Scanning Cities: Point Cloud Data and Reality Capture within Architectural Process

Rebecca De Cicco
Matt McCarter
The class will focus on the uptake and rise of laser scanning workflows in the architecture, engineering, and construction industry in the United Kingdom. We will discuss a variety of workflow options of scan data into ReCap software, Revit software, and Navisworks. The class will also delve into typical and best-practice workflows when it comes to using the scan data effectively on large-scale projects from an Architects perspective, as well as understanding how the use of the data can begin to replace traditional visualisation methods when communicating ideas to clients and consultants through differing stages of projects. The class will enable you to realistically help your staff to utilise the scan data and effectively manipulate it to produce typical architectural diagrams and drawings easily.
Key learning objectives

At the end of this class, you will be able to:

- Learn how to accurately capture & document buildings using laser scan data.
- Learn how to utilise scan data and effectively divide and manipulate the information.
- The workflow and manipulation of scan data into Autodesk Recap and linked into the Revit Environment.
- Discover differing versions of visualisation techniques from point cloud data and into varying Autodesk Software.
Laser Scanning
Adoption outside of Survey.

- Peak of Inflated Expectations
- Plateau of Productivity
- Slope of Enlightenment
- Trough of Disillusionment

TIME

VISIBILITY
Why?
Why?
Roles

Surveyor

Architect

- What Information exists?
- What do I need to deliver?
- What format is this?
- What information do I need?
- How do I use this information?
- Are these file formats useable?
Community BIM and UK

TWITTER
FACEBOOK
LINKEDIN
BLOGS
WEBSITES
GOOGLE HANGOUT
Background
Rebecca De Cicco

- David Miller Architects
  - Associate Director Innovation
- Construction Industry Council
  - BIM2050 Steering Lead
- KSS
  - Technical Associate & BIM Specialist
- HOK
  - Architectural Assistant
- HASSELL
  - Graduate Architect
- Tectvs
  - Graduate Architect
- Louis Laybourne-Smith school of Architecture & Design
  - Bachelor of Architecture (University of South Australia)
- Stafford Architects
  - Architectural Student
Background
Rebecca De Cicco
Background
Matt McCarter

- Working in survey industry 15 years
- Started laser scanning in 2000
- Joined London Underground land survey team in 2008
- Active in BIM community
- Member of Cabinet Office BIM Task Group “Survey4BIM” committee
- Blog on SPAR Point Group Website
- **Currently Laser Scanning Business Development** Topcon
To be “The Primary Source” of superior value positioning systems that significantly improve the productivity and quality of work performed in civil engineering, agricultural, mapping, and measurement applications.
Why BIM?

- Improved design reliability
- Reduced design risk
- Reduced waste
- More time to get the design right
- Enhanced coordination and fewer errors
- Improved decision making
- Greater productivity
- Higher quality of work
- Downstream uses for facilities management
- Supports sustainability
- Improved safety
- Computation of material quantities
- Improved planning, control, management of construction
- Enhanced communication
- Effective resource utilisation and coordination of activities
- Reduction in costs associated with planning, design and construction
- Reduced number of RFIs
- Improved collective understanding of design intent
- Less time documenting more time designing
- Quantity takeoff
- Client engagement
- Improved spatial coordination
BIM & UK Government

Government 2016 mandate

The Government Construction Strategy was published by the Cabinet office on 31 May 2011. The report announced the Government's intention to require: collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on its projects by 2016.

Source: http://www.bimtaskgroup.org/
Objectives
BIM4 Groups

Building Information Modelling (BIM) Task Group

BIM4 Groups

BIM4 Clients
Chair: TBC

BIM4Retail
Coordination: James Brown

BIM4PrivateClients
Chair: David Philp

BIM4Water
Chair: Jon De Jesus

Infrastructure Client Group
Kath Waler

BIM4FM
Chair: Geoff Prudence

SurveyBIM
Chair: Ian Bush

ACE
Sally Partidge

BIM4/5
Chair: Peter Capelhorn

BIM4/5 Matt
Chair: David Price

BIM4/5 Data
Chair: Emily Spinak

BIM4 Supply Chain
Chair: TBC

CIC BIM Regional Hubs
Chair: Liz Needham

UCCG
Chair: Bill Price

BIM4/5ME
Chair: Tim Wiles

Technology and/or Alliance
Chair: Bill Healy

BIM4/5 / CIC BIM White Paper
Chair: Rob Harvey (TBC)

Future Building / Academia
Level 3 vision team

BIM2050: Neil Thompson

BIM Academic Forum: Jason Underwood?

Schools COVO: Alison Watson

Council Heads of Built Environment: Rob Harvey (TBC)

Institutes
CIC BIM Forum: Rob Manning

CFIC – Unclass Forum

Digital Built Britain / Tech Standards
BBE: Nick Tune
BIM Standards
BIM Level Definitions

Level 0  |  Level 1  |  Level 2  |  Level 3
---|---|---|---
2D  | 3D  |  IFD  |  iBIM

CAD

BIMs e.g.

CPIC
Avanti
BS 1192:2007
User Guides CPIC, Avanti, BS

IFC
IFD
IDM
ISO BIM

Lifecycle asset management

© 2008 / 13 Bew-Richards

2016
Client Guidance

Client Guide to 3D Scanning and Data Capture
First BIM Task Group Technical Guide
Cross industry involvement
“Recruited” via Twitter announcement

Social BIM, Land Survey & Government

Will produce BIM focused survey guides

Will be endorsed by professional bodies and replace their existing documents with a common source

@Survey4BIM or #survey4bim on Twitter

Survey4BIM group on LinkedIn
What a Surveyor Does?

- Measures Stuff!
- First Information Delivered on Projects
- Establishes Site Control
- Delivering Information Accurately…
- Throughout Construction
Global perspective - Surveyors

- Licensing: UK vs US
- UK - RICS Certification by company / individual - Not required to practice
- US - By state survey licensing test is required to practice as a surveyor.
- UK Mature Laser Scanning Market
Old v New

- 2D vs 3D vs Scanning
- How do you get the information wrong?
- Ensuring you know who to go to - what to ask for?
- Understanding of reality of the industry and where the technical expertise lives
3D Scanning Basics
Site Work - Capture Accurately
Equipment Options

- Tape Measure
- GPS / GNSS
- Total Station
Equipment Options

Laser Scanner
GLS-2000

Mobile Mapping
IPS-2

Aerial Survey
Sirius Pro
Site Work
Site Work
Scanning Process
Environment Challenges

1. Shiny Surfaces
2. Dark Surfaces
3. Moving Objects, eg. People, Vehicles - do you really need a ‘cleaned’ point cloud?
4. Open vs closed site - don't just quote a sqm!
Registration

- Target Based
- Object Based
- Known Locations
- Cloud to cloud
Target Based

1. Targets placed
2. Scans Performed
3. Scan Registered
Object Based

1. Objects placed
2. Scans Performed
3. Scan Registered via points
Known Locations

1. Targets placed
2. Scans Performed
3. Scan Registered
Cloud to Cloud

1. Targets placed
2. Scans Performed
3. Scan manually stitched via matched points
Prior to Registration
Creation of a Registered Point Cloud
Surveyor Deliverables

Point Cloud Options
- Raw Scan Data
- Registered Point Cloud
- Geo-Referenced Point Cloud

Vector Options
- 2D Drawings
- 3D Wireframe
- 3D Surface / Solid Model
- Building Information Model
- Visualisation

Surveyor Information Delivery
Architecture & Scanning Process
Why Scan data?

- Capture
- Use/View
- Review
- Validate
How do we use it?

- Review accurate Site conditions
- 3D Survey Data
- Validation of Information through Construction
- Coordination with Existing Conditions
- Capturing As-Built Data
Deliverables - Client Expectations

- Define the deliverables
- Adequately communicate this to consultants prior to any work being undertaken
- Ensure the relevant Schedule of services documents relate to how the client expects laser scanning to be used
- Is the model a deliverable?

All consultants must adhere to the xxx BIM strategy and deliver their documentation in accordance with and in agreement to the Construction Industry Council (CIC) BIM Protocol (2013) to the end of RIBA Stage xx. This document provides the legal basis in using building information models by the consultant team upon appointment. In addition to this, the models and data shall be delivered in accordance with the following documentation:

1. The (project-specific) Employers Information Requirements (EIR's).
2. The BIM Standard.
3. The project Model Production and Delivery Table (MDPT) - which outlines all levels of detail and information at all key stages of the project.
4. The combined (multi-disciplinary) BIM Execution Plan (BEP).

Based on the CIC BIM Protocol, the Level of Development (LOD) will align to the Model Production and Delivery Table which is to be produced upon appointment of and in association with the consultant team.
Deliverables - Architects

- Early Design Concepts
- 2D Drawings
- 3D Model
- BIM
- Visualisation
- As Built Information

Architect Information Format
Point Cloud Tools & Architecture

MODELLING TOOLS
VALIDATION TOOLS
VISUALISATION TOOLS
FABRICATION TOOLS
POINT CLOUD TOOLS

3D PARTY TOOLS

@oatfedgoat    @becdecicco    @digital_node
Tools Architecture

ReCap
- Desktop product for editing and visualizing 3D data from laser scans
- Processes scans from any device and export to Autodesk products

Recap Pro features
- Snap registration for in-field data preparation and verification
- Add survey control to 3D data to tie into control and verify accuracy
- Autodesk 360 cloud publishing for sharing laser scans and 3D data

ReCap 360
- Central portal for all Reality Capture clouds services
- **Real View on ReCap 360**: Web service for sharing and collaboration of scans
How Scan Data aligns to RIBA PoW

The RIBA Plan of Work 2013 organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of key stages. The content of stages may vary or overlap to suit specific project requirements. The RIBA Plan of Work 2013 should be used solely as guidance for the preparation of detailed professional services contracts and building contracts.

<table>
<thead>
<tr>
<th>Step</th>
<th>Stage Description</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>Strategic Definition</td>
</tr>
<tr>
<td>1</td>
<td>Preparation and Brief</td>
</tr>
<tr>
<td>2</td>
<td>Concept Design</td>
</tr>
<tr>
<td>3</td>
<td>Developed Design</td>
</tr>
<tr>
<td>4</td>
<td>Technical Design</td>
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<td>5</td>
<td>Construction</td>
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<tr>
<td>6</td>
<td>Handover and Close Out</td>
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<tr>
<td>7</td>
<td>In Use</td>
</tr>
</tbody>
</table>

†As required.

© RIBA

Site Context Needed
Validation
Record
Appointed Consultants respond to the EIR and develop the BIM Execution Plan in line with the deliverables.

Client Driven Employers Information Requirements stating deliverables for project
Early Design & Preparation

**PROCESS**

- Photography

**TOOLS**

- Recap Photo / Project Memento
  - A360 Login

**WORKFLOW**

- Photography / Mesh
Photography

1. 5% Separation between photos
2. Avoid photos with Blur
3. Monitor any Brightness & Reflection
4. Time taken to create mesh - Allow time.
5. Recap Ultra required with Recap 360 account.
6. Recap Photo Preview only export to RCM AND OBJ
Recap Photo Workflow

Share scans to the cloud

Sample projects

Examples

Create 3D from photos

Learn more about ReCap Pro

Warrior

Gym Centre

Marriot

Alligator

New photo project

Sustainability Checkpoint — 1

Initial Project Brief

Required.

Preparation and Brief

Concept Design

Preparation and Brief

Prepare including outline proposals for structural design, building services systems, outline specifications and preliminary cost information relevant in accordance with Programme alterations to brief and issue Final Project Brief.

Develop Project Objectives, including Quality Objectives and Project Outcomes, Sustainability Aspirations, Project Budget, other parameters or constraints and develop Initial Project Brief. Undertake Feasibility Studies and review of Site Information.

Prepare Project Roles Table and Contractual Tree and continue assembling the project team.

Undertake Feasibility Studies and review of Site Information.

2. Review Project Programme.

Pre-application discussions.

Prepare Project Roles Table and Contractual Tree and continue assembling the project team.

Review Project Programme.

Pre-application discussions.

Prepare Handover Strategy and Risk Assessments.

Prepare draft Plan of Work 2013, including Technology and Communication Strategies and consideration of Common Standards to be used.

Agree Schedule of Services, Design Responsibility Matrix and Information Exchanges and prepare Project Execution Plan including Technology and Communication Strategies and consideration of Common Standards to be used.

Sustainability Checkpoint — 1

Initial Project Brief

Required.
Recap Photo Workflow

1. Capture Photography of Site and analyse accordingly.
2. Ensure all areas of the face of the building, or area of the site are captured accordingly.
3. Ensure that you have an A360 Account.
4. Open and upload to Recap Photo.
5. Notification via Email.
Recap Photo Export

Free- only to RCM or OBJ

RCM, .OBJ, .STL, and .PLY

Requires Recap360 Subscription for RCS FBX

Concept Design

Preparation and Brief

Prepare

including outline proposals for structural design, building services systems, outline specifications and preliminary Cost Information relevant in accordance with Programme.

Alterations to brief and issue Final Project Brief.

Prepare

Project Objectives,

Quality Objectives and Project Outcomes,

Sustainability Aspirations,

Project Budget,

other parameters or constraints and develop Initial Project Brief.

Undertake Feasibility Studies and review of Site Information.

Prepare Project Roles Table and Contractual Tree and continue assembling the project team.

Review Project Programme.

Pre-application discussions.

in creating a bespoke project or practice specific RIBA Plan of Work 2013 via www.ribaplanofwork.com a specific bar is selected from a number of options.

Prepare Strategy

Operational Strategy

Review and Undertake third consultations as required and any Development

Review and update Execution Plan

Consider Strategy fabrication, and develop and Safety Strategy

Prepare Handover Strategy and Risk Assessments.

Agree Schedule of Services, Design Responsibility Matrix and Information Exchanges and process parameters including Technology and Communication Strategies and consideration of Common Standards to be used.

Sustainability Checkpoint — 1

Initial Project Brief Required.

Required.

Required.
Project Memento

1. Preparation and Brief
   - Developing Project Objectives, including Quality Objectives and Project Outcomes.
   - Sustainability Aspirations, Project Budget, other parameters or constraints and develop Initial Project Brief.
   - Undertake Feasibility Studies and review of Site Information.
   - Prepare Strategy, including Operational Strategy, and Undertake third consultations as required and any Development Review and update Execution Plan.
   - Consider Fabrication, and develop and Safety Strategy.
   - Prepare Handover Strategy and Risk Assessments.
   - Agree Schedule of Services, Design Responsibility Matrix and Information Exchanges and prepare Project Execution Plan, including Technology and Communication Strategies and consideration of Common Standards to be used.

Sustainability Checkpoint — 1

Initial Project Brief.

Required.

Recap Photo OBJ Inserted

Export
to .OBJ, .STL, .PLY, .FBX, or save as .RCM

Image Courtesy of Autodesk
Concept Design

**PROCESS**

Scan of Site
Commissioned

Scan Registered prior to handover

**TOOLS**

Recap / Recap Pro / Recap Photo

Topcon Scanmaster
Faro Scene
Etc

**WORKFLOW**

Recap - Scan Cleaning & portioning.

Surveyor

Recap Free- Recap Pro

For insertion into Revit
## Concept Design

- Prepare Concept Design, including outline proposals for structural design, building services systems, outline specifications and preliminary cost information in accordance with the Design Programme.
- Agree alterations to brief and issue Final Project Brief.

## Developed Design

- Prepare including coordinated and updated proposals for structural design, building services systems, outline specifications, Information Strategies, Design Programme.

## Planning Applications

- Review Project Programme.
- Review and update Project Execution Plan.
- Consider Construction Strategy, including offsite fabrication, and develop Health and Safety Strategy.
- Undertake third party consultations as required and conclude Development Review and update Common Sustainability Checkpoint — 2 and 3.

## Select Scans to Import

- Select Scan Files
  - Test01.rcs
  - Test02.rcs

<table>
<thead>
<tr>
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<td>ZFPJR</td>
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</table>

Planning applications are typically made using the Stage 3 output. A bespoke RIBA Plan of Work 2013 is used in this specific instance.
Developed Design, including coordinated and developed information for structural design, building services systems, outline specifications, Cost Information and Project Strategies in accordance with Design Programme.

The procurement route may influence the specific stage dates and detailed programme durations. However, specific stage dates and detailed programme durations will identify when the planning and risk assessments will occur at each stage.

Review and update Sustainability, Maintenance and Operational and Management Strategies and specifiers, as required, in accordance with the specific project requirements.

Conclude activities listed in Contract and conclude administration of Building Contract, including agreement of information required for future projects.

Carry out activities listed in Handover Strategy, including agreement of information required for future monitoring and ‘As-constructed’ performance.

Sad as RCP Project

RCP = Point Cloud Project

RCS = Point Cloud File

Scan to Recap

Scan Format Files

RCS Files (Output Folder)

Adjust Import Settings

Indexing

Manipulate for Output

Save as RCP Project

Import Raw Scan Files
Review of Conditions

Developed Design

Prepare Developed Design, including coordinated and updated proposals for structural, building services systems, outline specifications, Cost Information and Project Strategies in accordance with Design Programme.

The procurement route may change overlapping or being undertaken concurrently. A bespoke RIBA Plan of Work will clarify the specific stage dates and detailed programme durations.

Review and update Sustainability, Maintenance and Operational and Handover Strategies and Risk Assessments.

Undertake third party consultations as required and conclude Research and Development reports.

Review and update Project Construction Plan including Change Control Procedures.

Review and submit Construction and Health and Safety Strategies.

Completed

Review and update Project Execution Plan, including Change Control Procedures.

Review and update Construction and Health and Safety Strategies.

Review and update Sustainability, Maintenance and Operational and Handover Strategies.

Review and update Project Execution Plan, including Change Control Procedures.

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Review and update Sustainability, Maintenance and Operational and Handover Strategies.

Review and update Project Execution Plan, including Change Control Procedures.

Review and update Construction and Health and Safety Strategies.
Planning applications are typically made using the Plan of Work 2013. They identify the specific stages and semester dates and provide the specific procurement activities to be undertaken. The procurement routes may overlap or be undertaken concurrently. A bespoke RIBA Plan of Work 2013 will clarify the stage overlaps and provide the specific tendering and procurement activities that will occur at each stage in relation to the chosen procurement route.
Managing Scan Data

Developed Design

Prepare Developed Design, including coordinated and updated proposals for structural design, building services systems, outline specifications, Cost Information and Project Strategies in accordance with Design Programmes.

The procurement route may, where overlapping or later stages of the project are needed, lead to the procurement of services at different stages. A bespoke RIBA Plan of Work 2013 will identify the specific stage dates and detailed programme durations.

Planning applications are typically made using the Stage 3 output. A bespoke RIBA Plan of Work 2013 will identify the specific stage dates and detailed programme durations.

Review and update Sustainability, Maintenance and Operational and Handover Strategies.

Review and update Project Execution Plan, including Change Control Procedures.

Review and update Construction and Health and Safety Strategies.

Undertake third party consultations as required and conclude Research and Development enquiries.

Prepare and submit Building Regulations submission and any other third party submissions requiring consent.

Review and update Project Execution Plan.


Sustainability Checkpoint — 3

Sustainability Checkpoint — 4

Developed Design, including the coordinated architectural, structural and building services design and updated Cost Information.

Required.
Developed Design

Managing Scan Data in Revit

1. Export Individual RCS or whole Recap
2. Import to Revit via Shared Coordinates
3. Set up Site (Grids, Levels etc)

Into Revit either:

- .RCP - Recap Project File
- .RCS

Raw Formats (as Recap) Not as extensive
Developed Design
Managing Scan Data in Revit

Point Clouds in Revit Tips:

1. **Section Boxes** - View what is necessary in a particular view.
2. **Workset Assignment** (As Cloud is visible in all views unless managed properly).
3. **Select Links Off** (So that users cannot move the point cloud).
Technical Design

Re-insertion of Scan Data into Revit & Navisworks

TIPS

1. Create Duplicate Recap files for relevant stages of projects should scans be delivered.

2. Import RCS - Revit

3. Append RCS - Navis - Append Model data

NOTE: RCP File appends in all versions of Navisworks
Construction
Re-insertion of Scan Data at Critical Milestones

- Record point clouds of key components
- Underground services, core, structural elements, MEP, dry wall etc
- Compare scanned objects to design model
- Compare to project program in a quantifiable and auditable way.
- Monitor site progress & compare against programme
- Identify re-work early
- Simplify prefabrication
- Design model migrates to “As Constructed”?
- Generates true ‘as built 3D BIM’ for use by CAFM systems.
### As Built Information

<table>
<thead>
<tr>
<th>6</th>
<th>Handover and Close Out</th>
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</thead>
<tbody>
<tr>
<td><strong>Handover of building and conclusion of Building Contract.</strong></td>
<td><strong>Conclude administration of Building Contract.</strong></td>
</tr>
<tr>
<td>Carry out activities listed in Handover Strategy including Feedback for use during the lifetime of the building or on future projects.</td>
<td>&quot;As-constructed&quot; Information as required.</td>
</tr>
<tr>
<td>Update of Project Information as required.</td>
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<td><strong>Sustainability</strong></td>
</tr>
<tr>
<td><strong>Sustainability Checkpoint — 7</strong></td>
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</tr>
<tr>
<td>Updated 'As-constructed' Information.</td>
<td>Re-constructed information updated in recognition of ongoing client feedback and any other third party submissions requiring consent.</td>
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<tr>
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<td>In Use</td>
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<tr>
<td></td>
<td>Checklist In Use services in accordance with Schedule of Services.</td>
</tr>
<tr>
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<td>Conclude administration of Building Contract.</td>
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Visualising Point Clouds

1. Revit - Image save extract as image
2. Navisworks - append PC and then extract image
3. Animation in Navisworks
4. Recap 360 Visualisations
5. Civil 3D and 3D Studio Max
6. Inventor
Visualising Point Clouds
Moving Forward

Increase in native point cloud use by non-survey disciplines - High Risk

External Tools to capture existing information (Project Tango etc)

Survey (via laser scanning) to be involved though multiple stages of the BIM process

Lots more scanning/3D data capture in Industry

Increase in ‘portable’ scanning devices and technologies

Thank you for Listening.

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