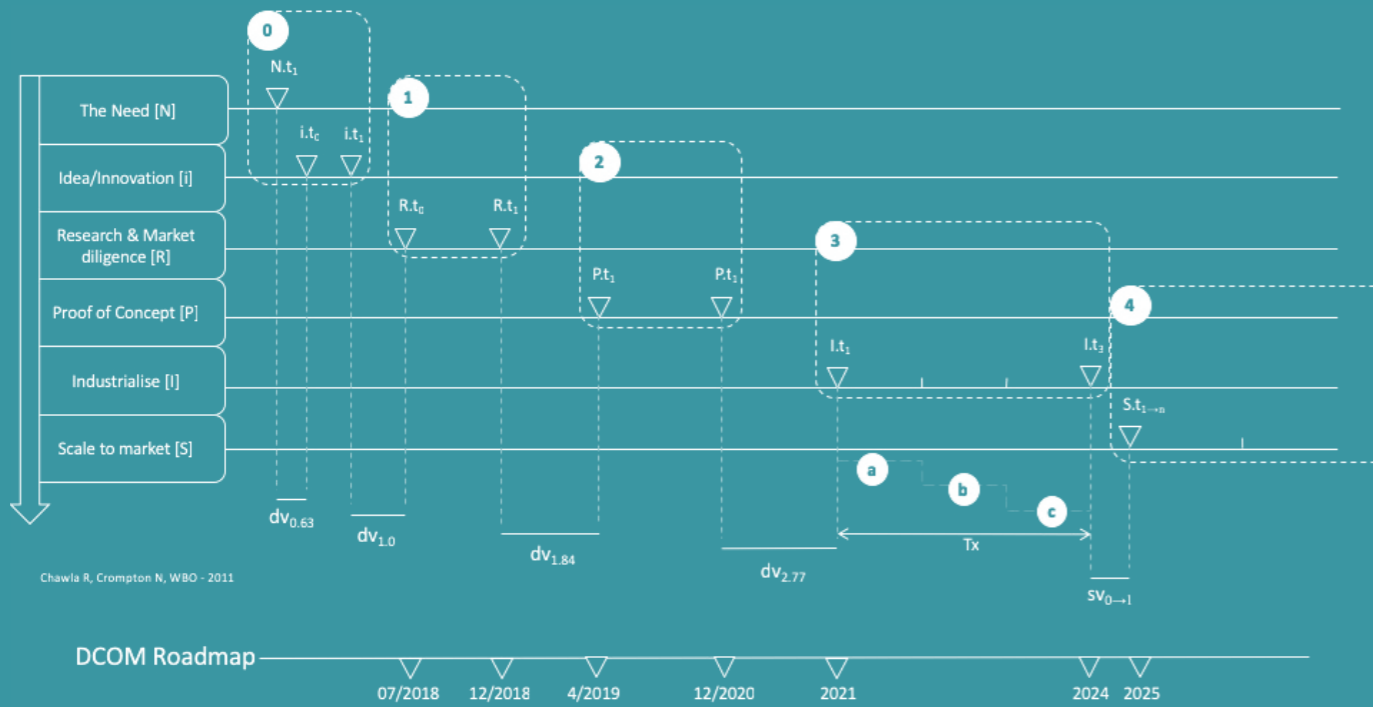
NEXT STEPS & ROADMAP

The Need [N]

Idea/Innovation [i]

Research & Market diligence [R]

Proof of Concept [P]

Industrialise [I]

Scale to market [S]

Chawla R, Crompton N, WBO - 2011

$N.t_1$

$i.t_c$ $i.t_1$

$R.t_c$ $R.t_1$

$P.t_1$ $P.t_1$

$I.t_1$ $I.t_1$

$S.t_{1 \rightarrow n}$

$dv_{0.63}$ $dv_{1.0}$ $dv_{1.84}$ $dv_{2.77}$

Tx

$sv_{0 \rightarrow 1}$

DCOM Roadmap

07/2018   12/2018   4/2019   12/2020   2021   2024   2025

Exhibit 5 – Innovation, product or process development framework (Chawla R, Crompton N, WBO - 2011)

2 > STAKEHOLDER ENGAGEMENT

D-COM proposes to commence with one set of the Building Regulations for our inaugural exercise.

This will require repurposing, cataloguing and prioritising of regulations and is to be conducted together with extensive consultation with Ministry of Housing, Communities and Local Government's building regulation policy unit and with Building Regulation Advisory Committee.

Desired outcomes: Establishing a rule developing methodology and governance to ensure statutory instruments, regulation clauses, and standards clauses are digitised. Implement protocols that allow the clauses to be accessible digitally.

Temper the level of bureaucracy allowing efficiencies to be embedded through automation of processes with a full audit trail.

3 > PILOTING AND PROOF OF CONCEPT

We envisage that the digital form of the regulations, standards and requirements will be a cloud-based system.

From a technical perspective, rule processes to track decisions, manage feedback, and removal of uncertainty will need to be developed within the automated compliance checking system.

Desired outcomes: Demonstrate working to a framework that is clear to follow and shows where the gaps are in capabilities and implementation.

The development of a system architecture to show relationships and to hold digitised requirements, regulations and standards, with layers of checklist, rules-based algorithms and responsibilities in complying with the regulations. Develop a consistent language and dictionary.

4 > INDUSTRIALISATION

This is divided into three stages; building of product or process to 90% of the finished article, trialling and testing of the product or processes – BETA, refining and readying the product or process for scaling.

The process of industrialising compliance checking will require actions in all three themes of Technology, Commercial and Political. The political context will continue to inform stakeholders with the effectiveness automation.

Audience specific guidance on digitisation of regulations requirements and standards will need to be created, along with a detailed evidence-based business model for digitization of regulatory compliance.

Desired outcomes: Test bedding the automated regulatory compliance process in a friendly open-minded local authority with big and small project compliance.

This would be done concurrently using new and existing systems to establish baselines and ability to develop a return on investment model.

Develop routes to export automated compliance checking tools to international audience.

A key demonstration would be an audit trail of responsibility in compliance, show the chain of custody of data, record and analyse departures if any, to feedback and inform the regulation clauses for future evolution.

A significant requirement at the end of industrialisation would be a demonstration and proposal of methodologies to scale for the regulatory authorities and public consumption.

5 > SCALING

Freeze system development for implementation period. Develop a guidance and help material with training programs to allow the use of automated compliance systems. Establish protocols and methods for consumer and user feedback.

Based on operational feedback, perform enhancements to refine consumer experience. Enhance back office and management reporting system to embed efficiencies.

Develop pathways for enhancements to support validation methods, inspection protocols for human or machine, protocols for in services sensor feedback and continuous real time compliance.

Desired outcomes: An automated compliance checking system, with tempered bureaucracy and full transparency.

WHO ARE THE NETWORK MEMBERS AND CONTRIBUTORS?

Nick Nisbet of AEC3 participated in D-COM workshops, developed the D-COM survey, authored the user stories and contributed to the state-of-the-art review and conduct of interviews.

Andy Holt of Azurelope participated in the in D-COM workshops and assisted with social media and dissemination activities.

Rosemarie Andrews of Bryden Wood participated in the D-COM workshops, assisted with the consultation event, helped analyse the questionnaire, conducted interviews and produced graphics for the final report.

Kieran Parkinson of BSI participated in D-COM workshops.

Thomas Beach and Simon Lamb of Cardiff University, led the D-COM network and made significant contribution to all aspects of the networks work.

David Owens of Costain participated in the D-COM workshops, assisted with the consultation event and contributed to the state-of-the-art review.

David-John Gibbs of HKA participated in the in D-COM workshops, assisted in conducting interviews.

Edonis Jesus of Lendlease participated in D-COM workshops.

Marzia Bolpagni of MACE participated in D-COM workshops, assisted in reviewing the state-of-the-art survey, assisted with the running of the D-COM consultation event, arranged interviews and assisted with social media activities.

David Greenwood and **Claudio Benghi** of Northumbria University, participated in D-COM workshops and contributed to the state-of-the-art review.

Raj Chawla of Process Innovation Forum (PIF) participated in D-COM workshops, organised the consultation event, and performed questionnaire semantic analysis, in addition to contributing to the design of the survey, conduct of interviews and the state-of-the-art review.

Andrew Bellerby and **Simon Gilbert** of Solibri participated in the D-COM workshops, assisted with the dissemination activities sand contributed to the state-of-the-art review.

Abdulgadir Ganah of University of Central Lancashire; participated in the D-COM workshops and assisted with social media and dissemination activities.

Zhen Chen of University of Strathclyde participated in the D-COM workshops.

Indre Zutautaite of HKA for creative design and artwork.

HOW DID WE GROW A COMMUNITY?

Over the course of the D-COM network activities a significant number of individuals and organisations have engaged with the network in a variety of ways:

- grown to include 14 organisations.
- held 4 workshops for network members.
- established a website at www.D-COM.org.uk
- established a social media presence on twitter and LinkedIn.

- conducted a survey that received 60 responses from industry professionals, of which 53 of which requested further involvement with the network.
- held a consultation event attended by 16 organisations and interviewed 6 more.
- in total 84 individuals (not including network members) have asked to be kept informed of network activities in the future.

HOW CAN I FIND OUT MORE?

A full copy of the report and further information on D-COM and how to particpate in the network activities can be found at: *www.dcom.org.uk*

WHERE CAN I FIND CENTRES OF COMPETENCE?

AEC3 has been implementing, developing and researching automated compliance of regulatory, requirements and recommendations since 1998, culminating in the development of AEC3 require1.

Bryden Wood are a multidisciplinary consultancy of Architects, Engineers and Data specialists. In addition to data analytics which inform platform-based designs and design for manufacturing technologies. Bryden Wood are working to unlock the power of big data and transform the way the construction sector interfaces with information, developing data tool kits which automate the design process, and interfaces including AR and VR which help organisations understand and engage with their data.

Cardiff University has been involved in research relating to the automation in compliance checking since 2012. They were the technical lead in the RegBIM project and led the development of a complete methodology for regulatory compliance (from specification of regulations by regulation experts, to data mapping between regulations and the IFCs, to rule based execution). Since the RegBIM project this technology has continued to be developed incorporating the latest advancements in semantics.

HKA is the largest provider of construction claim and dispute resolution services globally. HKA advise on how digital ways of working can address common points of failure and have been commissioned to undertake the most comprehensive BIM assurance review of the UK supply chain to date, advise the Mexican Government on national digital transformation, and investigate the legal opportunities and blockers of emerging digital technologies for i3P.

MACE is an international construction and consultancy company founded on the 'pursuit of a better way' of delivering the built environment. In recent years it has helped large public and private sector clients in digital transformation programmes, initially as part of the transition to 'BIM Level 2', but now more directly at each of enterprise, programme and project level. As part of this digitisation, Mace is helping clients explore the opportunities of automation, which includes automated checking and validation, and smart asset management.

Northumbria University has a strong reputation in the use of digital technologies for construction, with a particular focus on collaborative research with industry partners and projects funded by Innovate UK and its forerunner, the Technology Strategy Board. An example is its role in the development of the NBS Digital Toolkit, one of the so-called '8 pillars of Level 2 BIM'. The University is joint owner of BIM Academy, winner of the 2017 Times Higher award for 'Most Innovative Contribution to Business-University Collaboration'.

Process Innovation Forum (PIF) is an innovation platform where challenges are matched with innovative solutions. It scouts for ideas and innovations and graduates these within the AECO. PIF specialises in innovation management, discovery projects, developing business from innovations, industrialisation of products and processes and scaling to market. It provides business support and diligence for new innovations.

Solibri with its product portfolio, the Finnish software vendor Solibri has been standing for robust tools in the area of BIM-based quality checking and assurance (QA/QC) for almost two decades. The main product Solibri Model Checker (SMC) offers various rich and flexible technical features as well as a robust workflow to cover the real-world requirements regarding when it comes to the qualitative assessment of building models. Main strengths of SMC are: (a) Relying on openBIM Standards, (b) Define the Quality Assurance Process as you see it, (c) Customizable down to the last Detail and (c) Partner for Research and Innovation across the Globe

University of Central Lancashire has been in conducting research on innovative approaches in design and Health and Safety in construction industry and helped SMEs in adopting BIM to enhance their business.

University of Strathclyde has research strength in design and construction informatics through sustainability engineering for the built environment. The main focuses of relevant research initiatives are to adopt digital engineering concepts and tools in both research and learning to improve the dependability of buildings across various stages of RIBA Plan of Work, and to engage in new multidisciplinary research into BIM for the sustainable built environment.