

# Workflow for transforming 3D building models into spatially-aware GIS data

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# This presentation

## I. Where we came from

- Genesis for project

## II. Where we are

- Semi-automated workflow for transforming existing Revit models into a GIS

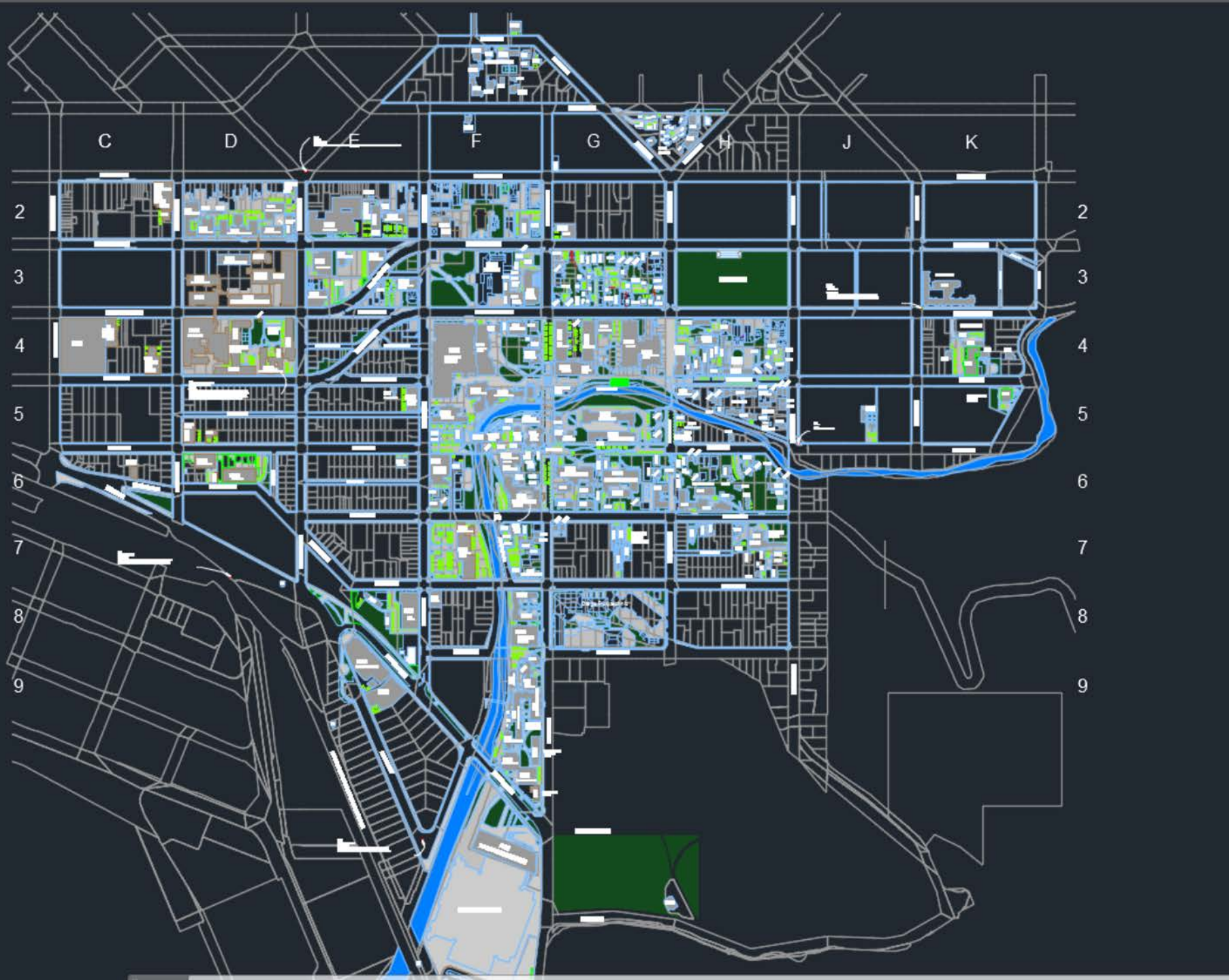
## III. Where we are headed

- An authoritative database of campus buildings that serves out immersive and up-to-date mapping products



- Design requirements:
  - Updateable and synced with existing building information databases
  - Accurate locations and geometries of assets such as buildings, doors, etc.
  - In a known (and absolute) coordinate system
  - Support multiple downstream formats (online, mobile, printed, integrated with existing uni databases such as timetabling, easy to use and customisable for conferences, etc.)
  - Can support future ad-ons like indoor/outdoor wayfinding and 3D buildings, AR/VR stops
  - Spatial and non-spatial data can be integrated into 3<sup>rd</sup> party systems like Google Maps for directions, bus timetables, cycling directions, etc.
  - Has privacy settings for public vs. non-public asset info.
  - Conforms with university branding
  - Can support growth: New uses, users, platforms
- **Usable (and engaging)**





**MAP DIRECTORY**

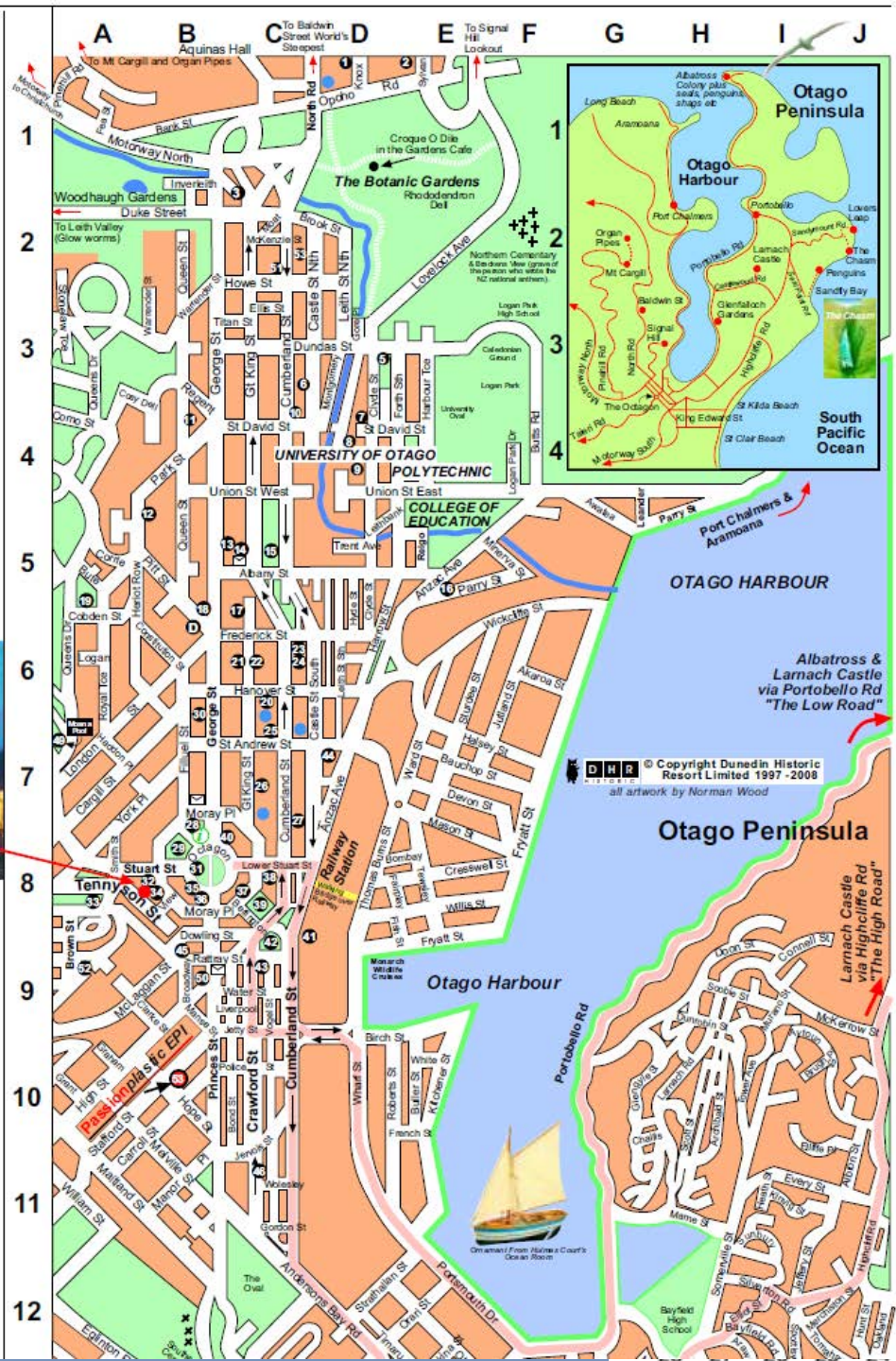
AA (Automobile Assoc), C8, 37  
 Airport (Road to), A13  
 Albatross Colony, H1  
 Archives New Zealand, B5, 13  
 Art Gallery, B8, 35  
 Avis Rent a Car, B8, 34  
 Baldwin Street (Steepest), C1  
 Bayfield High School, H12  
 Botanic Gardens, D1  
 Butterfly House, C5, 15  
 Bus - Intercity depot C7, 44  
 Cadbury Chocolates Fac., C7, 27  
 Carisbrook Rugby St., B13, 48  
 Casino, B9, 50  
 Chasm, J2  
 City Council, B8, 28  
 College of Education, E4  
 Crown Research, C4, 10  
 Dentistry School, B5, 17  
 Dept of Conservation DOC, L8, 38  
 Dentist - Norman's - Ray George, Lvl 7, Burns Hse, Octagon, 477 7993  
 Doctor - Norman's - Dr Alan Walker, 2 Pitt Street, Ph 474 0288, B6, D  
 Doctor - After hrs, 479 2900, C6, 20  
 Dunedin Cent, Octagon Map, L15  
 Dum Conference Mgt, C9, 43  
 Early Settlers Museum, C8, 41  
 First Church, C8, 39  
 Fortune Theatre, B8, 32  
 Glenfallloch Gardens, H3  
 Hertz Rent a Car, C10, 46  
 Hocken Library, E5, 16  
 Hospital, C6, 22  
 Hoyts Cinemas, B8, 35  
 Hulmes Court B&B, B8, 52  
 Intercity Bus Depot, D7, 44  
 Knox Church, B5, 18  
 Larnach Castle, I2  
 Library, B8, 28  
 Logan Park High School, F3  
 Lovers Leap, J2  
 Medical School, B6, 21  
 Meridian Shopping Mall, B7, 30  
 Metrop Town Hall Theatre, B8, 28  
 Moana Pool, A7, 49  
 Mount Cargill, A1 or G2

**Hulmes Court Bed and Breakfast**  
 52 Tennyson Street

**Red Dot is Hulmes Court**  
 52 Tennyson St

Motorway North, A1  
 Motorway South, A13  
 Octagon, B8, 31  
 Oveston, A5, 19  
 Organ Pipes, A1 or G2  
 Otago Girls' High Sch, Oct Map, K16  
 Otago Museum, C5, 15  
 Otago Peninsula, I2  
 Otago Polytechnic, E4  
 Passionplastic EPI Ltd, B10, 53  
 Penguins - Otago Peninsula Map  
 Pharmacy (after hours), C6, 20  
 Police, C7, 24  
 Post Office [ ]  
 Queens Garden, C9, 42  
 Railway Station, D8  
 Regent Theatre, Octagon Map, M16  
 Robbie Burns Statue, B8, 31  
 Rhodes Rent a Car, C7, 25  
 St Josephs Cathedral, A8, 33  
 St Pauls Cathedral, B8, 29  
 Scarfes House - the movie, A9, 52  
 Signal Hill Lookout, E1  
 Speights Brewery, K17, Oct Map  
 Sports Hall of Fame, in Rail Station  
 Supermarkets, [ ]  
 Taieri Gorge see Railway, D8  
 Toilets, WC  
 Town Hall, B7, 28  
 University, D4  
 University Bookshop, C5, 14  
 Visitor Centre, B8, 27  
 Woodhaugh Gardens, A2

**Halls of Residence**  
 Abbey College - Post Grad, C2, 53  
 Aquinas College, B1

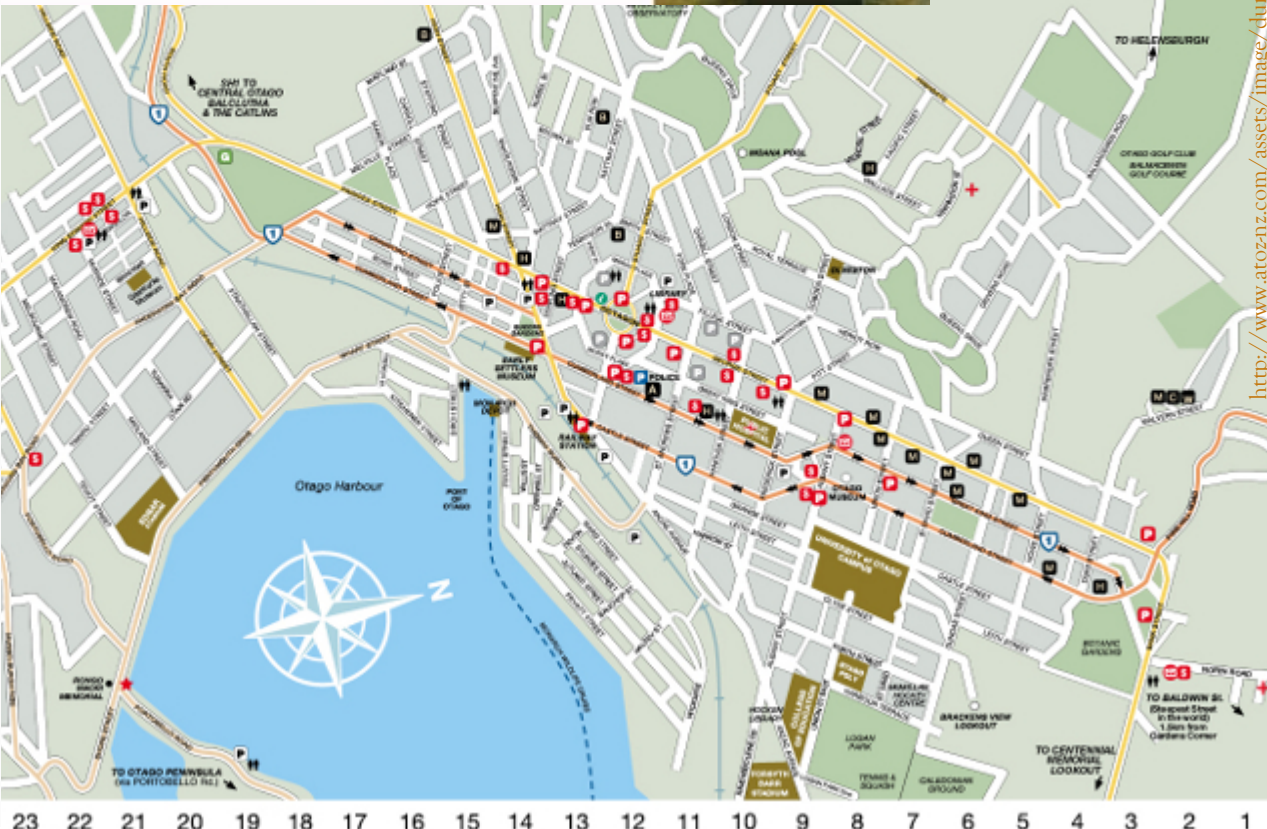


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6 THE OCTAGON [seriouslytwisted.co.nz](http://seriouslytwisted.co.nz)  
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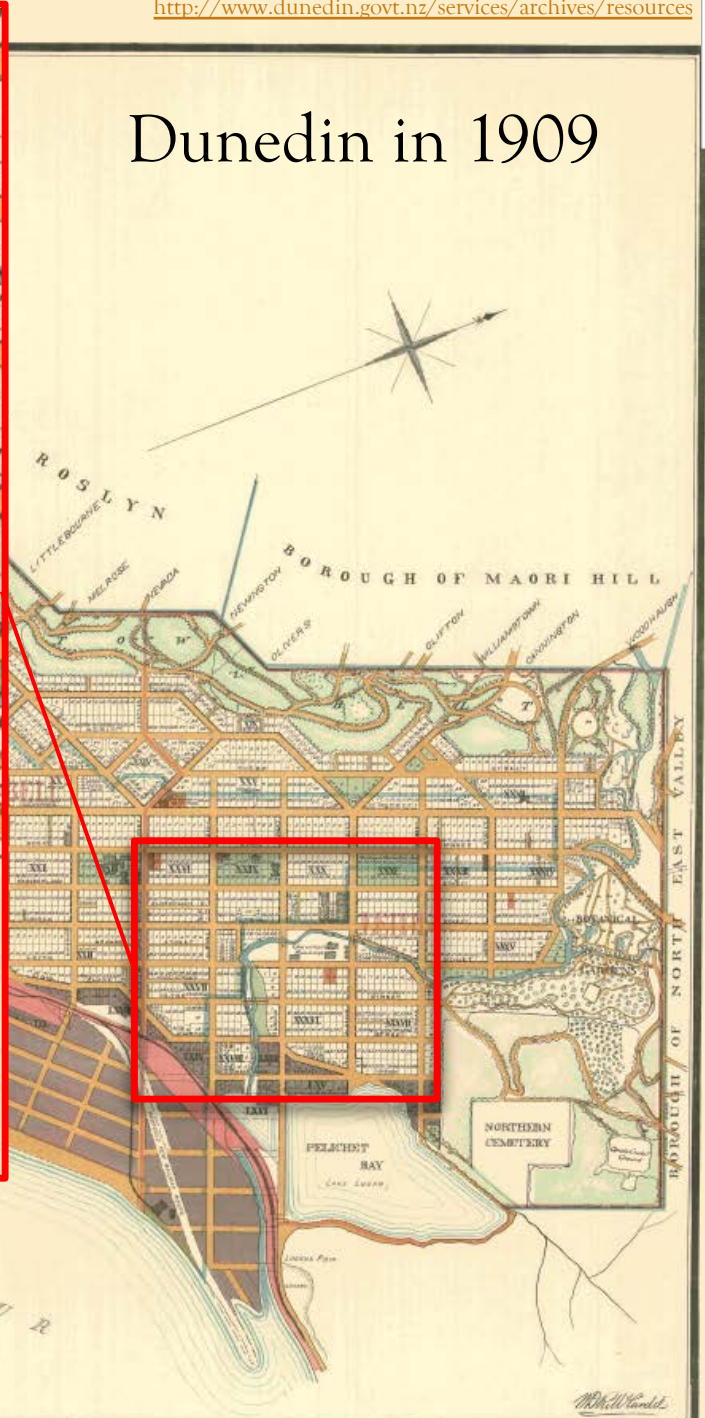
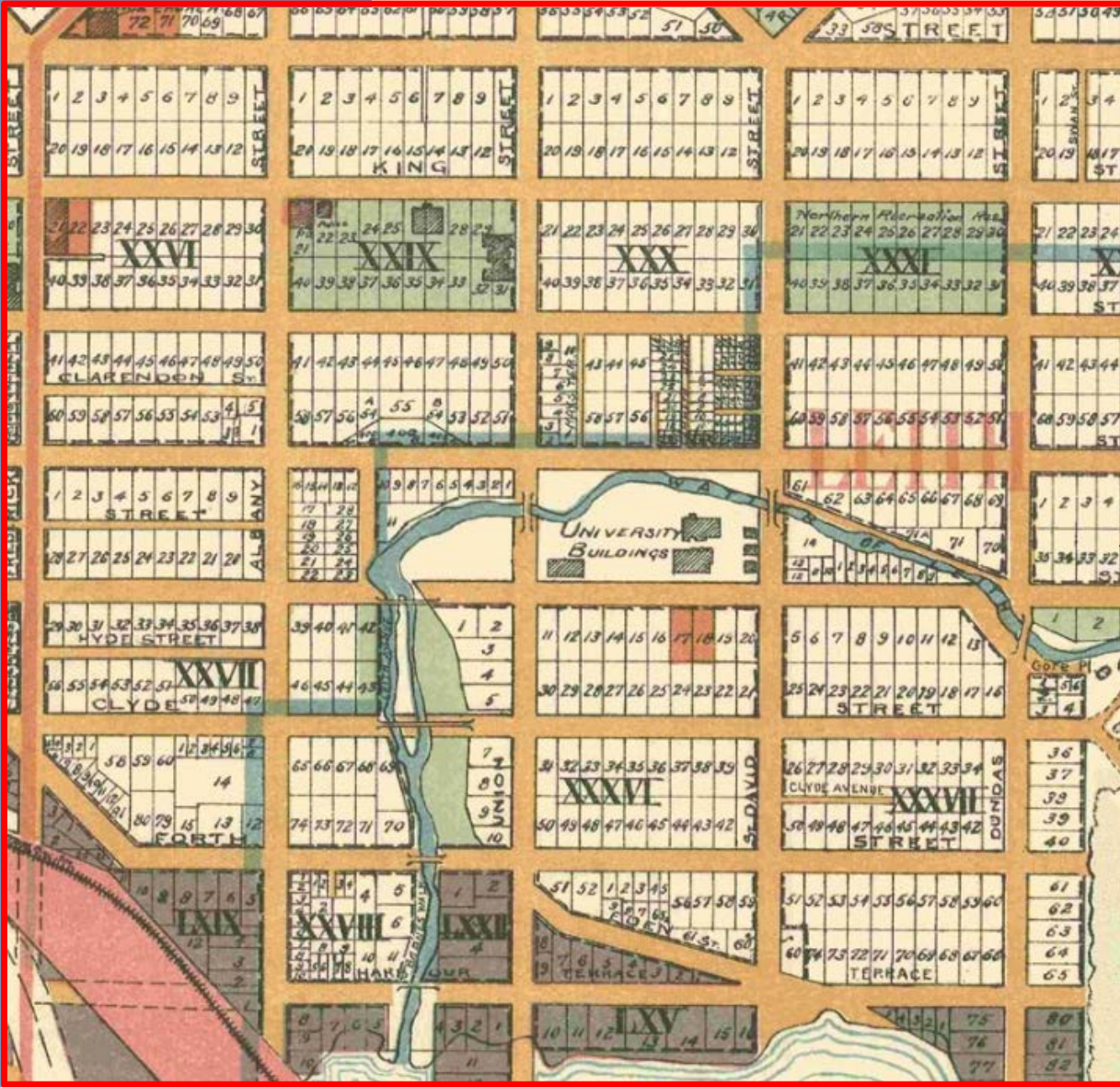
**KORU** KNITWEAR  
 MADE IN NEW ZEALAND

[http://www.hulmes.co.nz/images/hulmes\\_rampblbr\\_2008\\_back.pdf](http://www.hulmes.co.nz/images/hulmes_rampblbr_2008_back.pdf)

<http://www.atoz.nz/assets/image/dunedin/dunedincity.jpg>

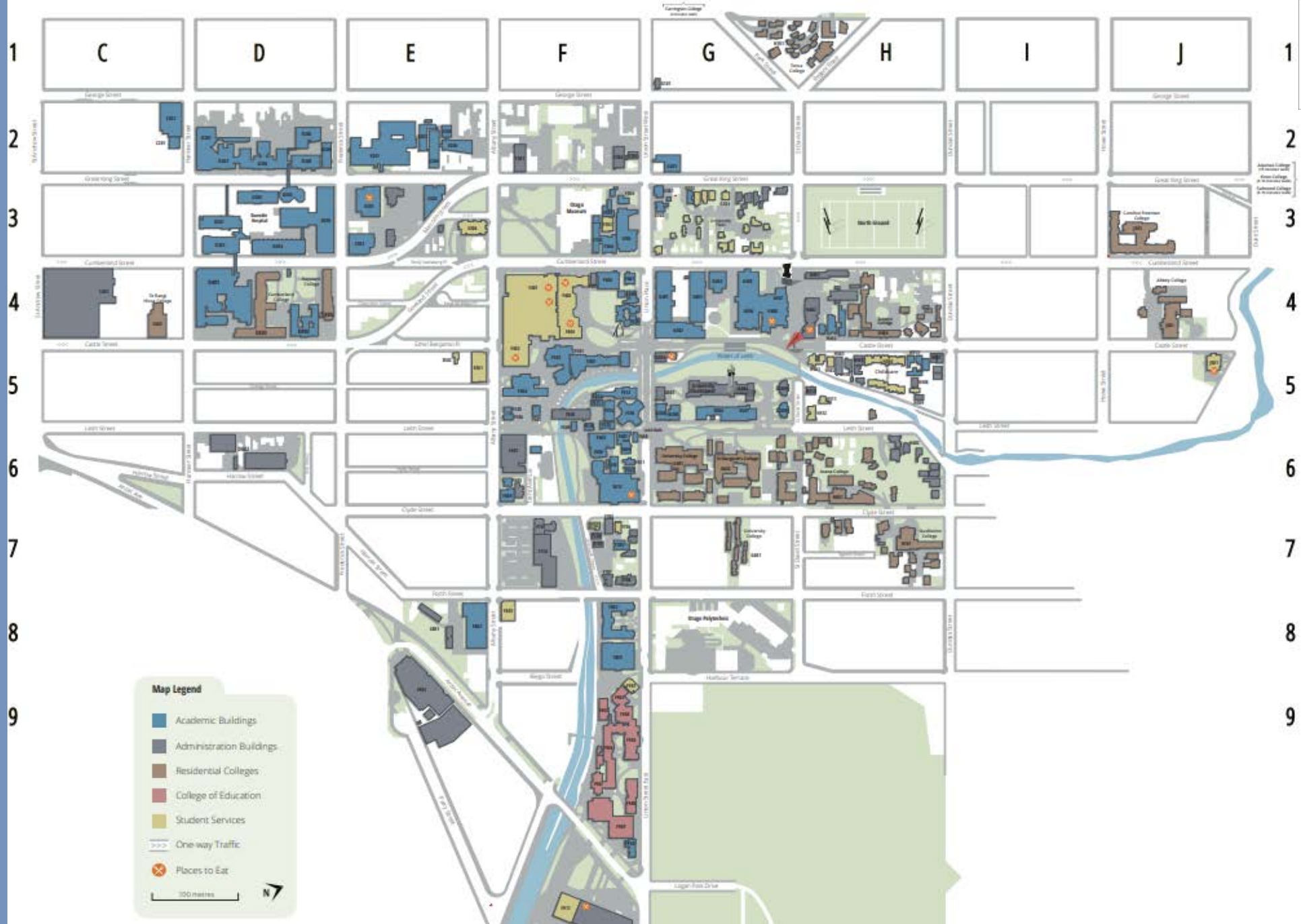
# Dunedin in 1909



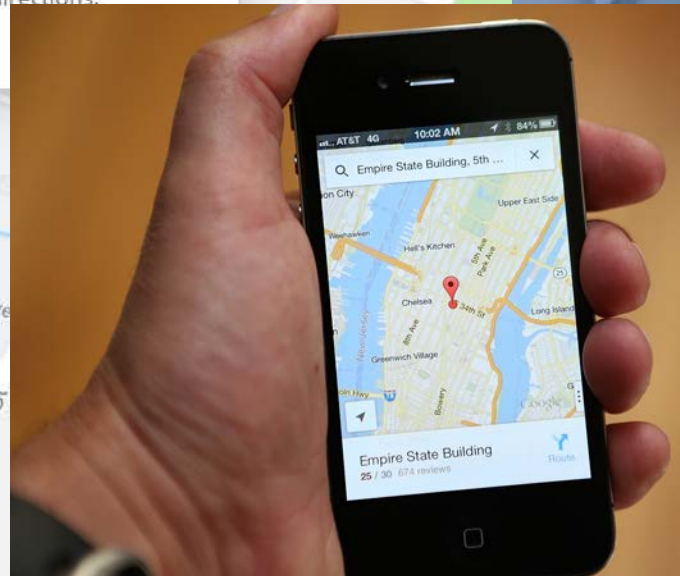
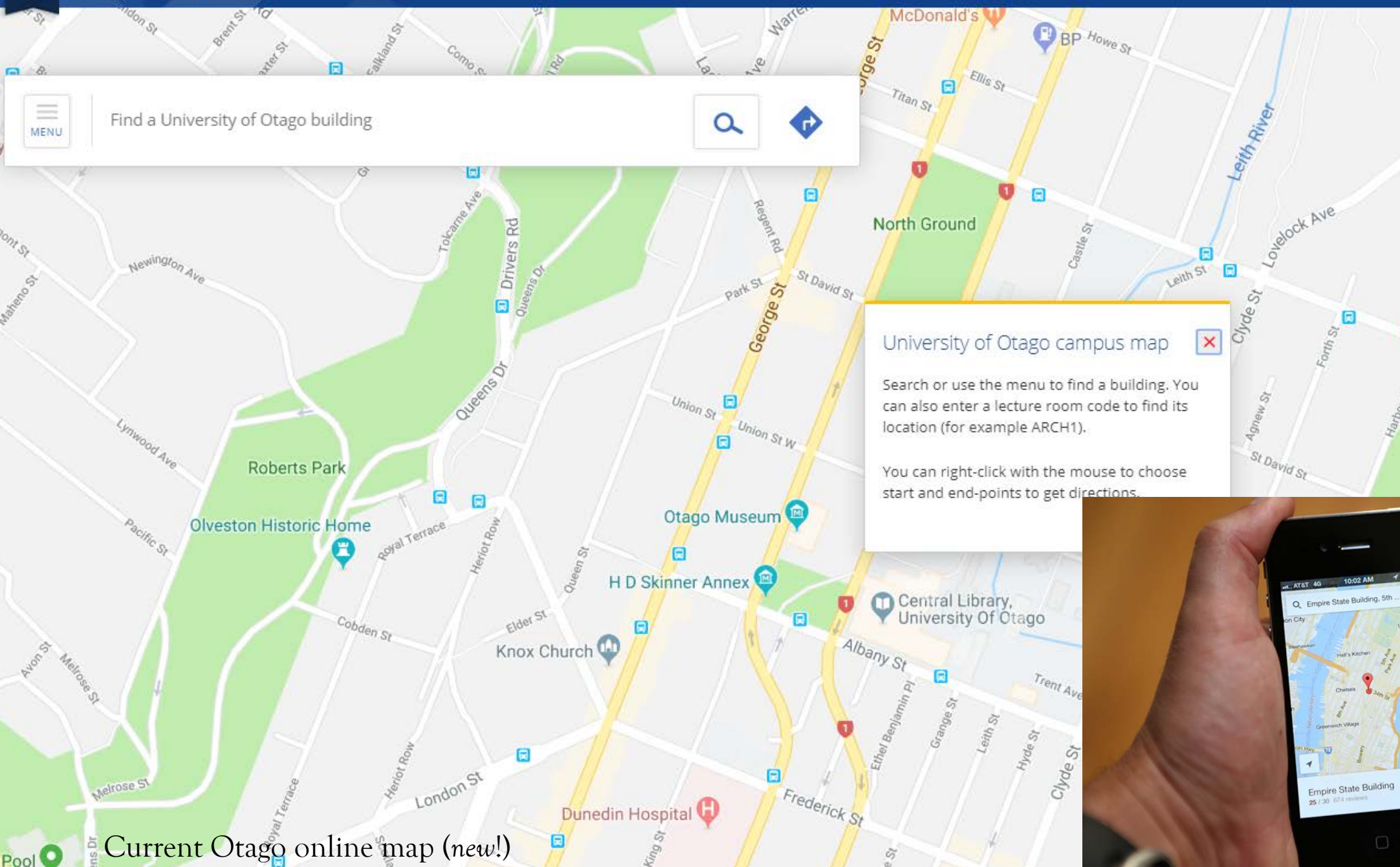
REFERENCE

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BRIDGE	—
DRYDO DATE	—
CLERE	—
BRICK ROAD	—
UNIMPROVED PROPERTY (CLERE)	—
MARBLE ROAD (CLERE)	—
SETBACK	—
DRIVE	—



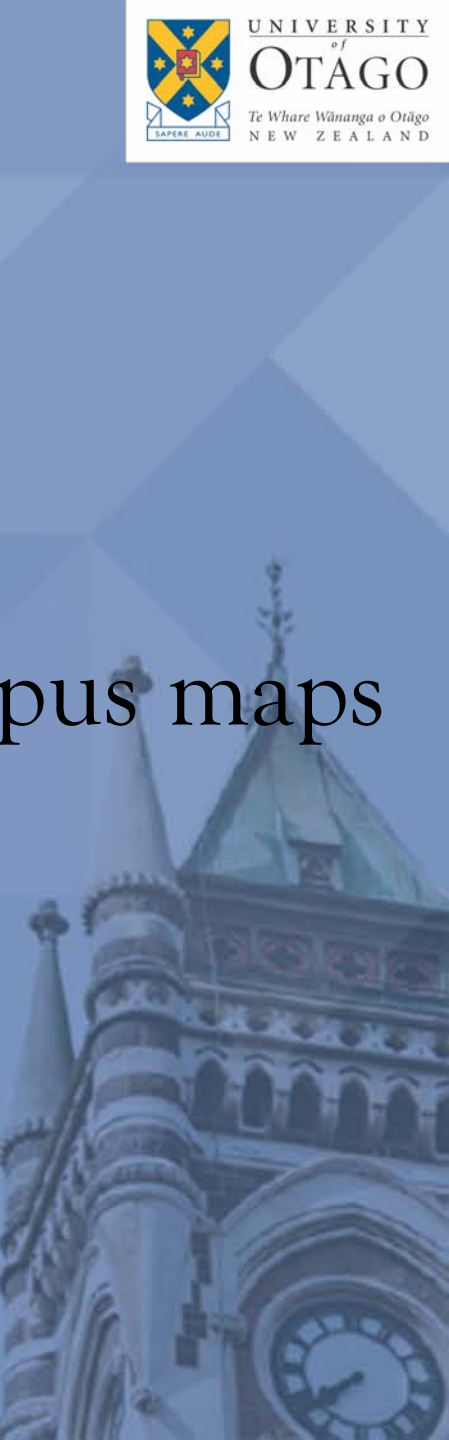
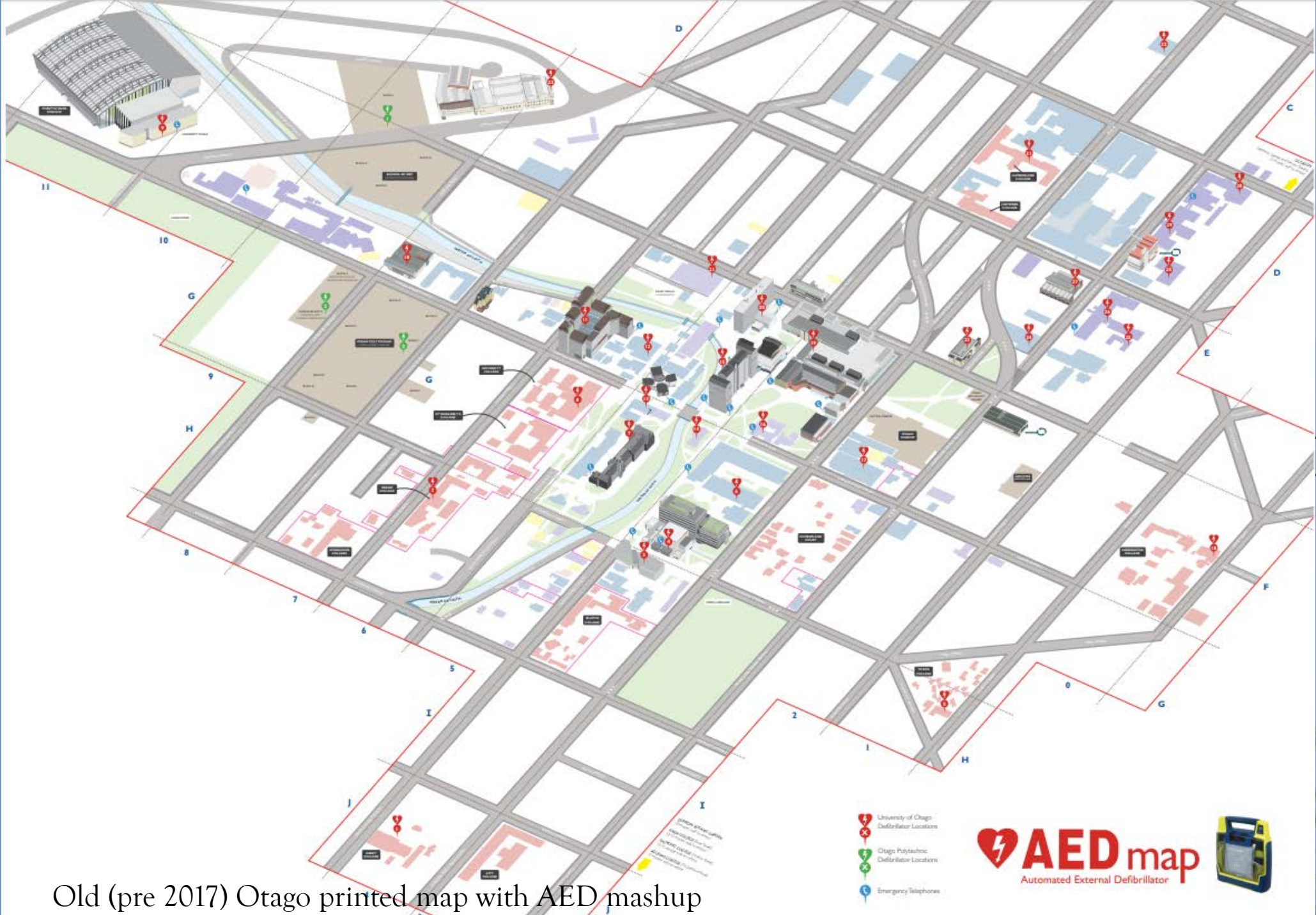


Current Otago printed map



Current Otago online map (new!)





# So, where does that leave us?

- Need a single source of good spatial information about where things are on campus
- It needs to be delivered digitally for integration with the  $n$  number of mapping uses at the uni.
- It needs to work alongside (and probably use) existing databases of campus assets
- It needs to be good enough that people will abandon the ad-hoc mapping methods of the past



# Our workflow

- We need a workflow that:
  - Exports existing building data from Property Services
  - Transforms data into a spatial data format for a GIS
  - Georeferences the data
  - Has quality control checks on data
  - Makes the data available to downstream services and wayfinding algorithms from spatial database
- *AND...* every step should be as automated as possible



## II. Where we are



# Where we are – Software we used

- Commercial computer-aided design software
- Drafting software
- Used by architects, project manager and engineers



- Building information modeling software
- Design buildings in 2D and 3D
- Add building information from database
- Tracks various stages in building lifecycle
- Used by architects, structural engineers and designer



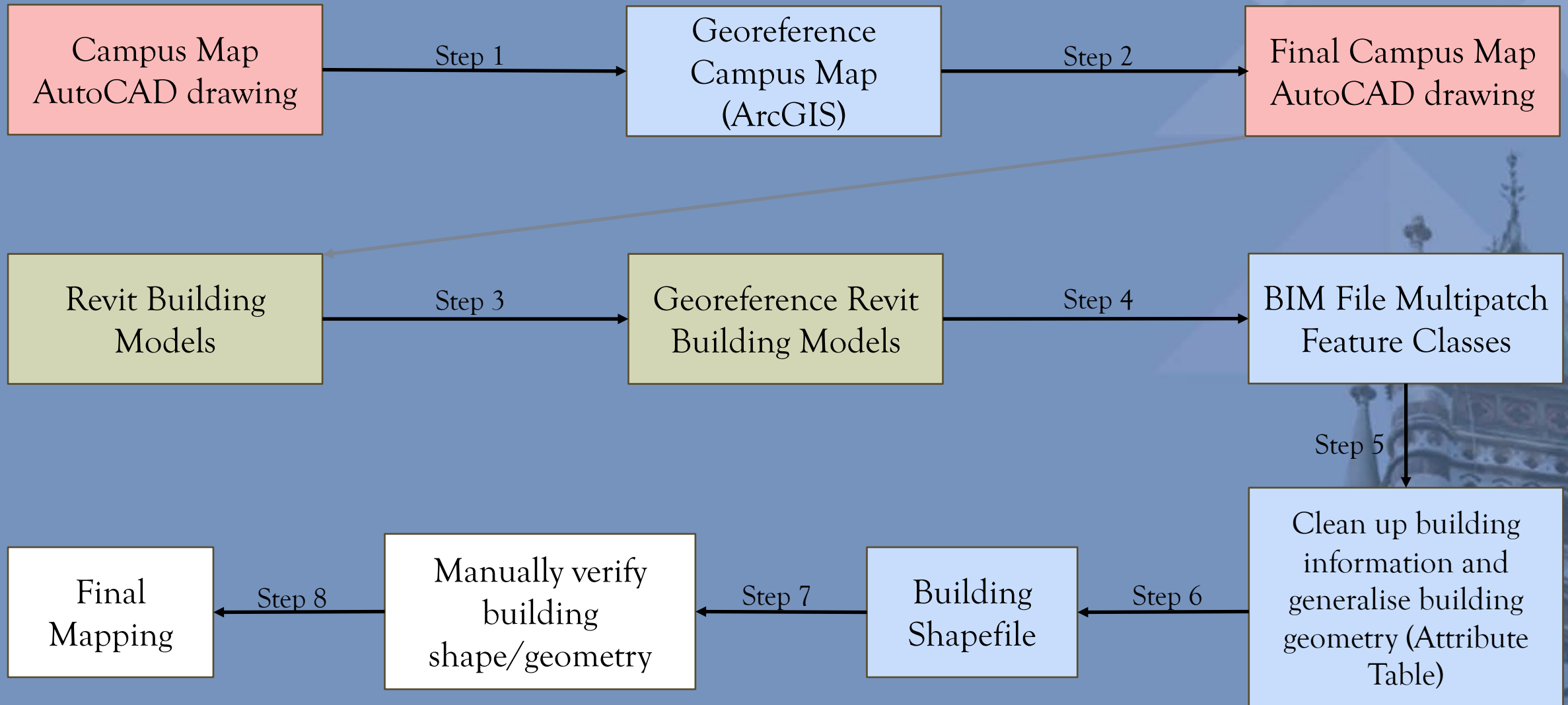
- Feature Manipulation Engine (FME)
- Translates spatial data, geometric and digital data
- Create simple to complicated workspaces



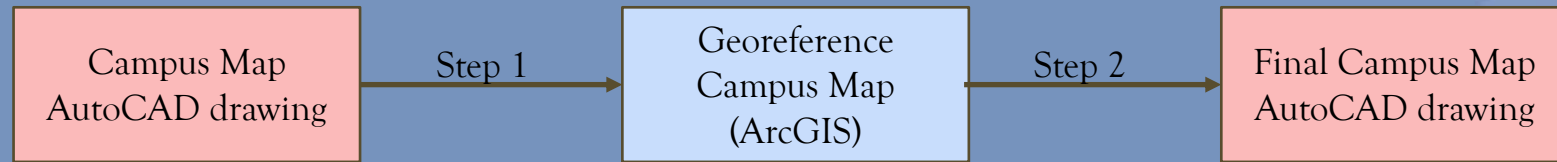
- Geographic Information System (GIS)
- Working with maps and spatial information
- Perform spatial analysis
- 2D and 3D workflows



# Where we are - Workflow




# Where we are – Step 1 and 2



- Investigate geodetic marks/ annotations in original .dwg CAD
- Create a table with NZTM coordinates
- Add the original relative coordinates from .dwg drawing (X and Y position) to table
- Georeference the Campus Map drawing in ArcGIS Pro
- Export a new georeferenced .dwg CAD for use as Revit site plan

# Georeferencing an AutoCAD Drawing



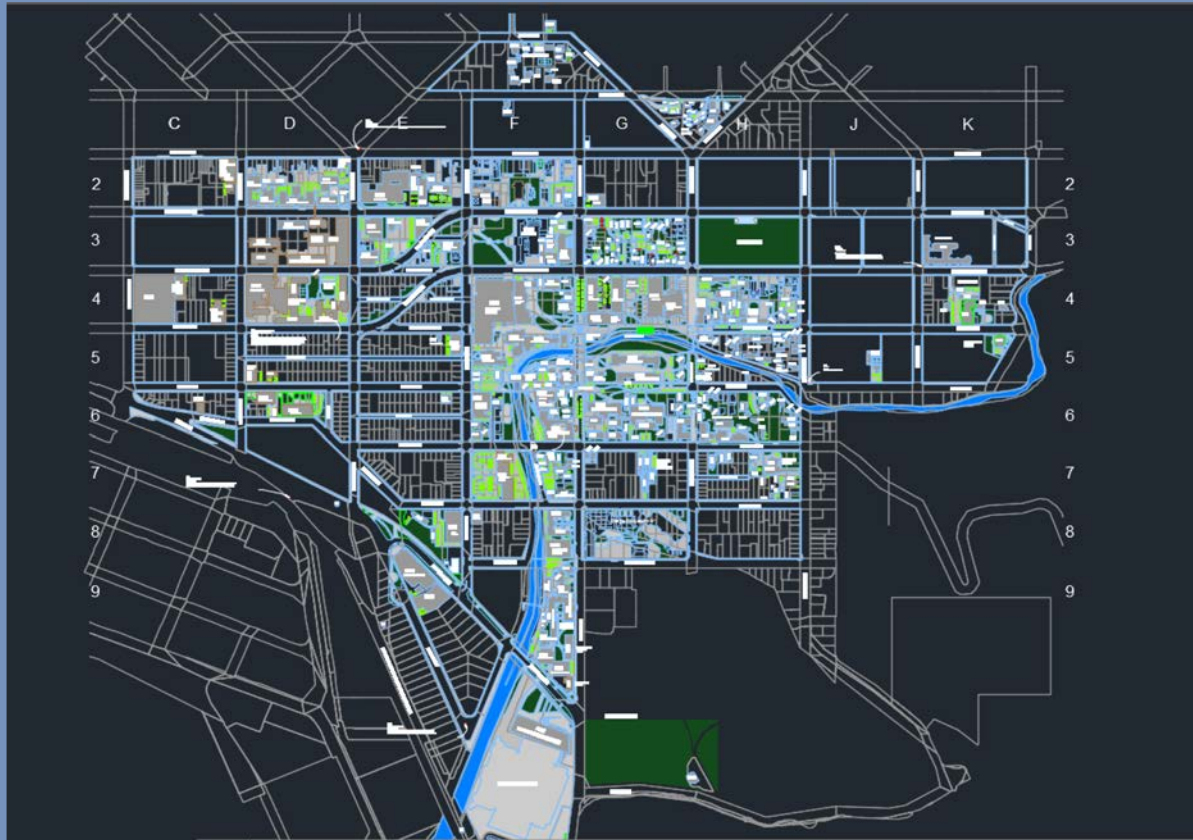
The image shows a portion of an AutoCAD drawing of a building floor plan. The drawing is in grayscale with green lines representing walls and structural elements. Two specific points are highlighted with white crosshairs and labeled: 'D404' on the left and 'D403' on the right. Below 'D403', the text 'Survey/Marine Science' is written. A white arrow points from the 'D403' label to the corresponding crosshair. The drawing is overlaid on a dark grid background.

OUSD  
Otago University Survey Department  
Survey School Otago University  
50212M001  
Descriptionvv  
Continuously operating GNSS station or CORS site. Mark is unable to be physically occupied. Pillar is on the rooftop of the Surveying School. Horizontal reference point is the centre of 5/80 thread. The vertical reference is the plate at top of pillar. 0.055m spacer is between GNSS antenna reference point (ARP) and vertical reference plate (antenna height). For more information see <http://www.linz.govt.nz/positionz>



# Where we are – Step 1 and 2

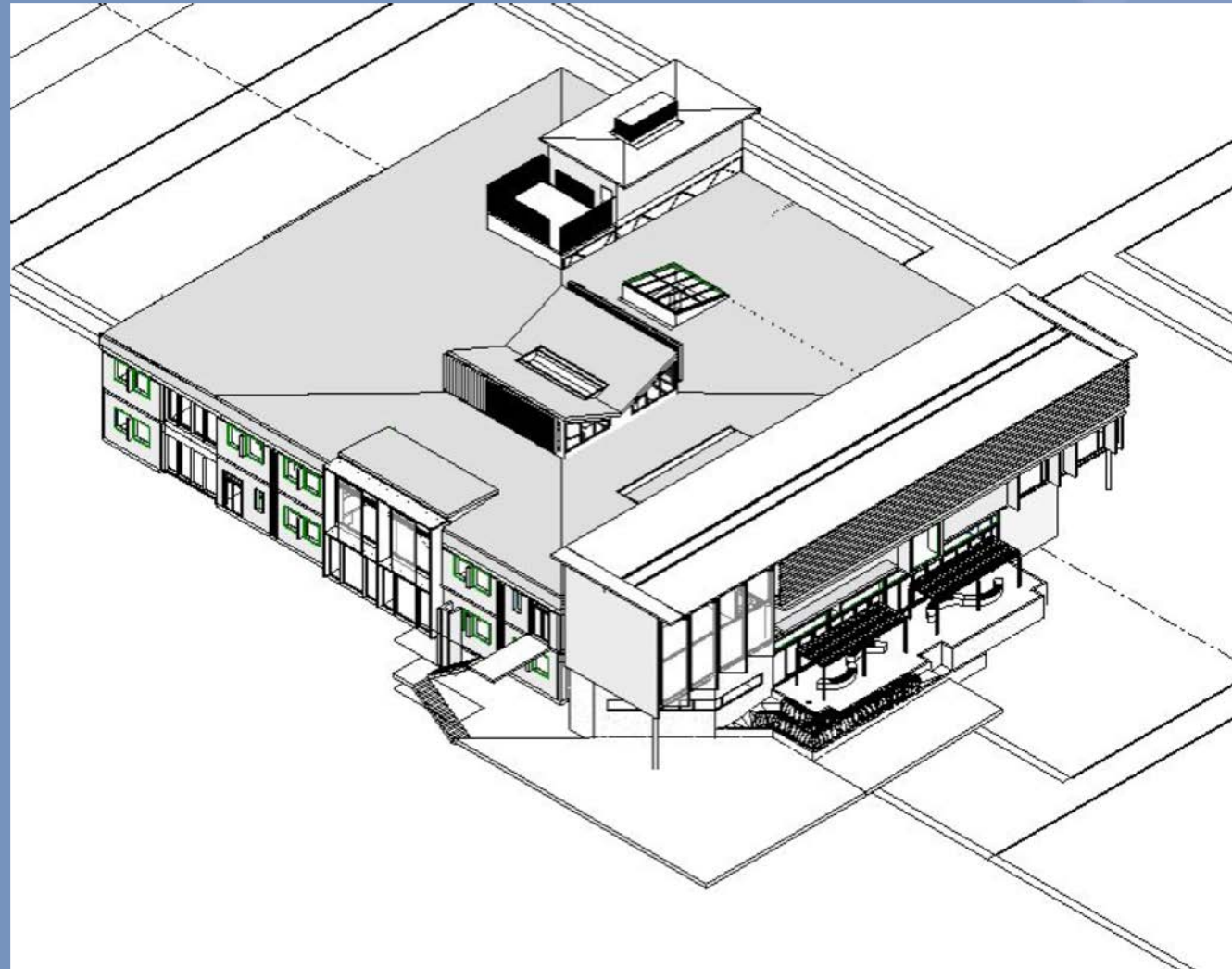
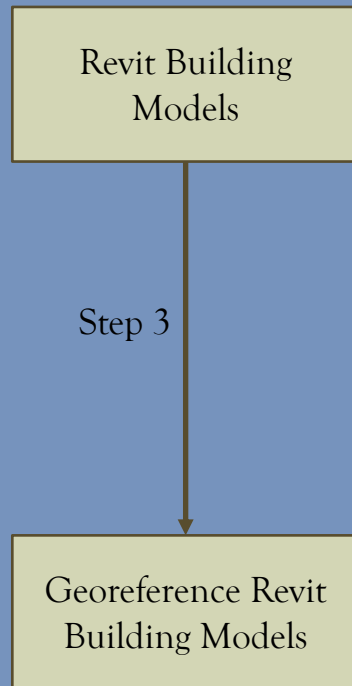
Original Campus Map



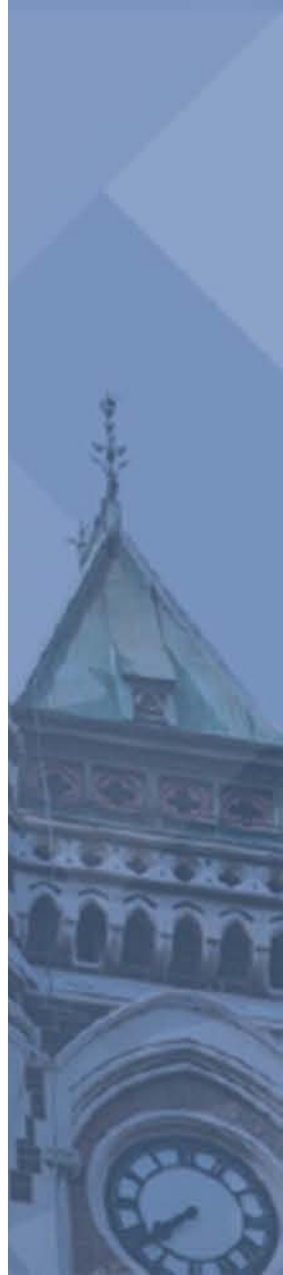
Georeferenced Campus Map



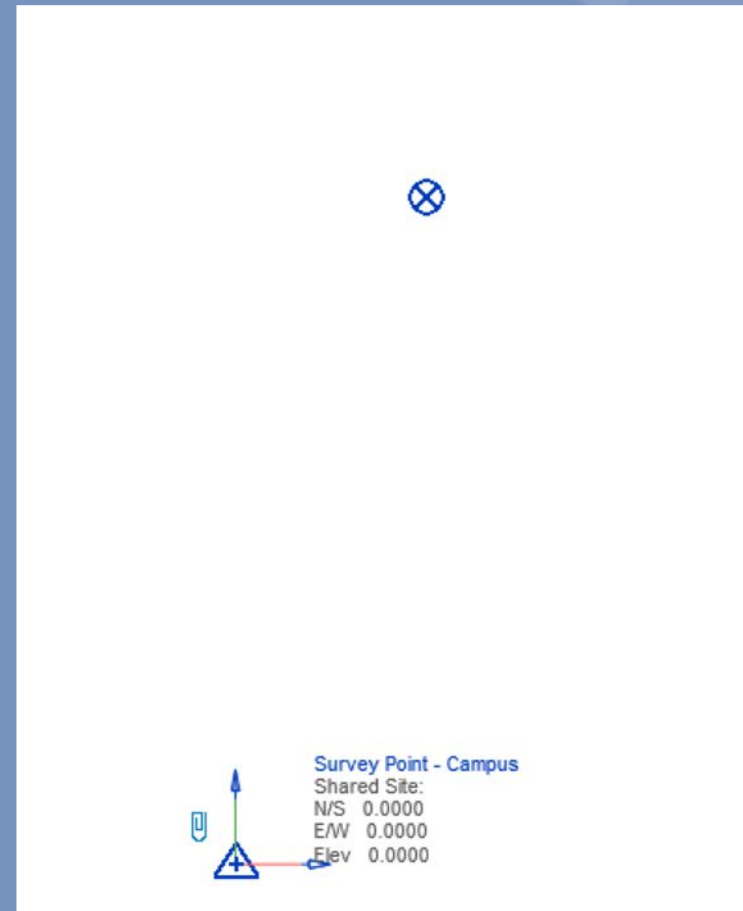
# Where we are – Step 3



# Georeferencing a Revit model



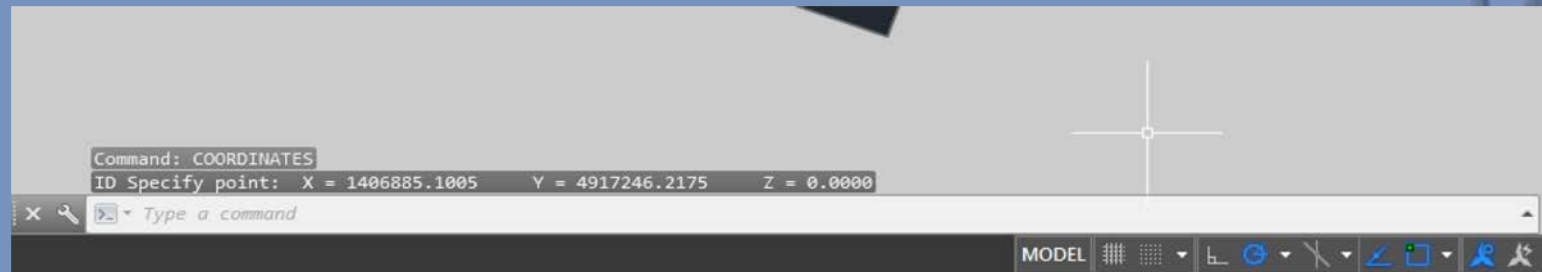
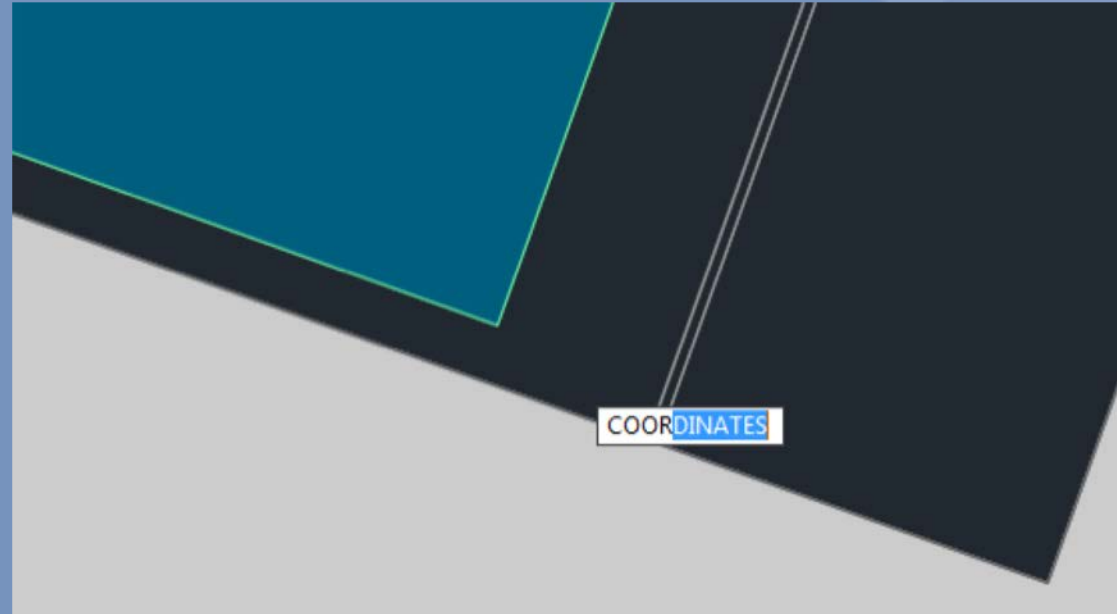
# Georeferencing a Revit model



- Set up individual project base point for each building

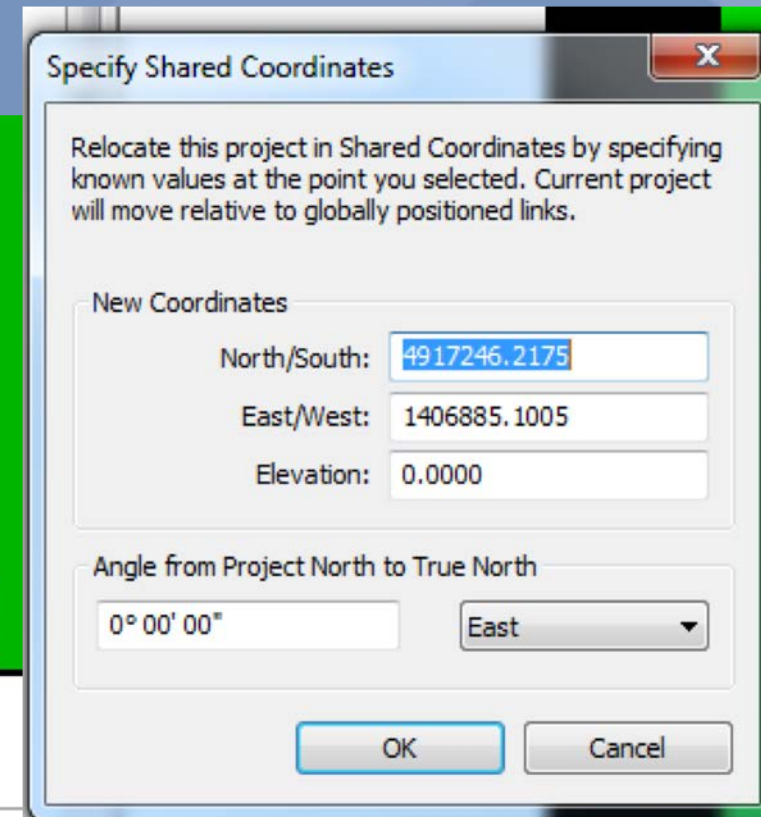
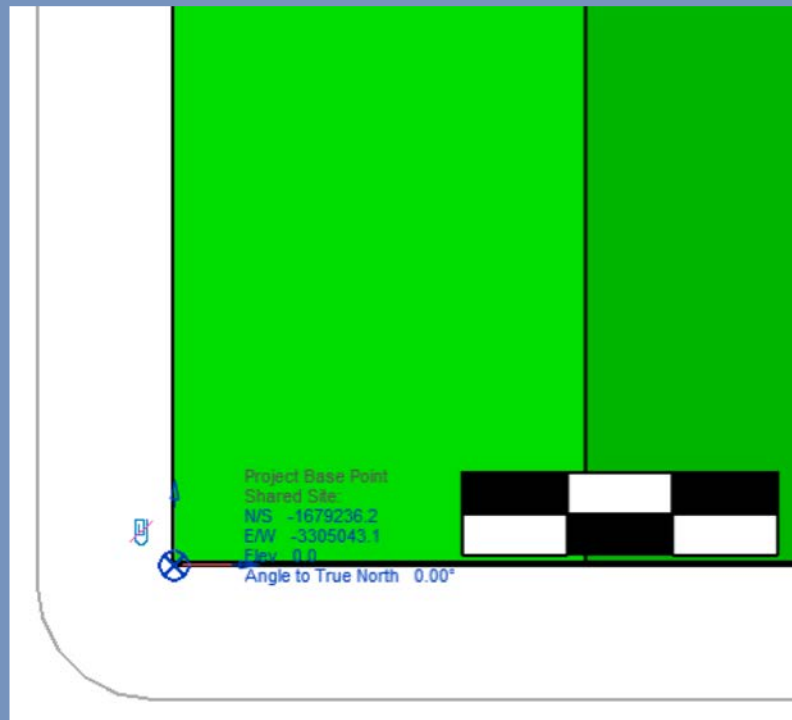
# Georeferencing a Revit model

- Acquire true north and XY coordinates from the georeferenced Campus Map CAD
- Move project point to corner of building from acquired NZTM coordinates
- Specify coordinates at project base point and angle to true north



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# Georeferencing a Revit model

Georeferenced Campus Map



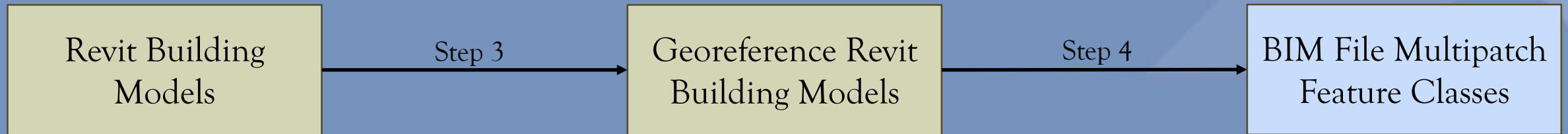
# Challenges – Step 3

- Different options when giving the Revit model spatial information
  - Shared coordinate system from AutoCAD
  - Survey point and project base point
- Original Revit model must not be moved
- Original AutoCAD drawing must not be deleted
- Survey point and project base point are not consistent through every model
- Units: Millimeter and meter
- University buildings outside the Dunedin City Campus have a different project North and require their own georeferenced CAD drawing





# Where we are – Step 4

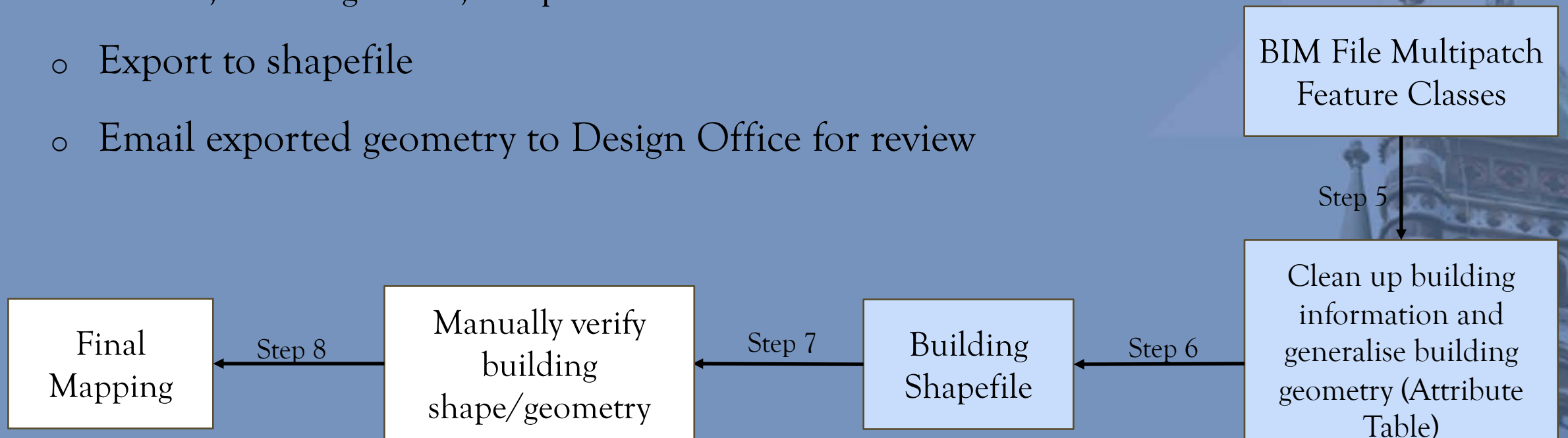


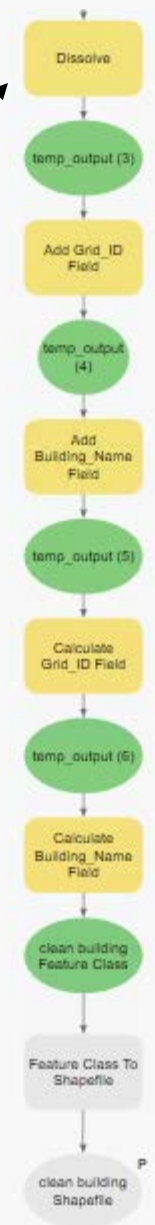
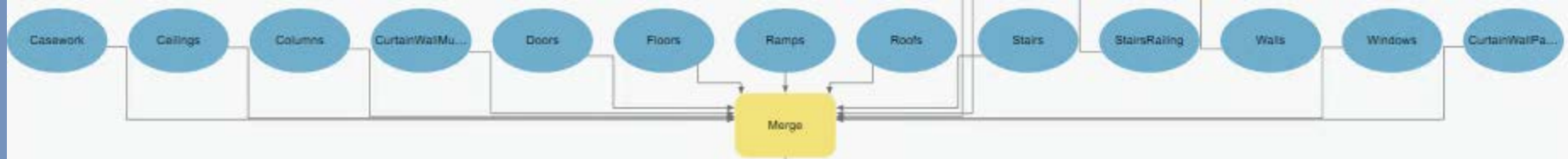
- Detach and export cleaned Revit models
- Load into ArcGIS Pro
- Define coordinate system
- Export needed geometric elements (walls, roofs)



# Where we are – Step 5 and 6

- Transform 3D multipatch to 2D footprint
- Clean up attribute table and add building information
  - I.e., Building Name, unique ID
- Export to shapefile
- Email exported geometry to Design Office for review

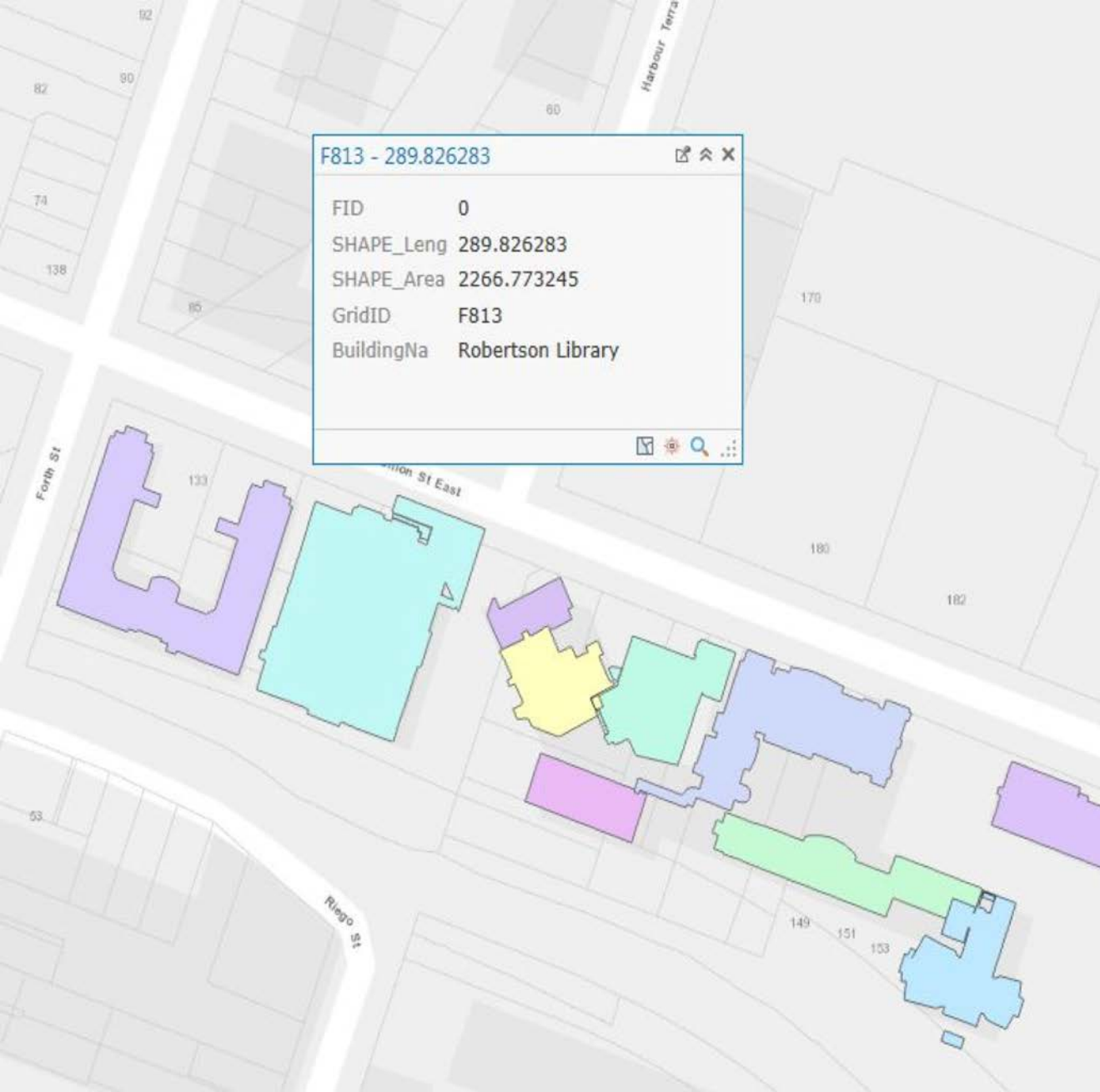




Choose output folder for the shapefile

You have to manually rename the clean shapefile. The default name will be: dissolve

From BIM feature to final output feature



# Automation

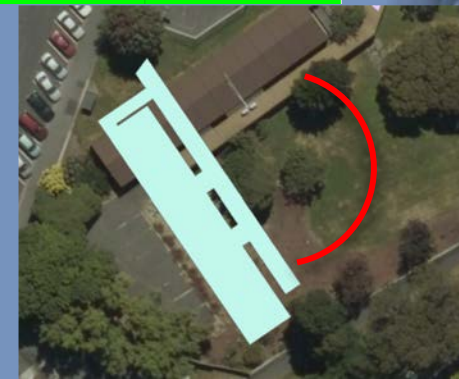
```
Settings.py x ProcessRvzFiles.py x RvzToCleanShapefile.py x MultipatchToFootprint.py x StepsDissolveToShapefile.py x
1 # Th
2 FEM_
3
4 # Th
5 STEP1
6
7 # Th
8 STEP1
9
10 # Te
11 TEMP_
12
13 # Li
14 all_
15
16
17
18
19 def
20
21
22
23
24
25
26
27
28
29
30
31 # outputDir = os.p
32 outputDir = os.pat
33 os.mkdir(outputDir
34
35 processDir(inDir=S
36
import os
from Settings
from geod
from geod
from rvz
def process
outP
if ne
geoDb
print
runF
# To
geoDb
if os
def multipa
"""
Convert
"""
arcpy.C
env.wor
try:
    fcL
    if
import arcpy
import os
from arcpy
# Base dire
from Settin
from Settings import generateFootprintShapefileName
_ARCPY_MULT
def processFootprint(workingDir, footprintShapefile, buildingCode, buildingInfo):
    """
    Needs to create temporary geoDb which is used at each step to calculate the intermediate transformation
    """
    arcpy.CheckOutExtension('DataManagement')
    try:
        footprintShapefileName = generateFootprintShapefileName(buildingCode)
        sourceGeoDb = os.path.join(workingDir, '{}.gdb'.format(buildingCode))
        tempGeoDb = os.path.join(workingDir, "temp.gdb")
        if not os.path.exists(tempGeoDb):
            arcpy.CreateFileGDB_management(workingDir, "temp.gdb")
        env.workspace = footprintShapefile
        footprintDissolveFeatureClass = os.path.join(tempGeoDb, "{}_dissolved".format(footprintShapefileName[
        # Execute Dissolve using LANDUSE and TAXCODE as Dissolve Fields
        arcpy.Dissolve_management(footprintShapefile, footprintDissolveFeatureClass, "", "", "", "")
        env.workspace = footprintDissolveFeatureClass
        fieldName1 = "GridID"
        fieldLength1 = 4
        fieldName2 = "BuildingName"
        fieldLength2 = 255
        arcpy.AddField_management(footprintDissolveFeatureClass, fieldName1, "TEXT", "", "", fieldLength1)
        arcpy.AddField_management(footprintDissolveFeatureClass, fieldName2, "TEXT", "", "", fieldLength2)
        env.workspace = sourceGeoDb
        table = os.path.join(sourceGeoDb, buildingInfo)
        inFeature = footprintDissolveFeatureClass
        joinField = "OBJECTID"
```



# III. Where we're going

- Buildings are showing up in a GIS in the right place but some topology errors persist
- Manual check of every building (~ 500) once with:
  - Designer familiar with each building on campus
  - GIS specialist to make edits to geometry/attributes as needed

	A	B	C	D	E	F	G	H
1	Revit File:	exported to rvz file:	send rvz to lea (date)	recieved rvz file (date):	Georeferenced:	Project Info	Door Information:	exported to final shapefile:
2	F419	F419-Information Services Building	12/03/18	12/03/18	yes	yes	yes	13/03/18
3	F601	F601-Information Science Annexe	12/03/18	12/03/18	no	yes		
4	F603	F603-Property Services	12/03/18	12/03/18	no (maybe the units are wrong, see	yes		
5	F903	F903 UOCOE Drama Centre & Theatre	12/03/18	12/03/18	yes	yes	yes, but no door set to exterior	13/03/18
6	F904	F904 UOCE Childcare Centre	12/03/18	12/03/18	yes	yes	yes, but no door set to exterior	13/03/18
7	F905	F905 UOCOE Auditorium	12/03/18	12/03/18	yes	yes	yes	13/03/18



# Assets are more than just buildings, e.g.

- Doors
  - Public (non-public) entrances, electronic door monitoring, loading docks
- Interior layout of buildings, multiple levels, shared buildings
- Parking
- Information sites, points of interest
- Underground infrastructure
- Network infrastructure (e.g. wireless points)

And...

We have 3D geometry, so let's make use of that Z info!





# Integration with various services/platforms

- Timetabling
- Exam Office
- Blackboard
- E-vision
- Student App
- otago.ac.nz websites
- 3<sup>rd</sup> party software like Google Maps and bus Timetables
- ...



# Historical and cultural exploration on campus

- To tell the University's story
  - Augmented Reality / Virtual Reality tours
  - Printed and digital media
  - 150<sup>th</sup> anniversary celebrations
  - Create a strong sense of space and place

## Take a Handheld Trip into the Past With This Historic Augmented Reality App

PIVOTtheWorld is like a time machine for your smartphone.

SHARE  TWEET 

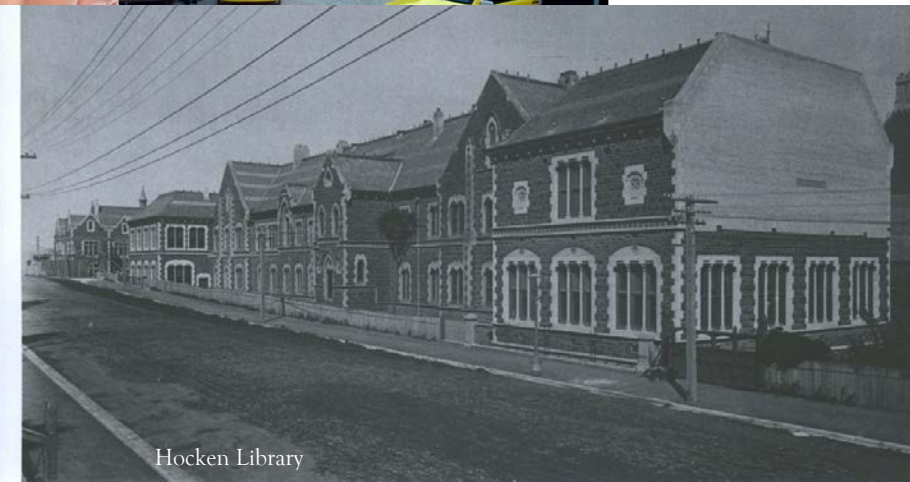
Sami Emory  
Feb 14 2015, 11:30am



<https://creators.vice.com>



<http://www.frontiere.eu/>



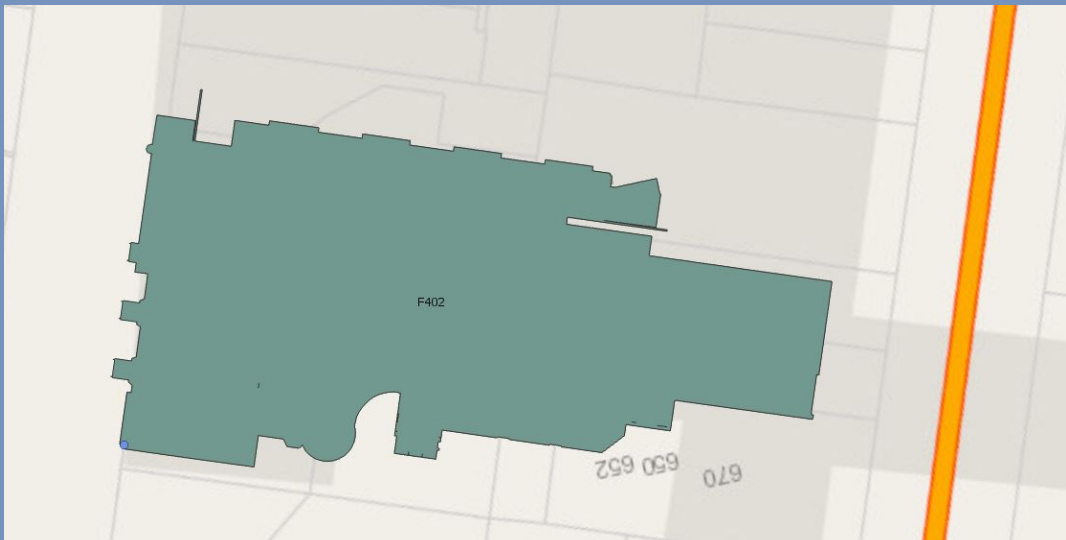
Hocken Library

# Some lessons learned

- The space between the worlds of architectural data and geospatial data is still vast
  - A lot of manual work goes into quality control checks even with tools designed to integrate datasets
  - Most institutions still update two systems separately
- METADATA and record keeping of asset data essential
  - Knowing what is where gets harder with older (maybe pre-digital) data and lots of data stewards

# Some lessons learned

- Large property holders like the uni. have to decide what kind of investment to make in spatial data
- Many universities face similar situation but the specific challenges are unique. Commercial growth in this area is gaining speed but slow, partly because of the unique challenges
- Much /most of the work is still done manually!



# Questions?

Thank you!



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OTAGO

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*Te Kura Kairūri*

Information Technology  
Services

*Te Wāhaka Matua Hakarau Mōhiohio*

UNIVERSITY OF OTAGO

Property Services

*Tiakina Whare Wānanga*