EICC, Edinburgh
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Session 2.2

Landscape architecture - A new BIM and computational design workflow

Alberto Dominguez (speaker), - Heatherwick Studio

Alfonso Monedero (co-speaker) - Heatherwick Studio

Class Description

Landscape architecture plays an increasingly important role in the development of large, multidisciplinary projects, yet it often struggles to fully engage with traditional BIM and computational design processes. These traditional workflows fail to address key characteristics of the landscape design process, ultimately alienating this discipline from the mainstream of the other stakeholder's collaboration methodology. This proposal discusses the particular challenges faced by landscape architecture and proposes a new BIM and computational design workflow for the effective design development, delivery and presentation of landscape projects.

This workflow proposes a new integrated approach to the use of Rhino, Revit and Unreal for the design and delivery of landscape projects. This session will describe the particular characteristics and interoperability requirements of these 3 platforms at the different stages of a typical landscape project. The class will focus on:

- The use of Rhino in coordination with Unreal as main platforms to facilitate landscape design exploration, modelling and visualization.
- The development of corresponding, bespoke landscape components in Rhino and Unreal
- The possibilities and advantages of using Unreal for the visualization and development of landscape design
- The coordinated set up of Revit and Rhino models for the design and delivery of landscape projects
- The challenges and workarounds for coordinated design and documentation of landform in Rhino and Revit
- The advantages of using Revit for design and delivery of landscape projects
- The creation of bespoke Revit content for landscape design and their role and representation at the different stages of project development
- Examples, demonstrations and lessons learned from real landscape projects

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About the Speaker:

Chartered Landscape Architect (Landscape Institute, 2003) and Architect (*Colegio de Arquitectos del Peru*, 1999) with over 17 years of professional experience on a wide variety of projects, ranging from detailed design of small public urban spaces and large multidisciplinary urban regeneration projects to rural landscape master planning and landscape character assessment studies.
Proficient in BIM (Revit) with experience in running the landscape design package of large projects from design inception to construction. Experienced working in multidisciplinary environments and convinced of the fundamental need for integration and dialogue between architecture and landscape. As an architect and landscape architect I am particularly interested in the sustainable integration of the natural, social and built environments.
Prior to joining Heatherwick Studio in 2016, I worked for HOK London (11 years) and Townshend Landscape Architects (4 years)
Education and Qualifications:
- University of Sheffield: Master in Landscape Design
- Landscape Institute, UK: Chartered Member of the Landscape Institute
- Ricardo Palma University, Lima, Peru: Architect
- LEED AP
- BREEAM Associate

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Alfonso is an architect leading BIM implementation in Heatherwick Studio. He has vast international experience in Spain, India, Chile and UK. Having worked as project architect and Head of Design in a leading practice in Chile, he decided to move to a more technical role after observing how technology skills, or the lack of them, influence and limit design creativity, and affect project outcome.
Alfonso started collaborating with Heatherwick studio in 2015 as BIM consultant, after successfully implement BIM in several projects, he moved to Woods Bagot to work as Design Technology Manager for the London office. In 2018 he came back to Heatherwick to continue the BIM implementation, a design driven studio.
His goal is to embed BIM in the design phase without limiting or hindering the design process.

1. Introduction

Heatherwick Studio is a team of 250 problem solvers dedicated to making the physical world around us better for everyone. Based out of our combined workshop and design studio in Central London, we create buildings, spaces, master-plans, objects and infrastructure. Focusing on large scale projects in cities all over the world, we prioritise those with the greatest positive social impact. Working as practical inventors with no signature style, our motivation is to design soulful and interesting places which embrace and celebrate the complexities of the real world. The approach driving everything is to lead from human experience rather than any fixed design dogma. The studio's founder Thomas Heatherwick comes from a background immersed in materials and making. His curiosity and passion for problem-solving matured into the studio's current design process where every architect, designer, landscape architect and maker is encouraged to challenge and contribute ideas. Positive and pragmatic, the studio's team are collaborators whose role is to listen, question, then lead the conception and construction of special and unusual places. Ingenuity and inspiration are used to make projects that are affordable and buildable. And our client is vital, who comes on the journey and challenges our thinking; together we look for the opportunities that might traditionally be overlooked. Our best future projects are the ones that will teach us the most.

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Landscape is an integral part of our design vision. ...and is present in most of our projects: From large scale, mixed-use, urban developments... Medium size buildings and public spaces... To small buildings and pavilions... As well as objects in the landscape!

Heatherwick Studio Projects

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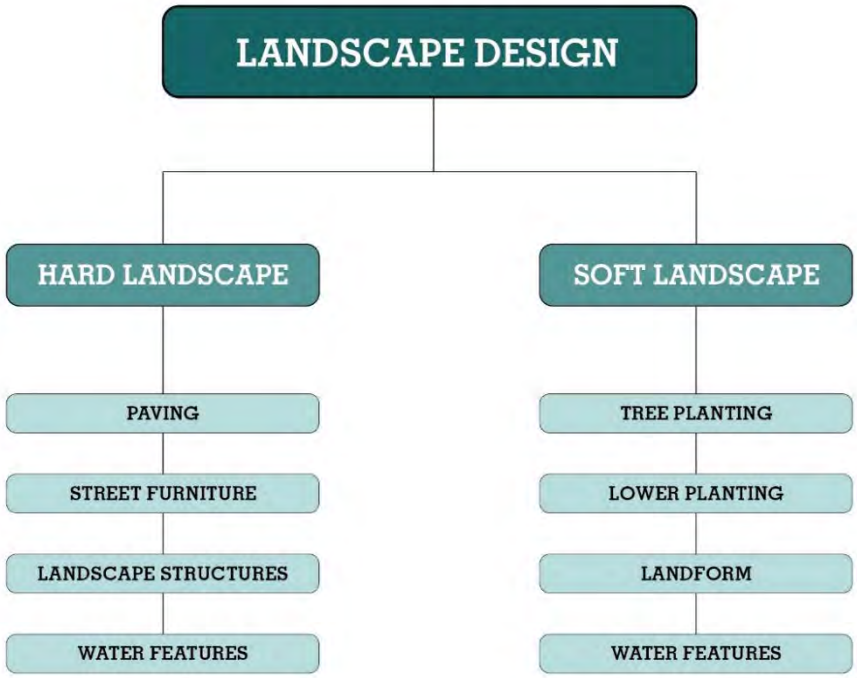
2. Landscape Design Scope

Landscape architecture plays an increasingly important role in the development of large, multidisciplinary projects, yet it often struggles to fully engage with 'traditional' BIM and computational design processes.
At the same time there is generally limited understanding of the real scope of Landscape Design as a discipline, even among construction industry professionals, often assuming it is focused only on planting (soft-scape).
The first part of this presentation will provide an overview of the typical scope of Landscape Design as a package or discipline in a construction project.

Typical Landscape Design Delivery Scope



Landscape Design Scope

The typical landscape design delivery scope is organised in 2 main packages: Hard-Landscape and Soft-Landscape.
Hard-Landscape consists predominantly of all material finishes to paved areas as well as structures such as retaining walls, steps and ramps; street furniture and furnishing such as gratings, railings and fences. Water features in the form of jet or block fountains, decorative pools or other types integrated to the hardscape/urban environment.

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Soft-Landscape includes the design of landform (slopes, mounds, pads/terraces, etc.) land drainage features such as swales as well as naturalistic water features such as ponds, lakes and streams. Planting is the key part of the Soft-Landscape package and is usually divided in tree and lower planting groups. Trees categorised by types/shape: deciduous or evergreen, globular, columnar, multi-stem, etc. Lower planting categorised according to types: shrubs, herbaceous, grasses, groundcover, aquatic, etc.

Landscape Delivery – Data Organisation

00. General

- Drawing list, graphic standards, general notes, etc.

01. Composite Plans

- Masterplan scale drawings (typically 1/10,000 to 1/500 – depending on site size) showing site and context, landscape scope, system plans as required

02. Hardscape Plans

- Layout of pavements identifying surface materials/finishes, patterns; water features - drawing tiles covering the whole site, typically 1-300 to 1-100 – depending on site size

03. Grading and Drainage Plans

- Contours, location of drainage features, spot heights, gradients/slopes on hard and soft surfaces – drawing tiles covering the whole site, typically 1-300 to 1-100 – depending on site size

04. Furniture and Furnishings Plans

- Landscape structures (pergolas, gazebos, shelters, etc.), street furniture (benches, bollards, poles, etc.) and furnishings (handrails, fences, gates, etc.)

05A. Tree Planting Plans

- Location and types of tree planting types/ species – drawing tiles covering the whole site, typically 1-100 to 1-300 depending on site size

05B. Lower Planting Plans

- Extent and location/ layout of lower planting, planting types/species– drawing tiles covering the whole site, typically 1-100 to 1-300 depending on site size

05. Enlarged Zones

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- Detail layouts of key areas of the site - typically 1-100 to 1-50 – depending on site size. Usually including detail section and 3D view

06. Landscape Sections

- Site-wide and enlarged – masterplan scale as well as larger scale to match tile drawings scale

07. Landscape Details

- Hard-scape and soft-scape details – typically 1/25 to 1/5 – including interfaces between hard and soft areas, building interface, street furniture, landscape structures, water features, tree planting, etc.

08. Design Studies

- Sketch layouts, 3D views, etc. illustrating design options and alternative layouts considered for discussion that need to be recorded as part of the design process in the drawing set

10. Landscape Schedules

- Tree Planting
- Lower Planting
- Hardscape/ Paving
- Street Furniture/ Furnishings
- Water Features

11. Landscape Specifications

- Outline or detailed according to stage. Description of requirements for landscape construction, materials, workmanship and maintenance

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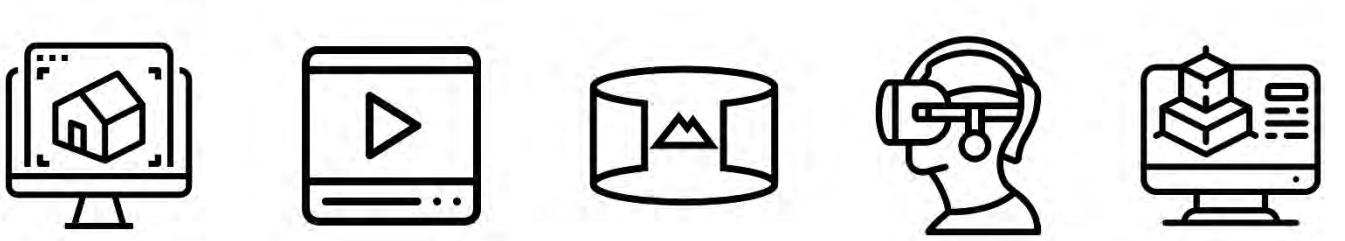
Landscape Visualisations

Landscape visualisations are usually difficult to handle in typical design and delivery workflows, particularly when it comes to the accurate representation of plant material and their correspondence with the information included design models.

The desired output for landscape visualisations include the below:



Rendered Views ***Videos*** ***360 Views*** ***Virtual Reality*** ***Interactive Model***

The below diagram/ chart compares 3 options/methods for the production of landscape visualisation outputs and assesses them according to overall quality, time required for production, scope for customisation, range of output potential, real time processing possibilities and fidelity to design.

a. 3D model geometry (Rhino) + Photoshop rendering

The standard, or most widely used process, involves 3D model geometry combined with Photoshop rendering. This method requires an advanced level of skill to produce realistic, good quality (Photoshop) material, it is very time consuming, and although has the potential for good level of planting assets' customisation, this is limited to a single output, namely the one view that is produced at any given time. It is also very difficult to achieve a good and realistic level of correspondence with the planting material as specified.

b. 3D model geometry (Rhino) + V-Ray rendering

An alternative method looks at combining 3D model geometry with V-Ray rendering. This method offers a very good level of output quality and (in theory) endless possibilities for customisation (in V-Ray). It also has potential to achieve very good fidelity to the

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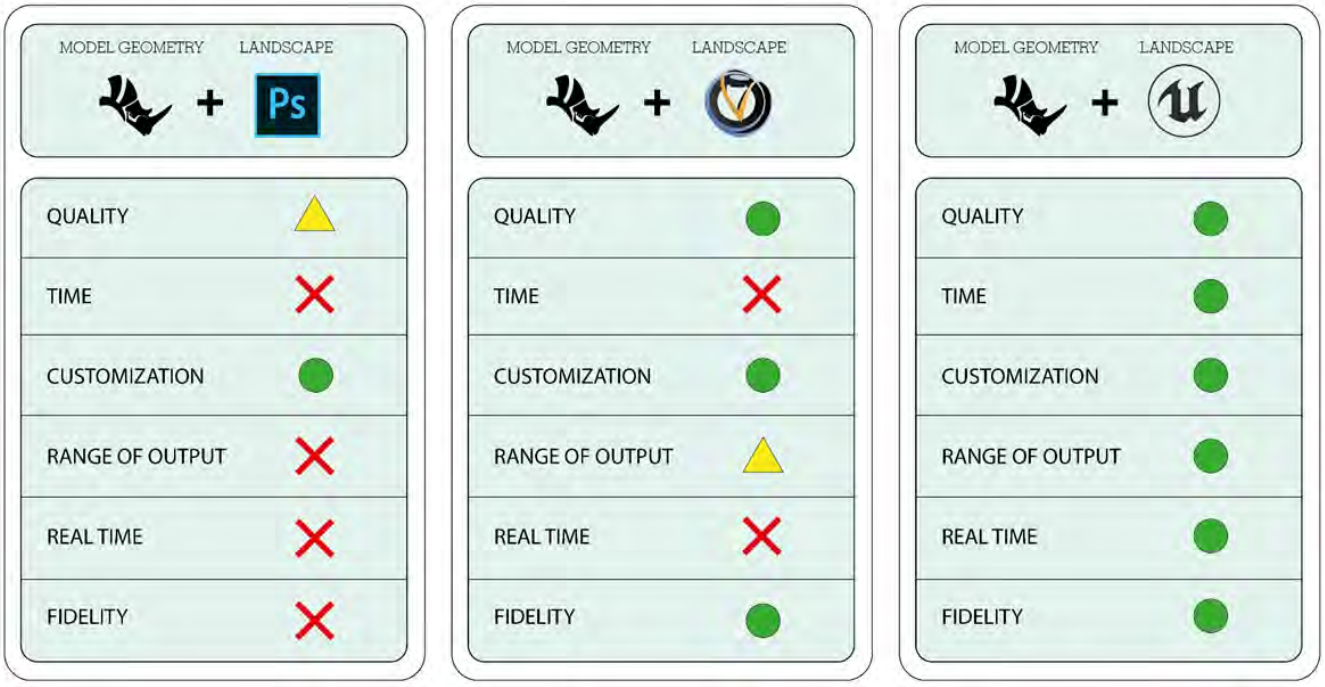
design layout as included in the 3D model. The negative aspects are the considerable amount of time (and skill) required for production and the lack of option for Real Time editing of models. And, although it offers better range of output than the first method, it still does not allow for interactive model reviews.

c. 3D model geometry (Rhino) + Unreal Engine

The advantages of the proposed workflow are indicated in the third column of the diagrams below. This method involves a combination of 3D model geometry (Rhino) and the use of Unreal Engine to generate the full range of landscape visualisation output. The main advantages of this method, apart from the quality and range of output, are the possibility for Real Time editing and interactive model reviews with design teams and/or clients. In addition to the above Unreal Engine offers endless possibilities for (planting) assets editing to match desired specification, design intent, seasonal characteristics, etc. The Unreal landscape model is developed in direct correspondence with the 3D geometry model (Rhino), replicating blocks with corresponding custom-created assets. Once the information is in Unreal it offers the possibility to extract endless number of visualisation outputs in a quick and straightforward fashion. Further detail of this proposed workflow is provided in the following chapters of this session.



Landscape visualisation methods comparison

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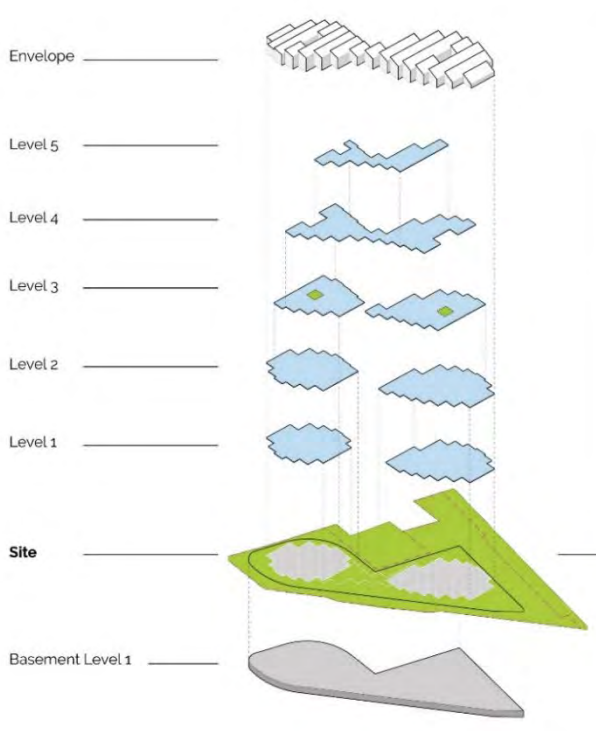
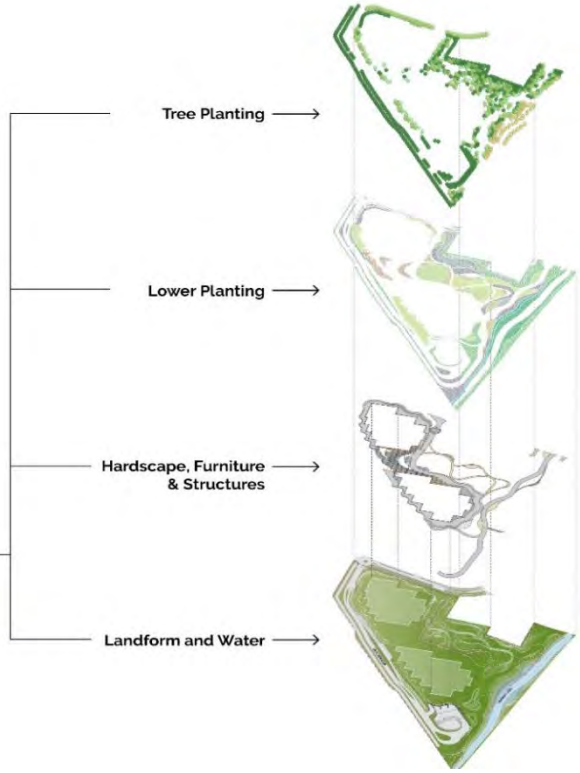
Project Case Study: HS' Google Landings Campus, California, USA



Project Layers



Landscape Layers

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The scope of the landscape design package for the Google Landings Campus can be summarised in 4 successive layers of information. These are:

a. **Landform and Water**
b. **Hardscape, Furniture and Furnishings**
c. **Lower Planting**
d. **Tree Planting**

HS' Google Landings 3D (Rhino) Geometry Model

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a. Landform and Water

Design Scope:

- Development of landform design layout
- Identify valleys, plateaus, low and high points
- Definition of accessible spaces
- Definition of paths' layout with accessible gradients (1:20)
- Definition of building pads and terraces
- Definition of slopes
- Identify need for slopes' soil stabilisation or reinforcement (geo-grids/mesh, etc.)
- Land drainage – network of bio-swales
- Expand flood plain for Creek
- Review flood levels/ water level
- Calculate cut and fill
- Calculate soil volume

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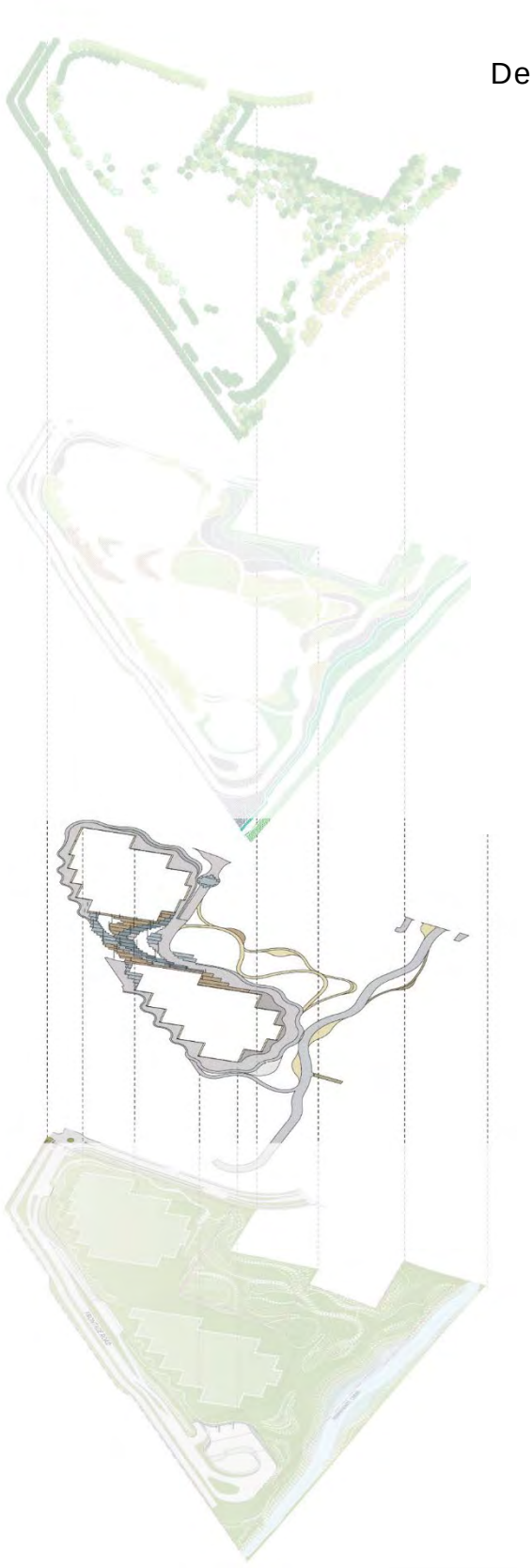
b. Hardscape, Furniture and Furnishings



Design Scope:

- Development of layout and types of routes and outdoor spaces
- Paved areas materials selection/ palette
- Paving pattern design
- Hardscape edging / transitions
- Work out levels and drainage strategy
- Workout interface with building structures
- Street furniture types and location
- Benches/tables, planters, lighting columns, bollards, wayfinding elements, cycle racks
- Layout of ramps and steps/ terraces
- Furnishings such as railings, balustrades or gratings
- Landscape structures such as retaining walls, gabions as well gazebos, shade structures, trellises, pavilions, etc.

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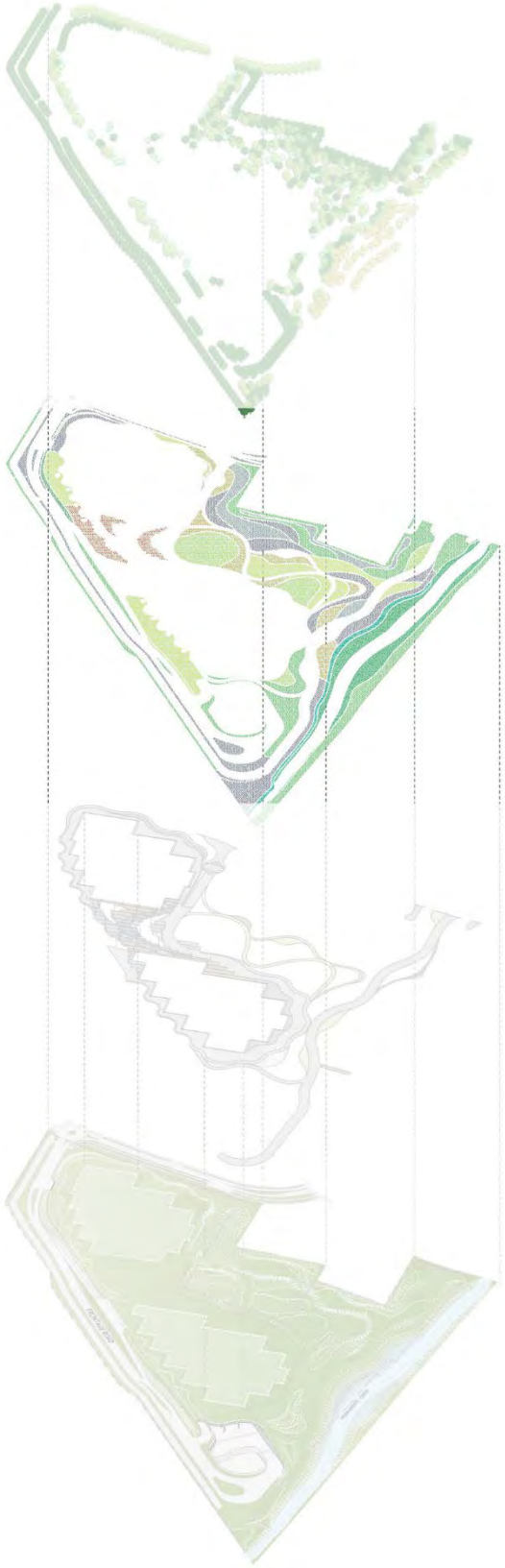
c. Lower Planting



Design Scope:

- Definition of character, layout and types of lower planting areas
- Identification of lower planting types
- Develop palette identifying and categorising shrubs, herbaceous, grasses, ground-covers, climbers, aquatic, etc.
- Develop planting mixes
- Determine plants per area and/or spacing
- Planting procurement strategy - sizes
- Irrigation strategy

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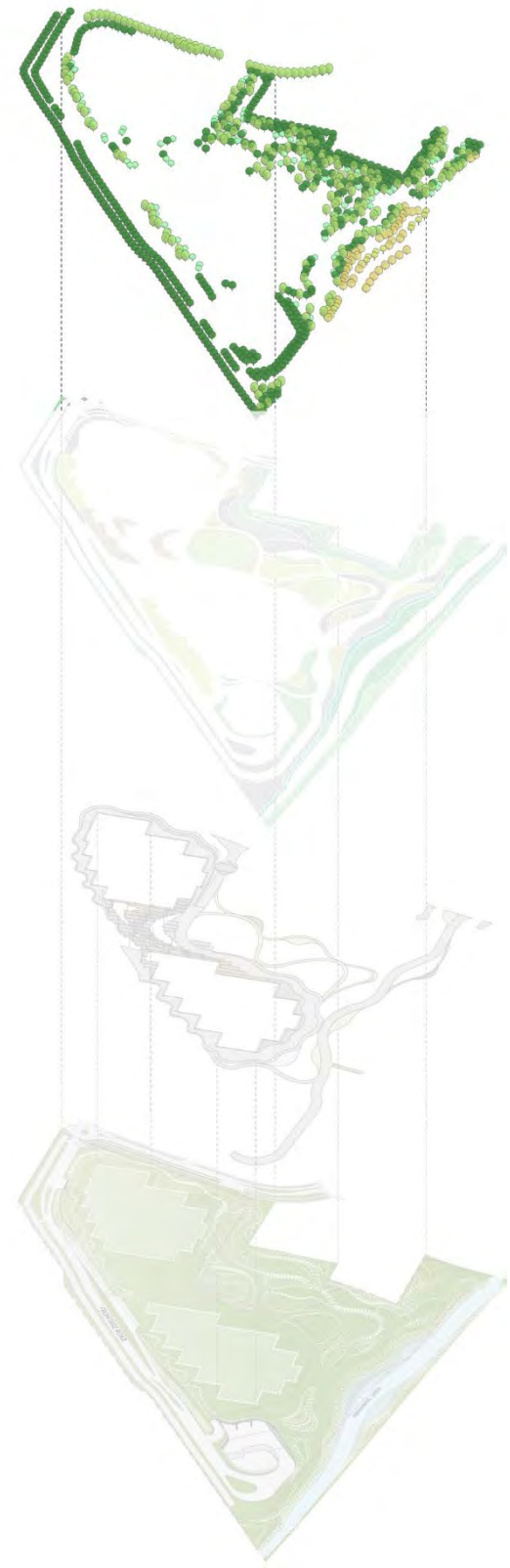
d. Tree Planting



Design Scope:

- Definition of character, layout and types of tree planting areas
- Identification of tree planting types
- Develop palette identifying and categorising by size, shape, habit, foliage type, flowering period, etc.
- Determine spacing and numbers
- Planting procurement strategy - sizes
- Irrigation strategy outline

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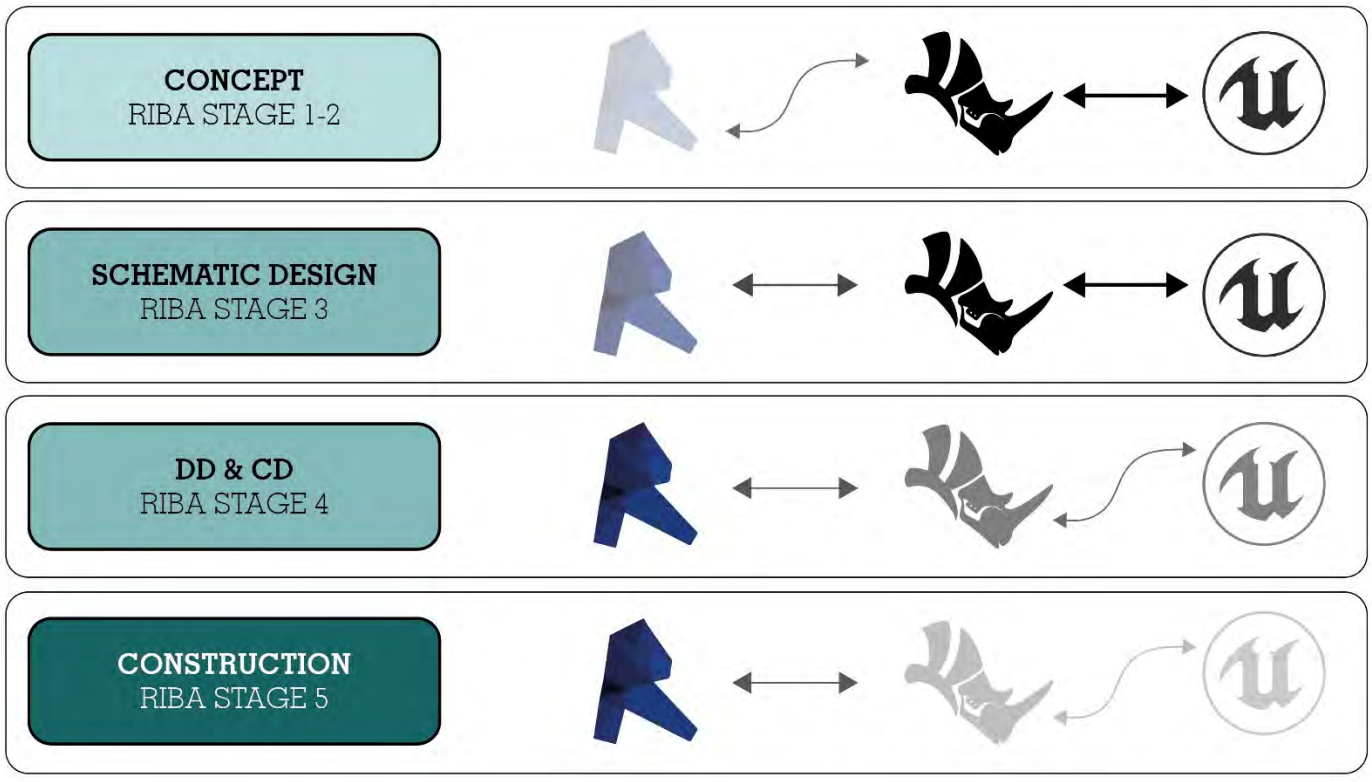
3. Landscape Design Interoperability Workflow

The workflow described in this document proposes an integrated and coordinated approach to the use of Rhino, Revit and Unreal for the design and delivery of landscape projects. The below chapters describe in more detail the particular characteristics and interoperability requirements of these 3 software packages at the different stages of a typical landscape project. In summary, Rhino is proposed as the main design development tool in coordination with Unreal, particularly during the early stages of design exploration and development. Revit is the main platform for design coordination and delivery. The 3 resulting models are expected to work together and kept fully coordinated as the project progresses. The diagram below outlines the inter-operability expected at different stages of work.



HS' Landscape Design and Delivery Workflow Summary – 'The Right Tool for the Job'

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Rhino to Revit landscape workflow

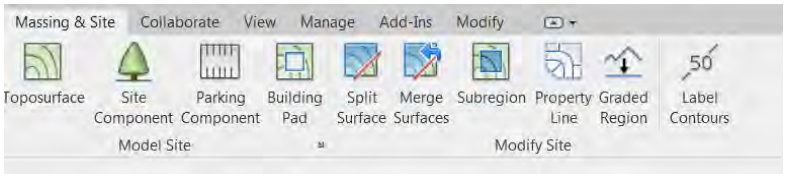
Landscape Revit Content

This proposal argues for the development of bespoke Landscape Revit components that match the specific needs and design/ delivery requirements of each practice. Although there are plenty of ready-made Revit 'out-of-the-box' (OTB) libraries/ Plug-ins/ components that can be purchased, these often include information that is not always relevant in the average landscape project, and/or have particular display characteristics that ultimately make the files heavy or difficult to edit/ manage (as well as creating dependencies with third-party suppliers at an additional cost).
The below discuss the general requirements and characteristics of landscape Revit components for a typical landscape project that can be achieved with the standard set of Revit tools

Landform/ Topography

Description:

- Use native 'Toposurfaces' to enable use of Revit topography documentation and Site tools
- Automated contour annotations
- Display of slope gradients
- Creation of sub-regions
- Calculation of cut/fill volumes
- Etc.



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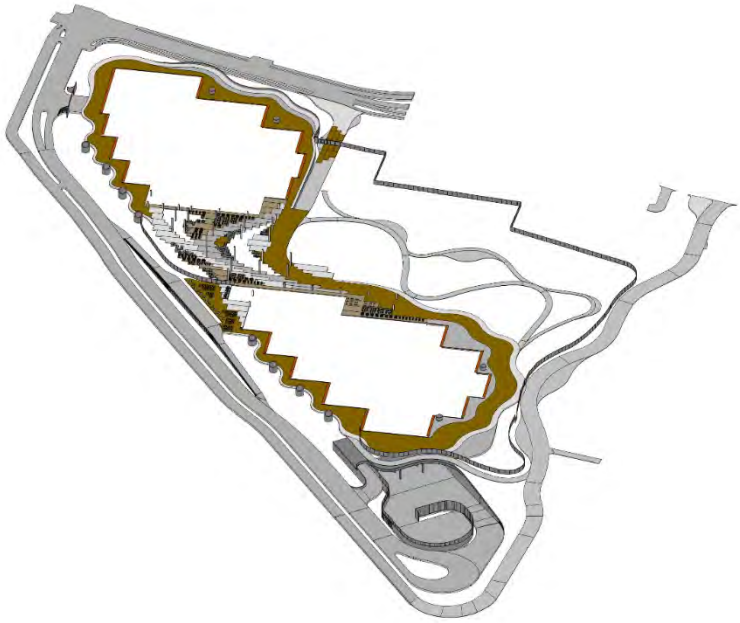
Hardscape

Description:

- Paving is created as standard Revit floors or Roof-by-Face+Type, depending on the complexity of their geometry.
- These are named and organised according to types of materials.
- Each floor contains the necessary parameters for scheduling as shown below.
- 'Type Comments' and 'Type Mark' used for schedule filtering and tagging respectively



Materials and Finishes	
Structural Material	PAV_01_900X300
Paving Size	895 X 295 X 50mm
Paving Pattern	Half lap bond
Paving Material	Giallo Avorio sandstone OR A215 granite
Paving Bedding	30mm mortar laying course
Paving Colour/Finish	Honed OR flamed and brushed (A215)

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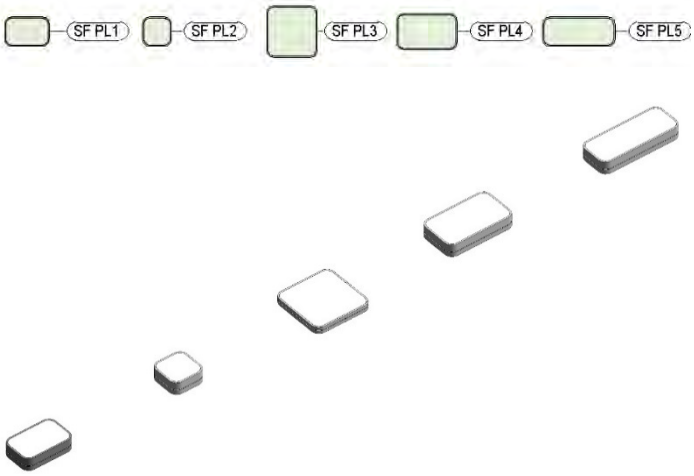
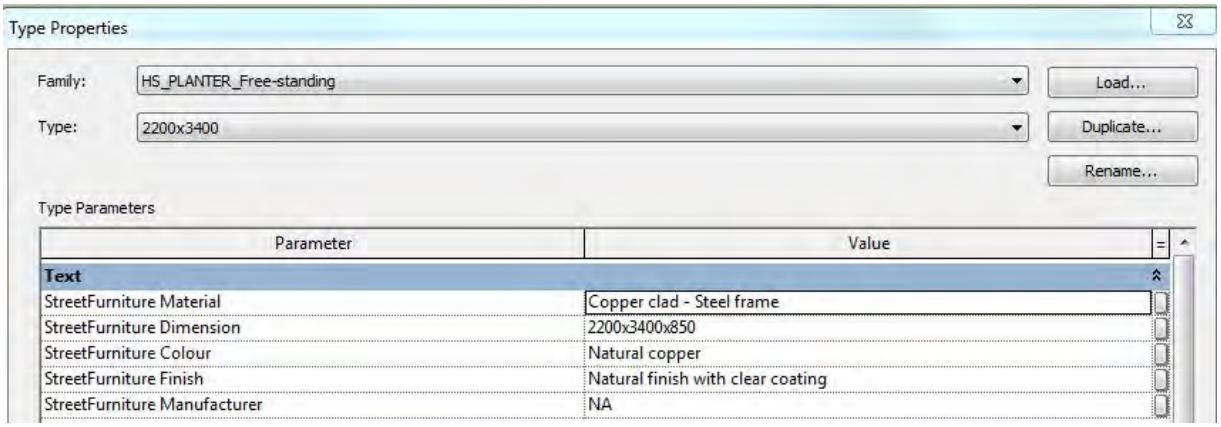
Furniture

Description:

- Furniture is created as Revit Families with Type parameters
- 'Type Comments' and 'Type Mark' used for schedule filtering and tagging respectively
- Standard parameters included for scheduling are shown below





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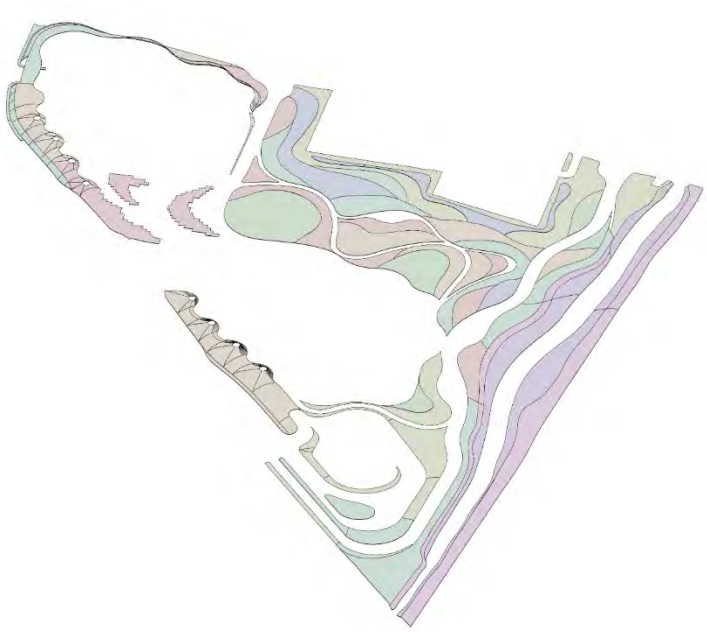
Lower Planting

Description:

- Lower planting is created as Roof-by-Face+Type and 'draped' onto Toposurfaces
- Organised according to type/species height
- Differentiated by colour and surface pattern
- Each 'Roof' to include the necessary parameters and formulas for plant numbers calculation, scheduling and tagging.
- Planting 'Roofs' are modelled to height according to planting type
- 2D detail elevation components matching each lower planting type can be used in sections where a more detailed representation of planting is required.
- Each planting Roof is matched also by a planting mix in Unreal for a range of visualisation options



Text	
Plant LatinName	Russelia equisetiformis
Plant Native	N
Plant MatureSpread	
Plant Pattern	Triangular matrix
Plant CommonName	Firecracker Plant / Coral Plant
Plant Size	5L pot, 60cm height
Plant Note	Red flower
Plant Deciduous/Evergreen	E
Plant MatureHeight	1-1.5
Plant Palette	N
PlantsPerSqm	1.400000
Plant Spacing	900mm

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Tree Planting

- Typical Off-The-Shelf Revit tree families are normally loaded with considerable amount of specialised information that would not normally be required by a standard landscape workflow.
- The proposed approach to user-defined Revit planting families focuses only on the overall physical characteristics required from each tree type and include only the necessary parameters corresponding to a typical tree planting schedule.
- These are organised according to typical tree shapes and with options of family types in different sizes.
- Tree Revit families would then be matched/replaced by detailed and bespoke equivalents in Unreal.
- 2D elevation detail components can be used for display on technical drawing sections where a more detailed representation of planting is required.

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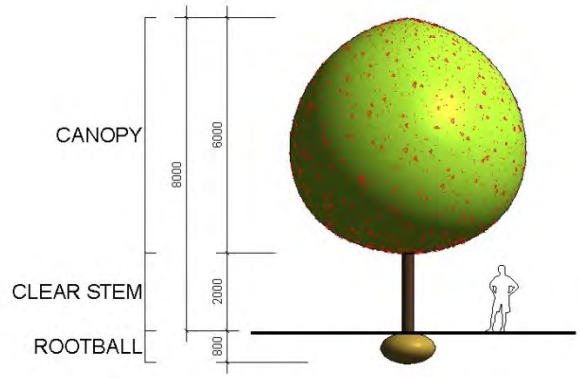
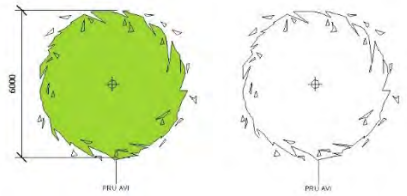
General Characteristics

Each tree family is structured in 3 key, basic parts: canopy, stem/trunk and rootball. These can vary in size according to family types.



Dimensions	
ClearStem	2000.0
Diameter	6000.0
Height	8000.0
Canopy radius	3000.0
Rootball W radius	700.0
Rootball H radius	400.0
Trunk	150.0

Text	
Plant LatinName	PRUNUS AVIUM
Plant Native	Yes
Plant Clear/Stem	2
Plant MatureSpread	10-15
Plant Pattern	
Plant CommonName	Wild Cherry
Plant Size	4m height, 1m clear stem, 3m leaf mass height, container grown
Plant Note	
Plant Deciduous/Evergreen	Deciduous
Plant MatureHeight	15-20
Plant Palette	



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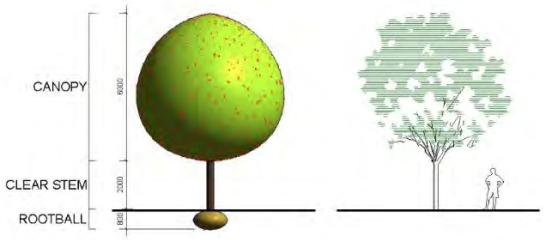
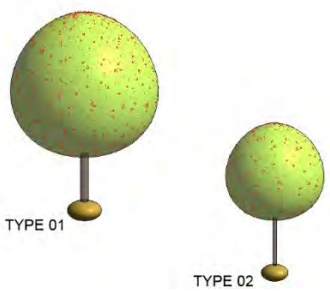


SECTION: REVIT FAMILY SECTION: 2D DETAIL ITEM

TYPE 02 TYPE 02

DETAIL LEVEL: **COARSE** DETAIL LEVEL: **FINE**



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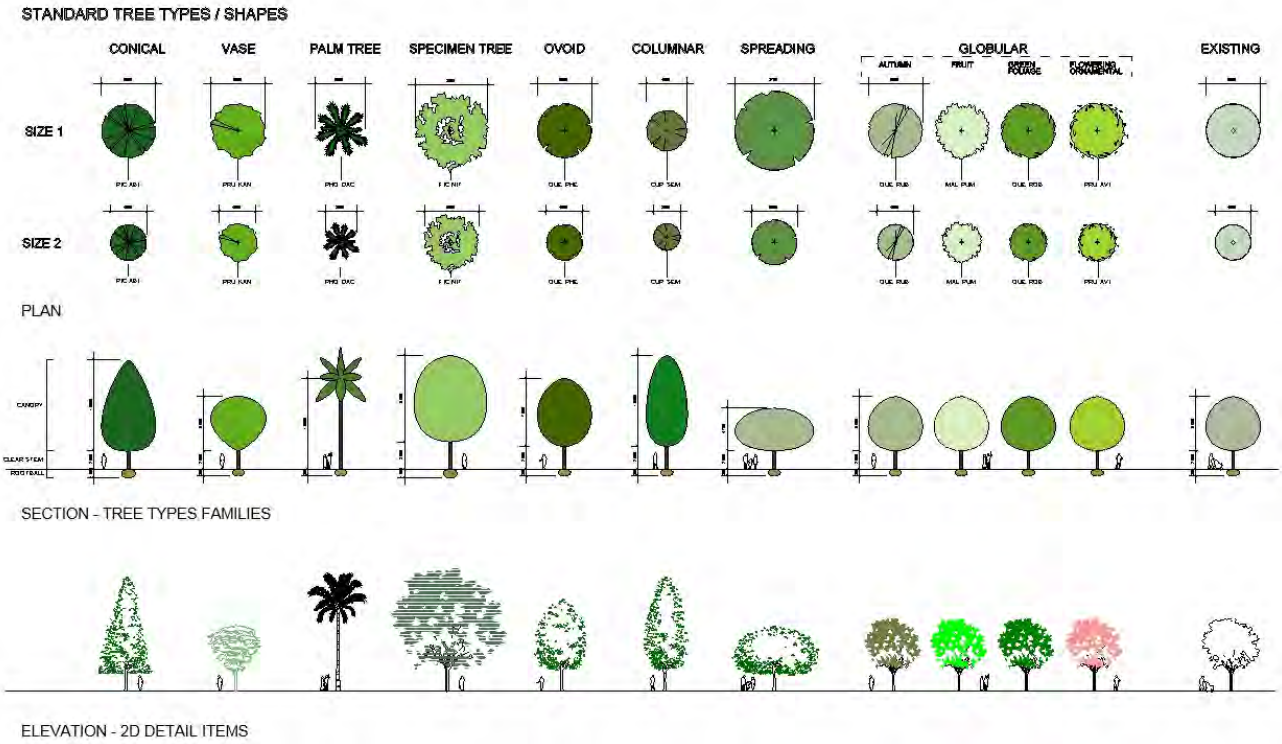

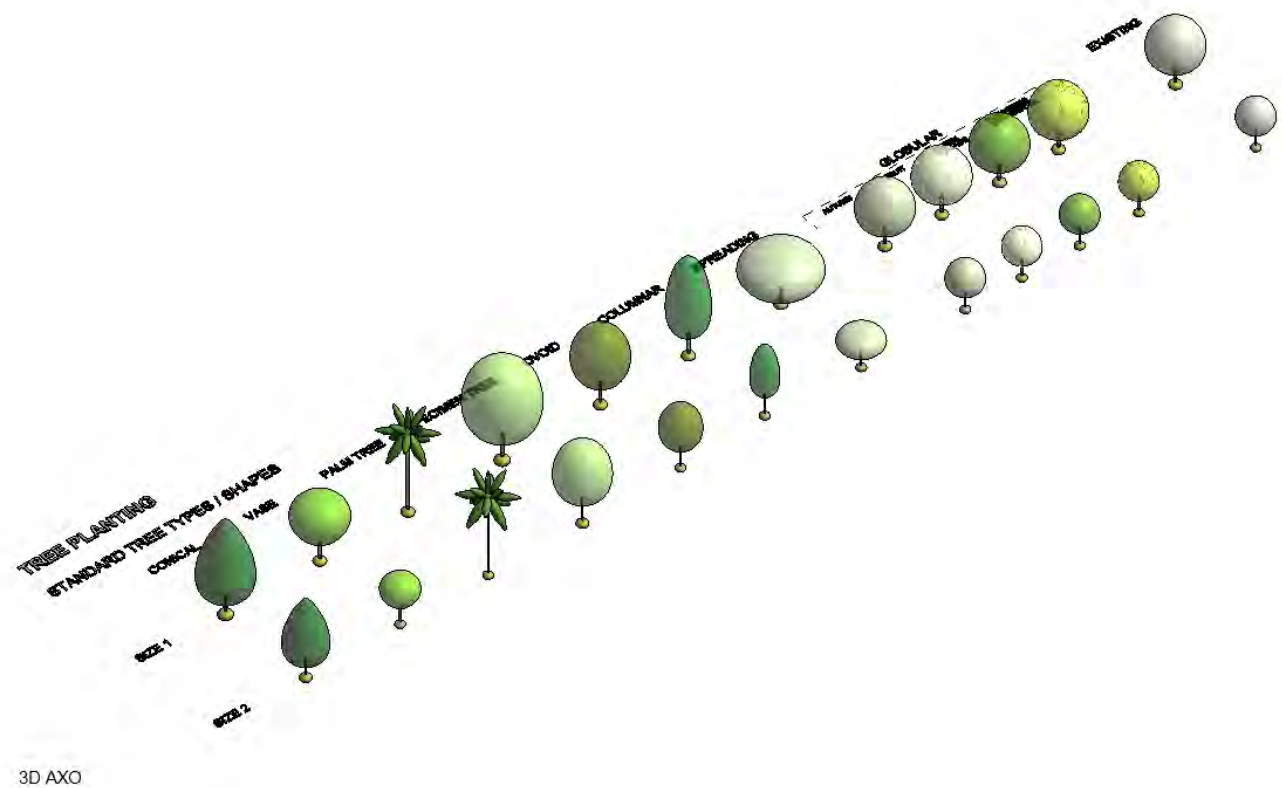

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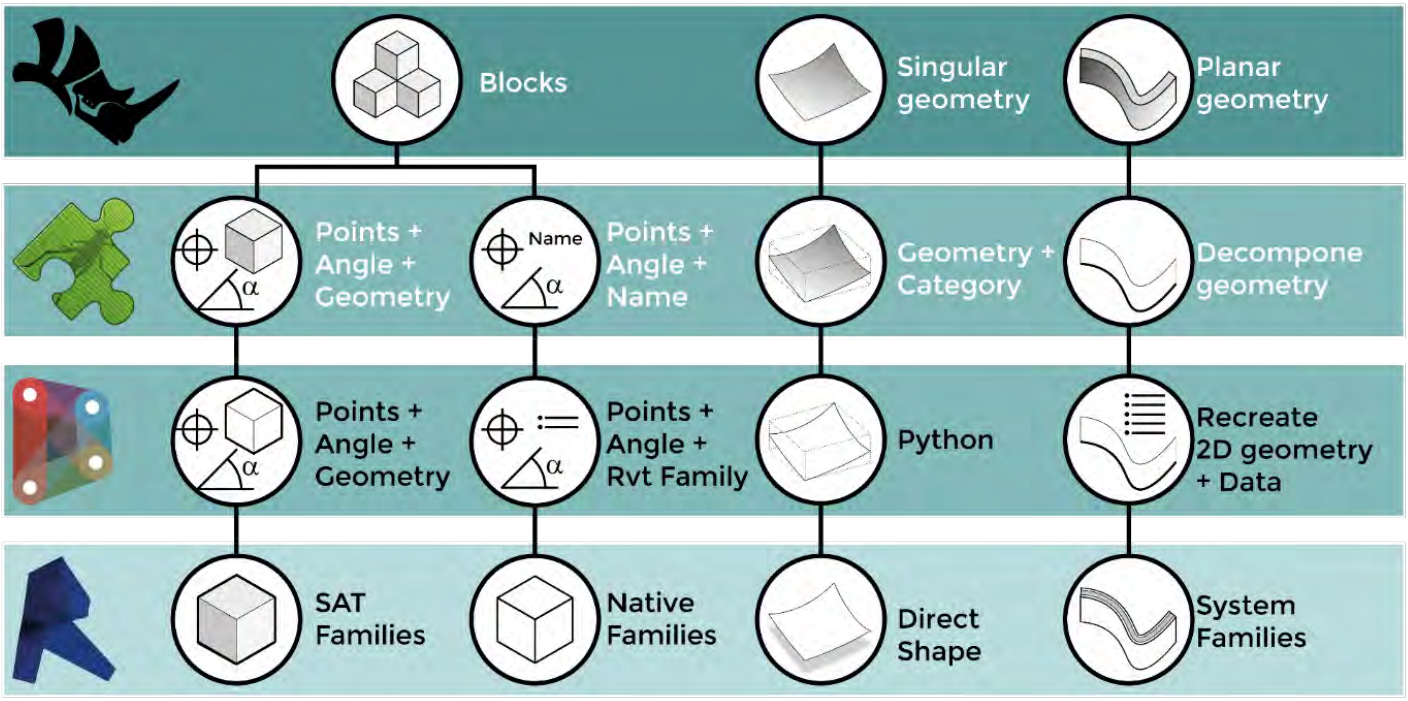
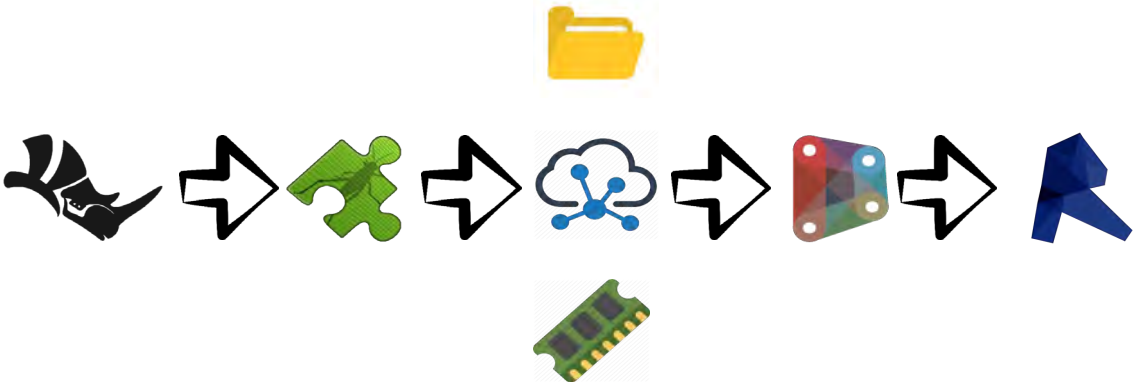
Rhino to Revit Interoperability strategy

Define your interoperability strategy depending on what you require in the BIM model, not every time the amount of data required in the model is the same.
If you need only geometry you can promote a direct translation, if you require more meta-data and be able to modify in the documentation platform, push for recreation of elements.



Example of interoperability strategy focusing in optimizing output in Revit

Sending information between Rhino and Revit is a complex task, there are different ways of doing this.



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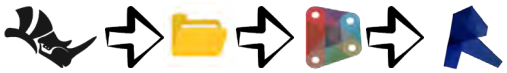
File

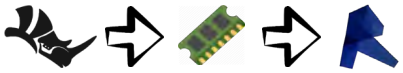
The data/geometry is saved into a file and reopened in the target program.
The data can be saved as 3DM, SAT, DWG, CSV, XLMS, GEO...
There is no link between platforms

- Rhynamo 
- MantisShrimp 
- Revit import 

Network

- Speckle 
- Flux (deprecated)

Memory

- Conveyor 
- Rhino.inside 

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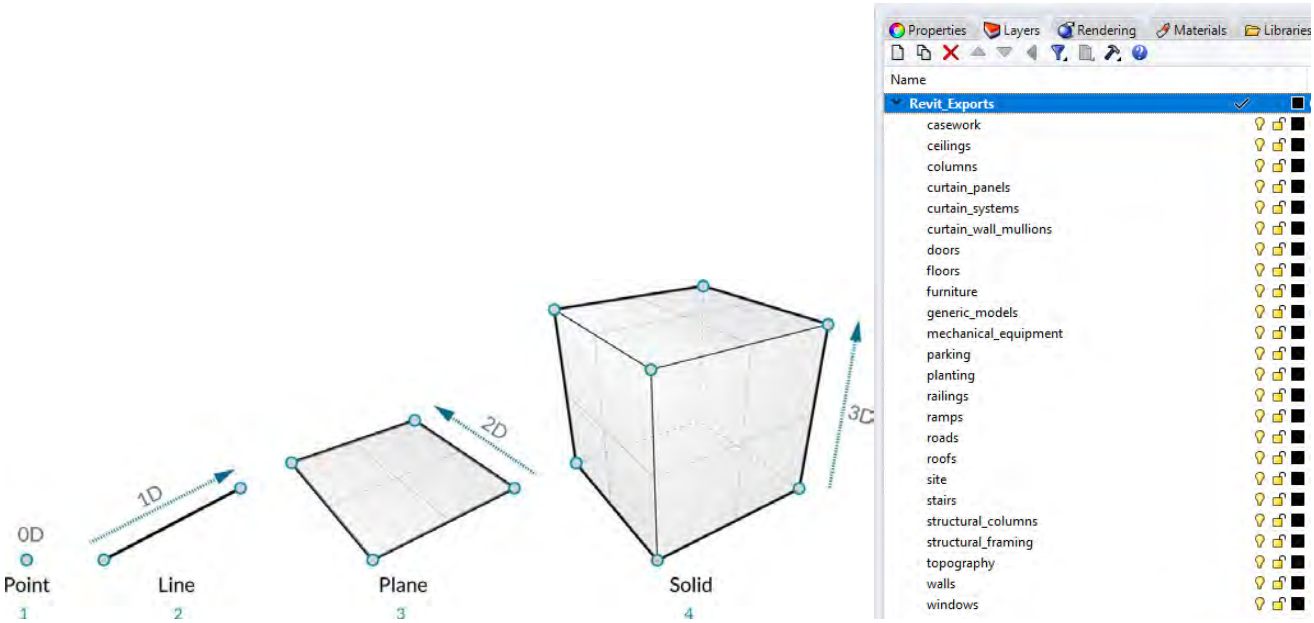
Modelling standards

Adapt your modelling standards to achieve a smooth transition, the more clear and better data you have at source, the easier it will be to achieve great outcomes. What you obtain at target can only be as good as what you have at source.
Some things to keep in mind while defining your modelling standards:

- **Layer structure and naming**

Keeping a layer for each object dimension will help sending simpler data between platforms. Adjust the layer structure to satisfy your interoperability strategy.



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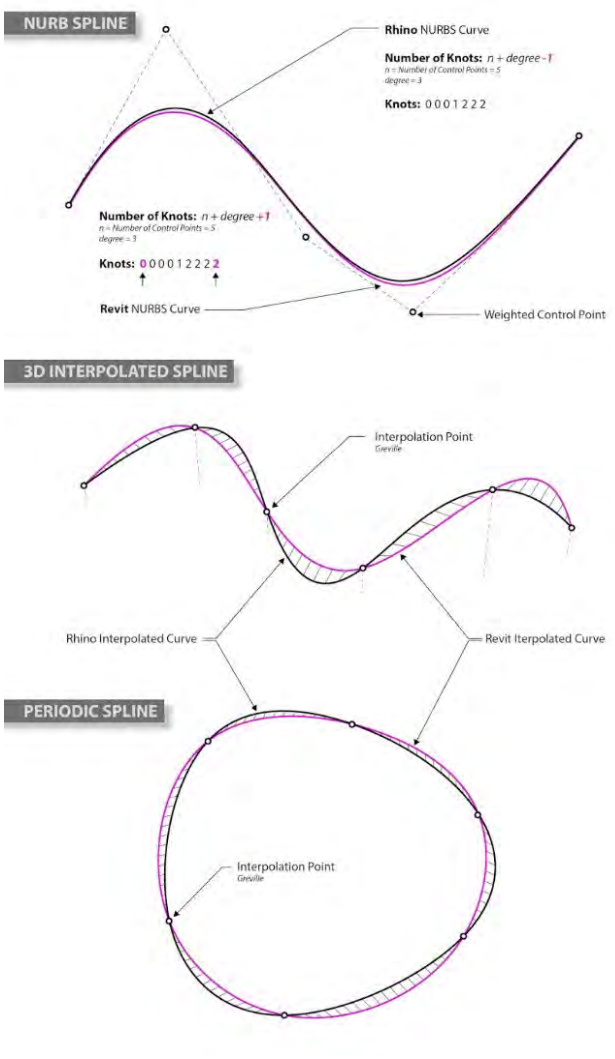
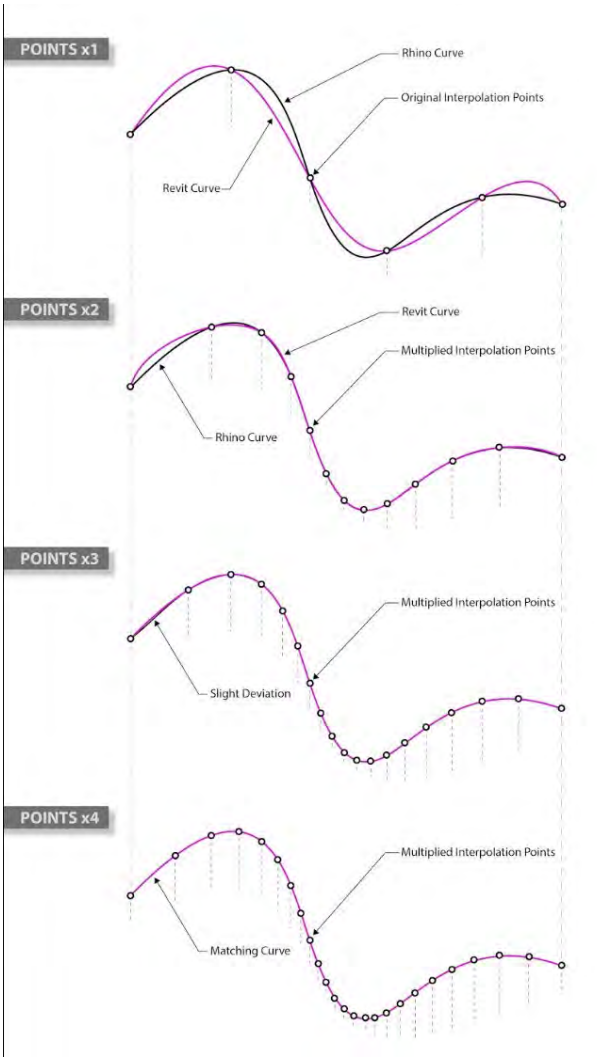
- **Lines and curves**

NURBS and Splines are not the same, be aware of deviation when recreating, increase amount of generating points to improve accuracy, but be careful! It will increase the size and complexity of your models.





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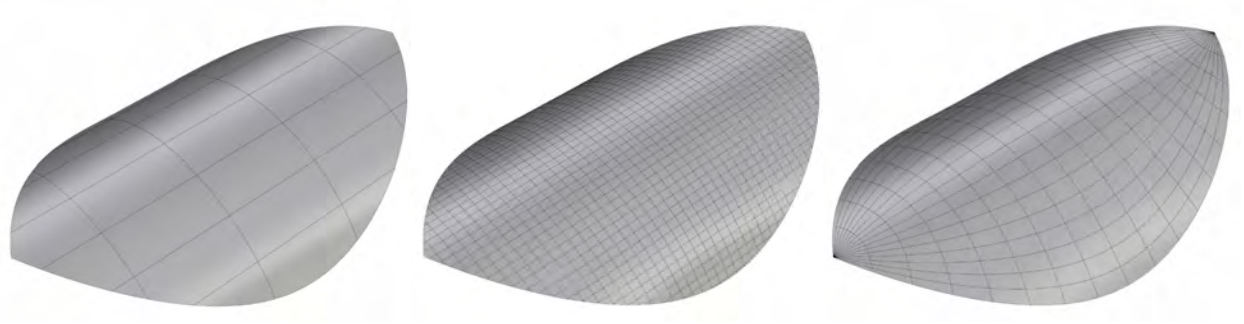
- **NURBS surfaces**

Avoid singularities that are allowed in Rhino but not in Revit. Reduce the amount of Points and degree of a surface to what is really needed. A single curved surface should have degree 1 in one direction.

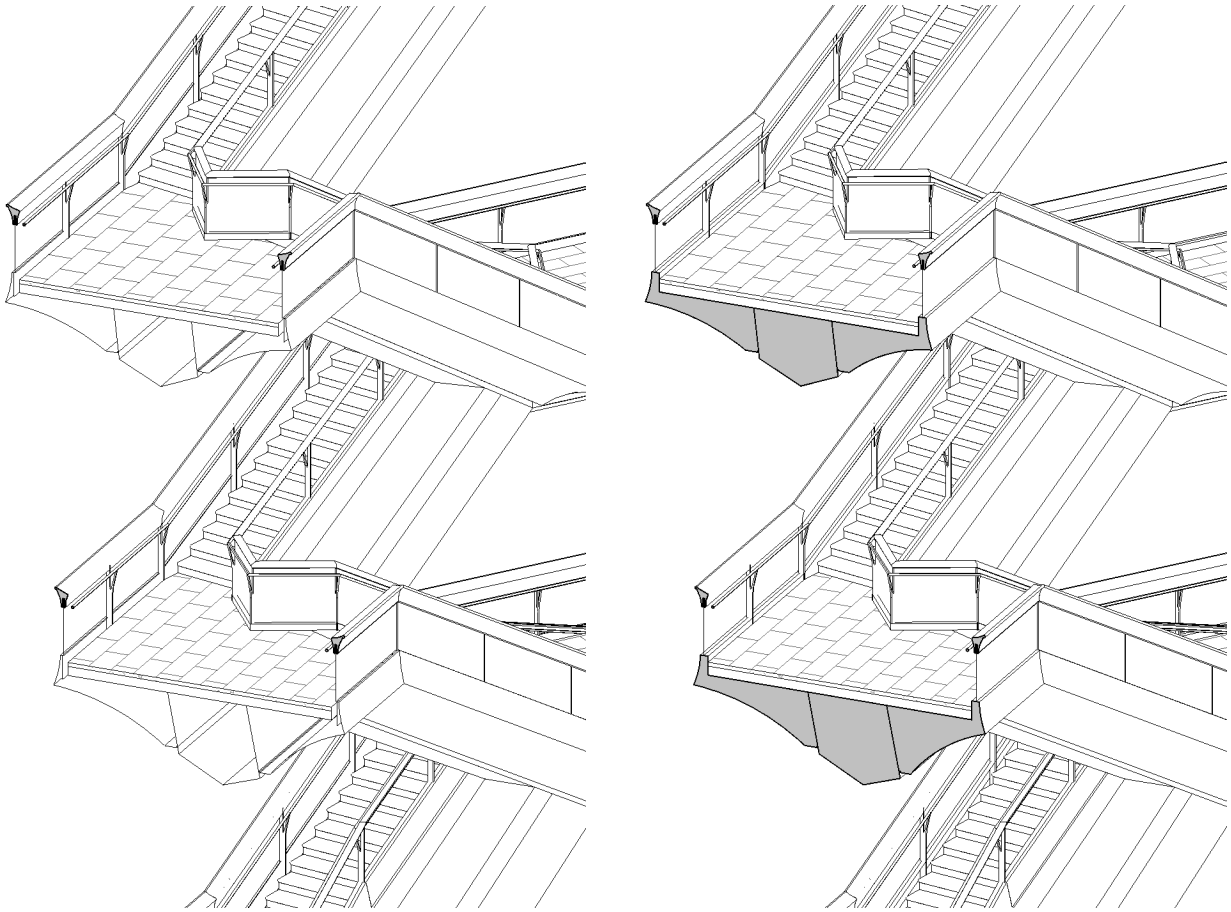


Correct ✓ Too dense ? Singularities ✗

- **Open vs Closed polysurfaces**

Open polysurfaces will be hollow and will require 2D work on top to make it look right.

Closed polysurfaces will become solids once in Revit.



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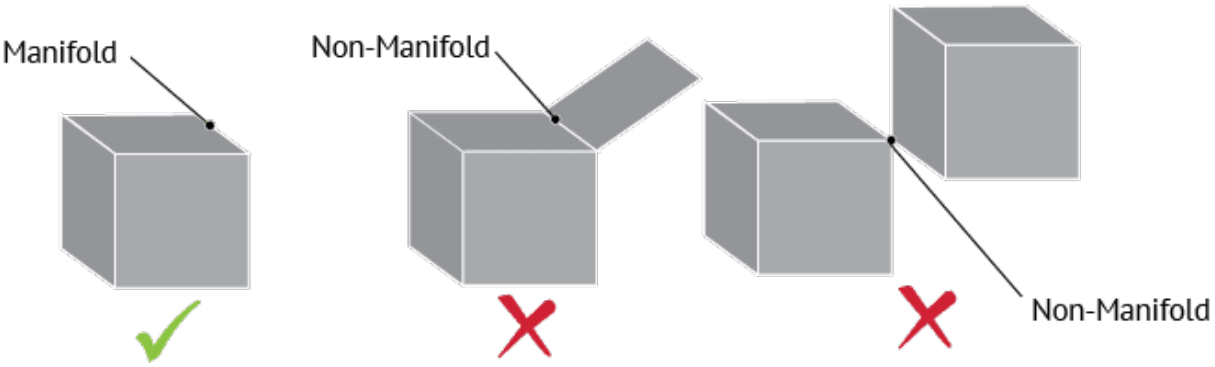
- **Object validity**

Make sure all your geometry is valid and you don't have non-Manifold geometry that cannot be converted to Euclidian space. This won't be converted and produce an error when translating.



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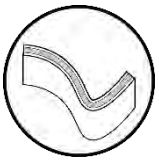
Interoperability workflow

i. Landform

Topography

Surfaces

Points + Outlines



Toposurfaces

Rhino:
Select all surfaces

Grasshopper:
Extract surface + contour lines points.
Extract outlines

Rhino.inside:
Feed list of points to Toposurface
+ Boundary Lines as Model Lines

Revit:
Manually split surfaces with Model lines

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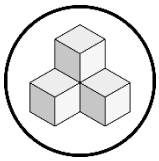
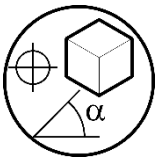
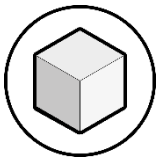
ii. Hadscape

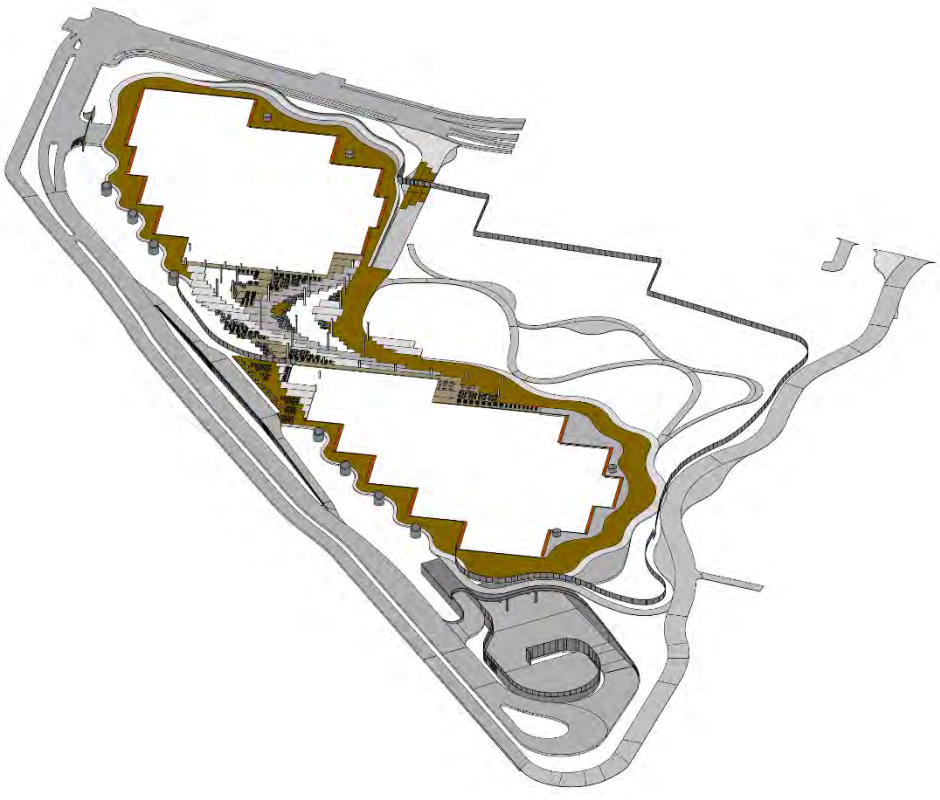
Paving / Structures		
		
Surfaces	**Outline + Type**	**Floors / Walls**
Furniture		
		
Block instances	**Geometry + Name + Location**	**Direct Shape Family instances**

Paving / Structures

Rhino:
Select all surfaces
Grasshopper:
Extract outlines
Obtain levels
Rhino.inside:
Feed boundary
Lines+Type+Level

Furniture

Rhino:
Select all blocks
Grasshopper:
Extract
Name+Geometry+Location
Rhino.inside:
Create Types,
Place instances



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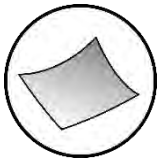
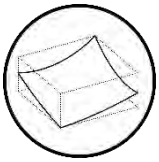
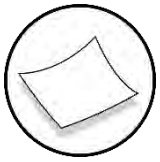
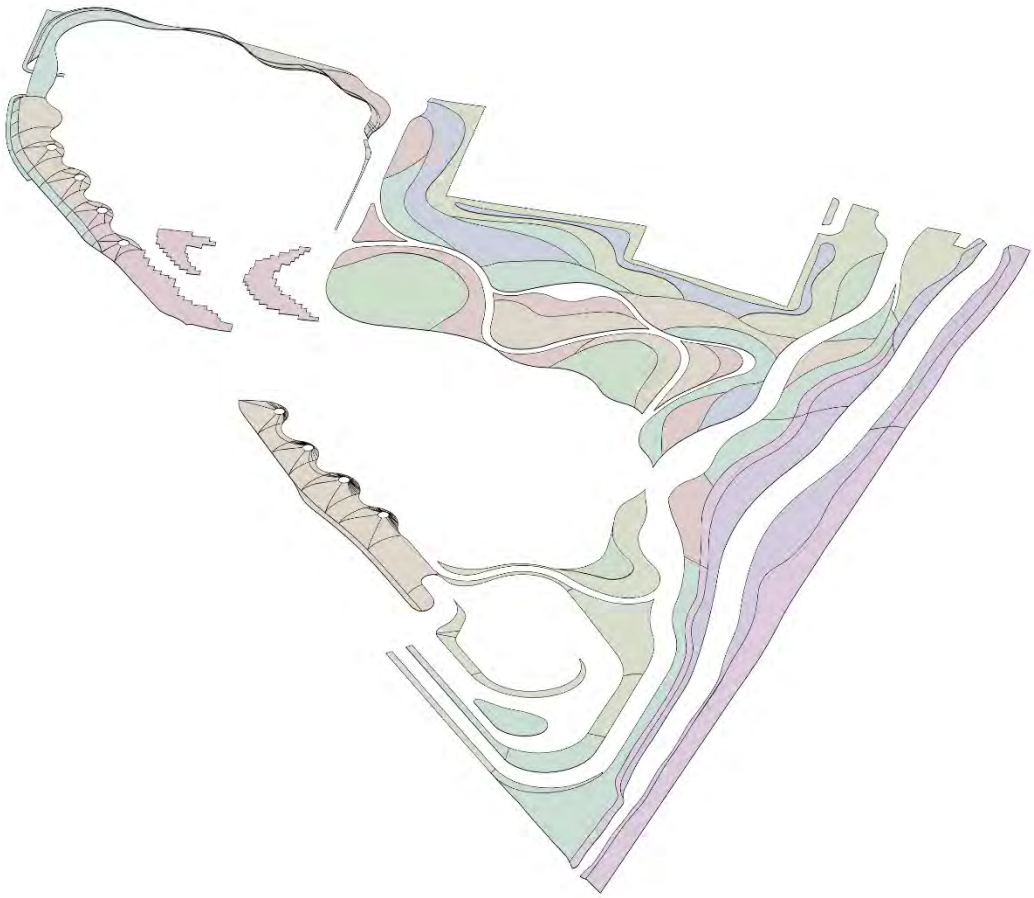
iii. Lower Planting

Paving / Structures		
		
Surfaces	Mass Family	Roof by Face + Type

Rhino:
Select all surfaces

Rhino.inside:
Feed geometry into a Mass family

Revit:
Load family into Model
Manually create Roof by Face with appropriate type



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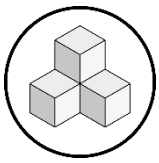
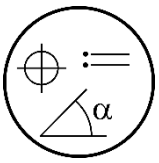
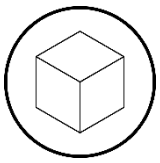
iv. Tree Planting

Trees		
		
Block instances	**Name + Location**	**Native Family instances**

Rhino:
Select all blocks

Grasshopper:
Extract Name+Location

Rhino.inside:
Map Rhino blocks to Revit families
Place instances

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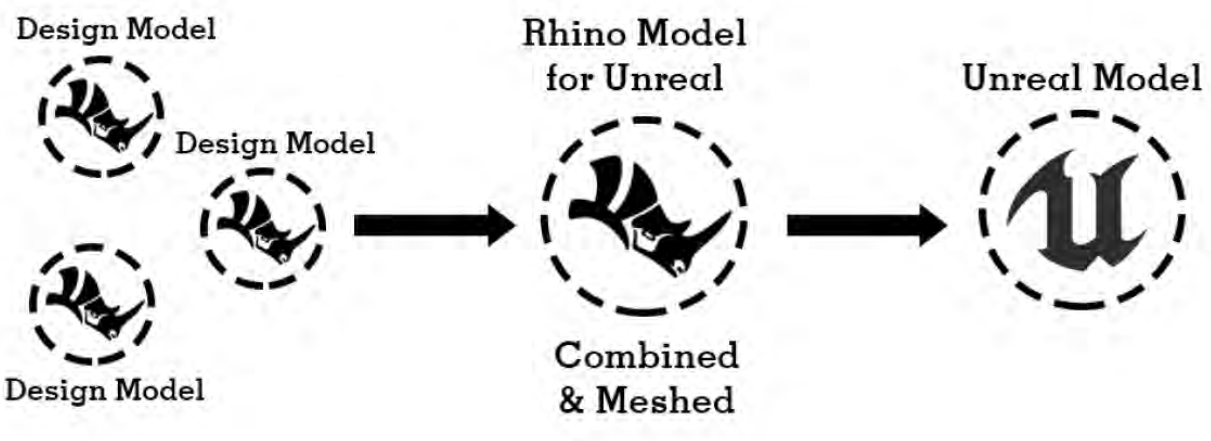
Rhino to Unreal Landscape Workflow

The above chapter on 'Landscape Visualisations' discussed the advantages of using Unreal, in coordination with 3D Rhino geometry, as the main tools for design exploration, development and visualisation. The main advantages of this method, apart from the quality and range of output, are the possibility for Real Time editing and interactive model reviews with design teams and/or clients. In addition to the above Unreal Engine offers endless possibilities for (planting) assets editing to match desired specification, design intent, seasonal characteristics, etc. The Unreal landscape model is developed in direct correspondence with the 3D geometry model (Rhino), replicating blocks with corresponding custom-created assets. Once the information is in Unreal it offers the possibility to extract endless number of visualisation outputs in a quick and straightforward fashion.

i. Rhino geometry development and export

Description of requirements and best practice for Rhino modelling for export to Unreal. Rhino objects, layers and materials set up. Mesh and materials. Rhino exporting process. All design Rhino models that are part of a specific project should be combined and meshed in a separate file in order to create the Unreal model.



ii. Unreal model set up

Use of templates and recommended settings. Importing into Unreal. Organising objects, textures and materials.

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iii. Development of bespoke Unreal planting assets

Bespoke Unreal planting components/ assets are created from standard Unreal libraries.

From a standard/base component the size, shape, bark and foliage texture/ colour are modified to recreate the desired tree, shrub or herbaceous planting. These components then made to match the outline dimensions of the respective Rhino and Revit blocks/ families.

Lower planting areas are populated using the 'Foliage' tool and by selecting the plants corresponding to specific lower planting mixes, and then retouched locally where required.

The below images show examples of planting assets created for the Google Landings Campus project.

Structural Tree Planting

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Small Ornamental Tree Planting

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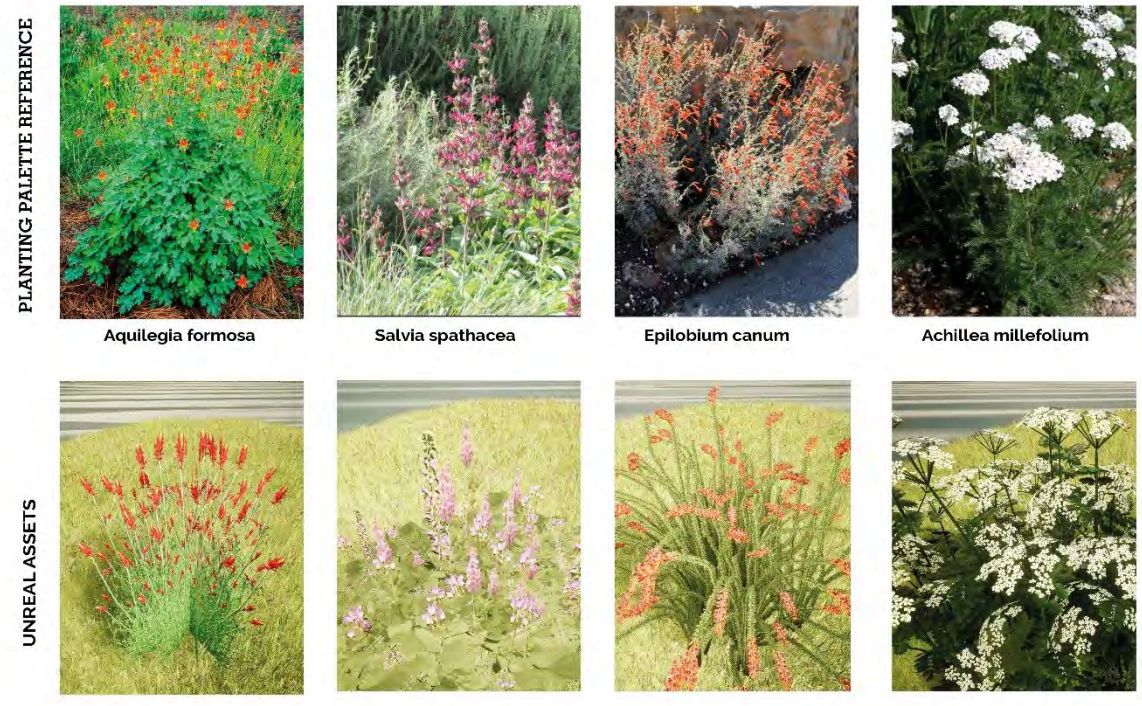
Shrub Planting

Herbaceous Planting



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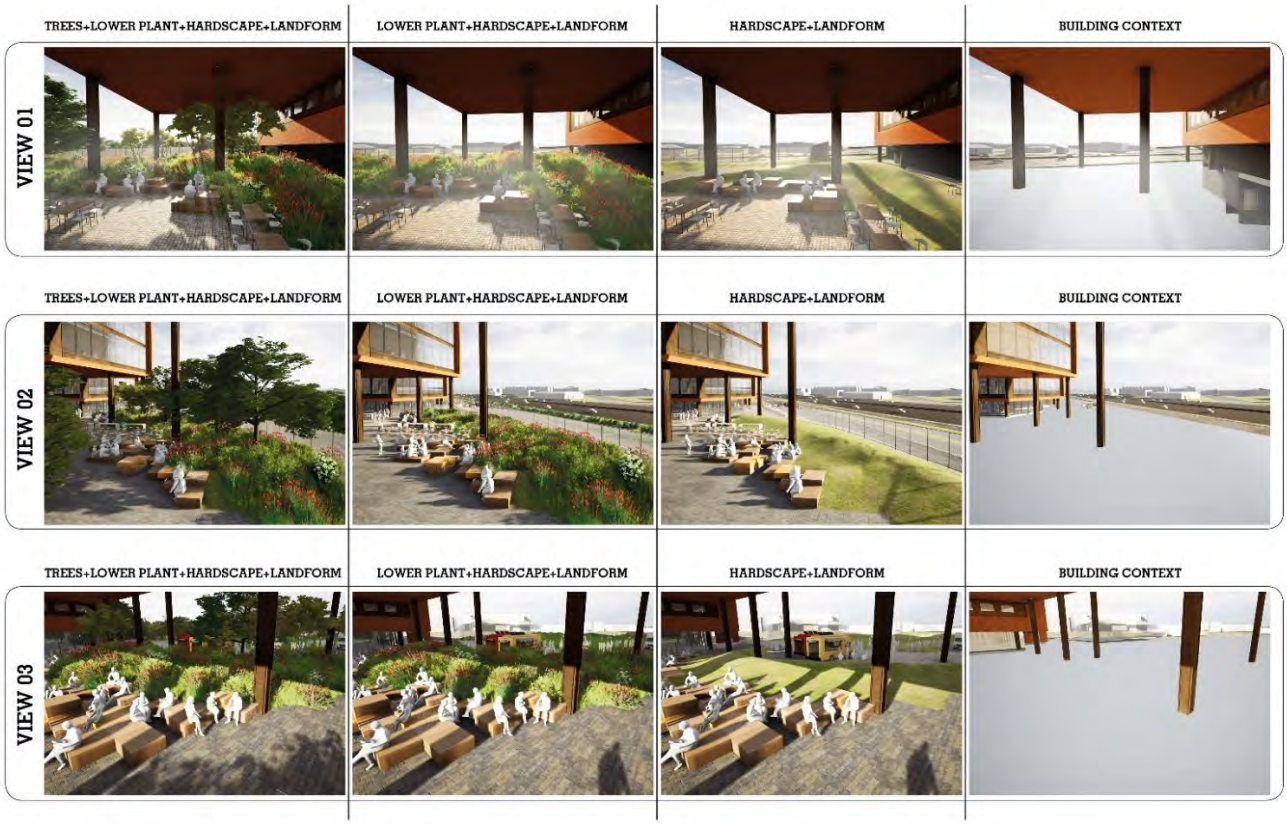
iv. Developing a Scene

Populating scenes. Adding entourage and other assets. Lights and effects

Unreal Landscape Output

The sequence of images below show the layering of landscape information in the Unreal model for the Google Landings Campus project. These of views have been deconstructed to demonstrate the organisation of landscape design components according to the workflow and data organisation discussed in previous chapters of this presentation.



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Landscape Workflow Summary

Correspondence of information and components in the models of the 3 software packages is illustrated and discussed. A video / Fly-through provides a summary and overview of the proposed workflow process and output.

Unreal

Rhino

Revit

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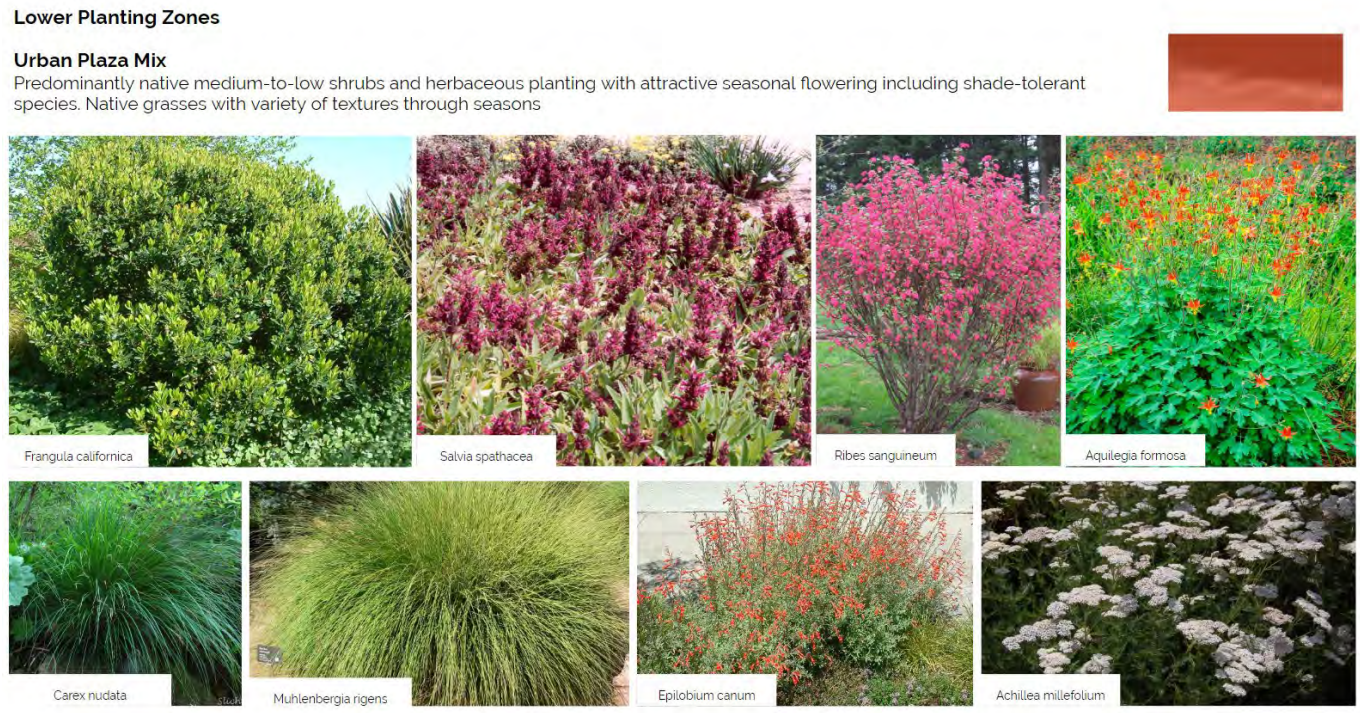

Unreal Model View – HS Google Landings Campus – Plaza Planting – Spring/Summer season

---------- **END** ----------

Session 2.2 - Landscape architecture - A new BIM and computational design workflow

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