# CDBB
# Capability Framework and
# Research Landscape Scoping Workshop

Workshop: Capability to create and manage
the BUILT ASSETS that enable the services and
benefits of digital built Britain

Centre for Digital Built Britain

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UNIVERSITY OF
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Centre for Digital Built Britain

This document captures the working notes from the workshop "Capability to create and manage the BUILT ASSETS that enable the services and benefits of digital built Britain ", held at Churchill College Cambridge on 10-11 April 2018

The summary sheets are assembled from the separate working groups from each of two streams; Research and Applications.

The details of the outputs from the individual working groups are captured in turn.

This material was used as a starting point for the creation and development of the Capability Framework and the Research Landscape.  It is provided as source material for the interested reader.

## Create and Manage Built Assets - Research summary

| Rank order | Topic title | |
|---|---|---|
| 1 | Digital twin | - How will we build it, how will we visualize it and make use of Augmented Reality (AR) and Virtual Reality (VR)<br>- Linking real assets with virtual model<br>- Fuzzy digital twin during design with range of tolerance on every attribute to aid decision making<br>- data architecture |
| 2 | Lifecycle | - Post-occupancy analysis feedback. Could this be mandated through Government Soft Landings?<br>- National record to encourage a lessons learned culture to decrease risk<br>- Process modelling and whole lifecycle digital thread |
| 3 | Information and knowledge extraction | - Data exchange and interoperability<br>- Integrate legacy data, existing building<br>- Data driven decision making - machine learning to extract knowledge. How is this implemented? |
| 4 | Visualisation | - AR and VR - are they appropriate technology and what are their limitations?<br>- Identify new use cases for AR and VR like asset management<br>- Use cases for capabilities and research needed |

| Research Topic: … | |
|---|---|
| Create and manage the Built Assets (at multiple scales and degrees of integration) that enable the services and benefits of DBB | |

| Scope: | | |
|---|---|---|

| Scope - In | Scope out | What sub-topics might overlap with other topics? |
|---|---|---|
| **A**<br>• Historic asset information & supply chain uniqueness<br>• Data desert. Missing/acquiring data sets<br>• Element data chain<br>**B**<br>• Define data requirements for whole-life asset management<br>• As designed, as built, as constructed vs as repaired data<br>• Data evolution and starting point<br><br>**C**<br>• Machine learning to support whole-life asset management<br><br>**D**<br>• Linking views of actual building with sensor data, O&M manuals<br>• Localisation<br>• Is AR/VR adequate to support operations VR beyond training<br>• Digital twin → Linking asset info → Remote expert management<br><br>**E**<br>• Material embedded sensing/diagnostics<br>• Data capture degradation modelling<br>• Establishment of data analysis indicators of performance<br>• Defect ontologies<br><br>**F**<br>• Manage Assets<br>  > Cyclic/planned maint<br>  > Reactive maint<br>  > Optioneering<br>  > Phased delivery<br>• Built assets as services<br>• Integrate info about services to improve delivery of buildings | | • User/occupier. Data harvesting automatic sensors into BMS<br>• Rapid energy performance assessment<br>• New profession<br>• New skills required<br>• E Procurement<br>• asset sensor → decentralise maintenance<br>• Block chain |

| Step 2. Scope change by thinking about stakeholders |
|---|
| • Design to construction to operation<br>• Buildings as a service<br>• Design & build vs design, build and operate<br>• Different interest from different parties at different stages of whole-life cycle eg construction vs operations |

| Step 3. Scope change by thinking about spatial differences | | |
|---|---|---|
| e.g. National/Regional | e.g. City/local | e.g. Asset specific |
| | • How to model interaction between assets? | |

| Step 4. Scope change by thinking about the lifecycle of assets and services | | | | | | |
|---|---|---|---|---|---|---|
| Articulate user needs and requirements | Conceive, plan and design (including optimisation and integration) | Build and commission (including optimisation and integration) | Manage and Operate (refine and enhance, optimise and integrate) | Provide valued services to users (and minimise downsides for non-users) | Retrofit / Renew / Decommission (with attention to the whole cycle) | …Assess, feedback and optimisation |
| | | | | | | |

| Research Topic: | |
|---|---|
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| Scope: | | |
|---|---|---|

| Scope In | | Scope out | What sub-topics might overlap with other topics? |
|---|---|---|---|
| • Digital twin for built asset life cycle<br>• Digital twin models through Duma<br>• Information requirements/properties of BIM components & legal Issues related to the digital twin (building/operation)<br>• New tools/methods to collect data for existing built assets and integration to the BIM model<br>• How can we effectively create digital as-built assets? (Laser scan only works on line of sight)<br>• From design intent to as built information<br>• Process mapping/modelling re-engineering/optimising<br>• Digital workflow across lifecycle digital thread<br>• Smart meters | • How to monitor occupants' health without affecting their privacy<br>• Water requirements for asset life-cycle monitoring (safety vision)<br>• Rule based design (& construction) - algorithmic design<br>• New types of contracts for the digital twin use<br>• Visualising SHM using emerging tech (VR, AR, gamification etc)<br>• QR/AR enabled building management/maintenance<br>• Using VR & AR for built asset across their lifecycle<br>• AI application for monitoring/updating the changes across the disciplines in the design phase<br>• Reason causing performance gap between predicted and actual performance | • How can we learn from post-occupancy evaluation of design decisions?<br>• Integration GIS/mapped catalogue of assets<br>• Benchmarks to transfer lessons learnt<br>• How to improve existing internet infrastructure/speed to deal with large information/data needed for DBB?<br>• Examining & quantifying trade-offs between investment & maintenance<br>• Uncertainties quantification & management<br>• How do we bring end users & operators into the design process? | • Modelling water and energy performance<br>• Insurance requirements.  Risk. |

| Step 2.  Scope change by thinking about stakeholders |
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| Step 3. Scope change by thinking about spatial differences | | |
|---|---|---|
| e.g. National/Regional | e.g. City/local | e.g. Asset specific |
| | | |

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| | • Reconfigure parametric designing | | • Develop maintenance techniques that minimise disruptions to transport network<br>• Improving road network to be robust to self-driving cars | | | |

| Research Topic | |
|---|---|
| **Create and manage the Built Assets (at multiple scales and degrees of integration) that enable the services and benefits of DBB** | |

| Step 1. What are the major research clusters/themes? | What are capabilities and research that will be needed as DBB matures from 'deliver' to 'operate' to 'integrate'? | | | | | |
|---|---|---|---|---|---|---|
| | *Deliver (create the built asset)* | | *Operate (manage asset through life and deliver the services that derive from and depend on the asset)* | | *Integrate (deliver services and benefits based on integrated systems and organisations)* | |
| | *What capabilities and enabling research?* | *Which people / institutions are working on this?* | *What extra capabilities and enabling research?* | *Which people / institutions are working on this?* | *What extra capabilities and enabling research?* | *Which people / institutions are working on this?* |
| • Data capture | • Sensor data. Historical data. What about not visible data?<br>• Digitalisation of legacy data | | • Harvesting data from users. Comfort levels heat/light productivity<br>• Localisation | | • Improve data management practices | |
| • Information extraction | • Interoperability. Info exchange<br>• How to enable data-reusability? | | • Machine learning to extract valuable information<br>• Data-driven design-making | • BDAL (VWE) | • Integrating old/legacy data with new Portfolio Asset Management<br>• Focus on integration of different varied assets<br>• Legacy data interaction between assets<br>• Prioritize existing building stock | |
| • Visualisation AR/VR | • VR as a tool for design<br>• VR/AR usability problems. Motion sickness<br>• VR beyond training | • BDAL (VWE)<br>• University of Huddersfield Architecture<br>• CSEI Imperial College London | • AR/VR development of asset management tools<br>• AR registration problem | | • Are AR/VR mature enough? | |
| • Whole-life building as a service | | | | | | |

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| | **Deliver** *(create the built asset)* | | **Operate** *(manage asset through life and deliver the services that derive from and depend on the asset)* | | **Integrate** *(deliver services and benefits based on integrated systems and organisations)* | |
| | *What capabilities and enabling research?* | *Which people / institutions are working on this?* | *What extra capabilities and enabling research?* | *Which people / institutions are working on this?* | *What extra capabilities and enabling research?* | *Which people / institutions are working on this?* |
| • Digital twin | • New assets<br>• Mapping of built environment assets<br>• Data requirement:<br>  > Information flow<br>  > Data architecture | | • Existing assets (80%-90%) | | • Platform that can federate different models (Revit, IFC) | • Hypercat (IoT consortium & standard) |
| • Lifecycle information feedback loop to design | • Whole life cost | • Bryden wood:<br>  > MTC<br>  > Duma<br>• CIBSE | | • Soft landing<br>• RICS<br>• BSRIA<br>• Innovate UK | • Management of connected built investment assets | • We need 'Tinder' for Research! |
| • Visualisation of data to stakeholders (VR/AR) | • VT & AR in delivery operation services | | | • BC Group (Asset Data Platform)<br>• LocLab (gamification)<br>• Catapult (satellite agency) | | |
| • Digital workflow (digital thread) | • Automated data capture & structure | • BSI<br>• IT/software developers | | | | |
| • Statistical variability (attributes/cost etc). Stop designing with absolutes | • Identification of mechanisms that influence on cost variation<br>• Range of values for components/systems attributes - possible architects??? | • Parametric components that can cope with range of values (similar to tolerance for geometry)<br>• Digital 'mock up' tolerance parameter measured risk manage | | | | |

| Create and Manage Built Assets - Application summary | |
|---|---|
| **Rank order** | **Topic title** |
| 1 | Digital twin (Use Case: Rail infrastructure)<br><br>- Define it, understand data and how it links with contextual data<br>- Define outcomes required from data; Define data required; How to integrate contextual data with asset data (a consistent approach to gather data needed; security implications need to be considered; Who owns that data and how it can be used (sharability)); Automated response to service data in real time |
| 2 | Hierarchy of asset types<br><br> - Define information and data types, performance requests of asset types<br>- Agreement needed across industry of how to define assets, an approach like uniclass needs to be mandated to mitigate contractual and legal requirements standard format<br>- Address lack of awareness of what is required and communications breakdown<br>- A clear, up to date workflow linked to payment could be a solution |
| 3 | Framework for end users to report faults and report feedback (FM, AM) This should happen across lifecycle (Link with |

| Application Topic: … | |
|---|---|
| Create and manage the Built Assets (at multiple scales and degrees of integration) that enable the services and benefits of DBB | |

**Step 1. Scope:  What topics should we include in this part of the framework  – and what demonstrators would illustrate / stretch the boundaries?**

| Scope - In | | Scope out | What sub-topics might overlap with other topics? |
|---|---|---|---|
| • New definitions of performance that enable services related to built env → to drive the design<br>• Methods of analysis of;<br>- organisational information requirements<br>- asset inf req<br>• Capturing change<br>• Establish asset relationships: parent → child subcomponent/dependant<br>• Framework for communication between sub-contractors on maintenance operational stage<br>• Data on legacy/existing built assets | • Develop a robust BIM Level 2 for better asset information delivery<br>• Level system for built asset:<br>  - Level 0:        ( Fix on fail)<br>  - Level 1:<br>  - Level 2:<br>  - Level 3: (Full digital arrangement)<br>• Training and upskilling <u>clients</u> on guidelines for asset management, ie PAS 1192-3 | • Performance monitoring of assets<br>• Capability & capacity<br>• Degradation modelling<br>• Condition monitoring of asset | • Interface between individual assets (inc environment) and DBB<br>• Wider asset estates<br>• Neighbours (all) |

**Step 2.  Scope change by thinking about stakeholders  (Are there new / different aspects of the topic and its demonstrators?)**

| |
|---|
| • Employers requirements<br>• Legislation<br>• Supply chain<br>• Technology<br>• Change in demographic<br>• Government policy guidelines linking ie Academia & research DBB<br>• Increasing exposure of projects (through data integration at wide scales) → Increasing number of stakeholders |

**Step 3. Scope change by thinking about spatial differences (e.g. to consider how can scale make a difference to the demonstrators we would propose)**

| e.g. National/Regional | e.g. City/local | e.g. Asset specific |
|---|---|---|
| • Value engineering/budget change<br>• Sustainability scope for social constructs | • Energy generation. Pollution<br>• Level of detail/verification.  Roll out of infrastructure projects<br>• Analytics suitable for various spatial scales<br>• LOD and required level of detail to be determined for various spatial scales | • Environmental impact on assets/performance<br>• Availability of product data/models |

**Step 4. Scope change by thinking about the lifecycle of assets and services: Are there new / different aspects of the topic and its demonstrators if we think through the lifecycle of the assets and the services?**

| Articulate user needs and requirements | Conceive, plan and design  (including optimisation and integration) | Build and commission (including optimisation and integration) | Manage and Operate (refine and enhance, optimise and integrate) | Provide valued services to users (and minimise downsides for non-users) | Retrofit / Renew / Decommission (with attention to the whole cycle) | …Assess, feedback and optimisation |
|---|---|---|---|---|---|---|
| • Clear OIR process translated into air EIR from client to supply chain<br>• Incorporate GSL policies and guidelines as early in the design process | • Design in flexibility | • What is 'performance' and how it translates between various stages? | | • Performance monitoring smart infrastructure/data mining for assets | • Change of use<br>• Legislation change - effect on lifecycle costing | • Post occupancy evaluation<br>• Methods for user and manager feedback |

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| • Transpose the existing built asset into a combined 3D model<br>•  Combining technologies in order to get as much information as possible automatically (ie Libar & Sonar to identify materials only by scanning)<br>• Adding a mandatory BIM "sign off" within all built asset inspection programmes<br>• Automatic generation of semantically enriched, geometrically accurate digital models of existing assets<br>• Feeding the physical back to the digital<br>• Digital twins for asset integrity management: enhanced 3D models with information layers<br>• Integrating sensor monitoring data into BIM models (as per CSIL project with Manuel Davila)<br>• Linking relevant standards such as BIM, Smart Cities and IoT to enable smart buildings/infra and digital twins<br>• Data analysis (Analytics)<br>• Data capture (in use)<br>• Review what is being done in others industries eg Gas, Oil, Car manufacturer | • Framework Development:<br>  - New assets<br>  - Legacy assets<br>for asset & integrity management standards/policies<br>•  Augmented reality progress monitoring of construction - comparing as-built BIM model<br>• Data requirements definition (various delivery stages & operations)<br>• Look at current industry practices for delivery, ie Industry foundation classes (IFC); Constructions, Operations, Building, Information Exchange, Cobie<br>• Open standards for reliable data exchange<br>• Connectivity of tools and platforms (enforced open API)<br>• Dramatically improved IT infrastructure to cope with connectivity and big data | | |

**Step 2.  Scope change by thinking about stakeholders  (Are there new / different aspects of the topic and its demonstrators?)**

• Integration of  stakeholders; DBB, UKBIM Alliance
• Will CDBB outcomes and standards only be mandated for central gov depts
• BIM for Rail and BIM for Infrastructure;
- Structure to scale up
- Common language → Involve subcontractors
• Raising awareness with clients/end users
• BIM 4 communities (eg BIM4Rail, BIM4Housing, BIM4Heritage)
• CDBB to provide funding for BIM implementation on projects across industry?

**Step 3. Scope change by thinking about spatial differences (e.g. to consider how can scale make a difference to the demonstrators we would propose)**

| e.g. National/Regional | e.g. City/local | e.g. Asset specific |
|---|---|---|
| • More detailed BIM standards to be implemented<br>• Integrating digital city models to create a national digital twin<br> • Buried asset data - national archive - potential barrier<br>'• National inventory of infrastructure assets (start with National Digital Bridge Inventory) | • How will local gov (council) clients be engaged by legislation to adopt DBB agenda<br>• Integrating of BIS and survey datasets | • Common standardised asset naming/taxonomy developed across all assets & sectors<br>• Knowledge transfer amongst industries: Oil & Gas - Construction - Infrastructure |

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|---|---|---|---|---|---|---|
| • Brief template | • Define/outline integrated design approach | | • What do asset managers need? | | | • User interaction with asset feedback mechanism |

| Application Topic | |
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| Step 1. What are major demonstrators that are required? | What capabilities / functionalities of the demonstrators illustrate the maturing of DBB from 'deliver' to 'operate' to 'integrate'? | | | | | |
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| | *Deliver (create the built asset)* | | *Operate (manage asset through life and deliver the services that derive from and depend on the asset)* | | *Integrate (deliver services and benefits based on integrated systems and organisations)* | |
| | *What would be the big challenges?* | *How?* | *What would be the big challenges?* | *How?* | *What would be the big challenges?* | *How?* |
| • What are the assets?<br>• Developing hierarchy of assets<br>• Define performance requirements for various asset levels/types<br>• Define information and data requirements for various asset levels/types | • Cross industry/organisation requirements | • Mitigate contractual and legal requirements<br>• Mandate(perhaps) the use of data definition standards e.g. uniclass | • Finding reliable and missing data in a standard format<br>• Breakdown in communication or lack awareness of what's required from sub-contractor | • Classification v data aggregation | • Live updates to data<br>• Common data language | • Clear update workflow linked to payment mechanism |
| • Framework for end user to report fault/failure/feedback<br>• + FM Ops maintenance | • Measuring the realisation of declared benefits<br>• Evidence-based design<br>• Silos (information)<br>• Lack of clear roles and responsibilities | | • Continuous learning improvement<br>• Keeping asset information up to date and live data | • CAFM | • Data analytics for feedback and sense-making strategies<br>• Commercial advantage/loss<br>• Investment, data security on sensitive/high security projects<br>• Intellectual property | • Cloud storage systems for data integration<br>• FM industry share data<br>• Understanding what data is sensitive |

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| | What would be the big challenges? | How? | What would be the big challenges? | How? | What would be the big challenges? | How? |
| • Retrofit<br>• Define digital twin (BIM, AIM, Sensor, Buried asset, Legacy enterprise systems, planning, survey)<br><br>• Rail infra:<br>- stations<br>- signalling<br>- track | • Defining the data required<br>• Defining the outcomes<br>• Collecting existing datasets to create digital twin<br>• Integrating | • Standardized approach for collecting information during survey (point cloud etc)<br>• Security and accessibility of data. Define. | • Who owns/maintains/uses data<br>• What do they use it for?<br>• How is it maintained and used? | • Integration and interoperability of tech and tools | • Capture service use data/define<br>• Monitor and actuating response<br>• Optimizing user experience | • Sensor data<br>• Automated response (Gates closed, apps updated) |