Mixed 2D and 3D Survey Plans with Topological Encoding

Rodney James THOMPSON, Australia,
Peter VAN OOSTEROM, The Netherlands,
Kean Huat SOON, Singapore

5th INTERNATIONAL WORKSHOP ON 3D CADASTRES
October 2016 – Athens

Aims

An encoding that will:

- Have minimal redundant data
- Carry the full 3D definition of spatial units
- Can also be used for 2D cadastre
- Allow a rich selection of geometric shapes

What is a Cadastral Survey Plan?

- Traditionally, a piece of paper which records the measurement and location of a cadastral parcel of land, which becomes the legal definition (in conjunction with title and/or deed documents)
- The need for a paper document is being challenged by digital counterparts
- But the requirements remain the same

Requirements of a "Plan"

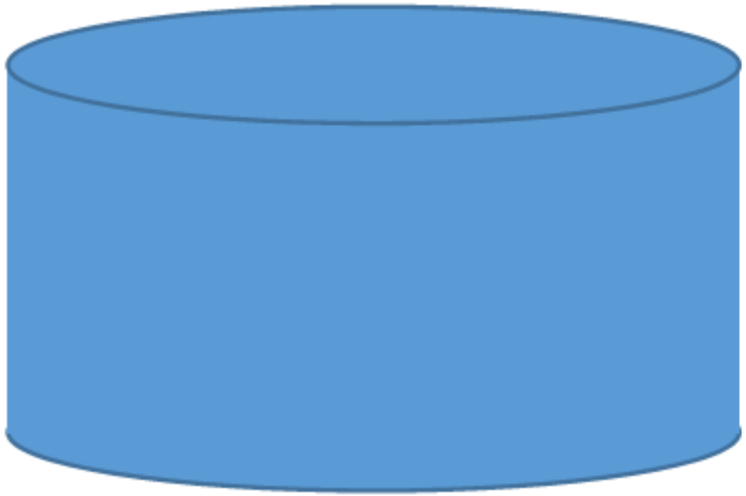
- Record the survey measurements
  - To assist with later surveys
- Define the cadastral property for registering RRRs
- Reassure interested parties (e.g. prospective buyers)
- Identify the property to municipal authorities

- In addition, information from the plan is amalgamated into a Cadastral Database

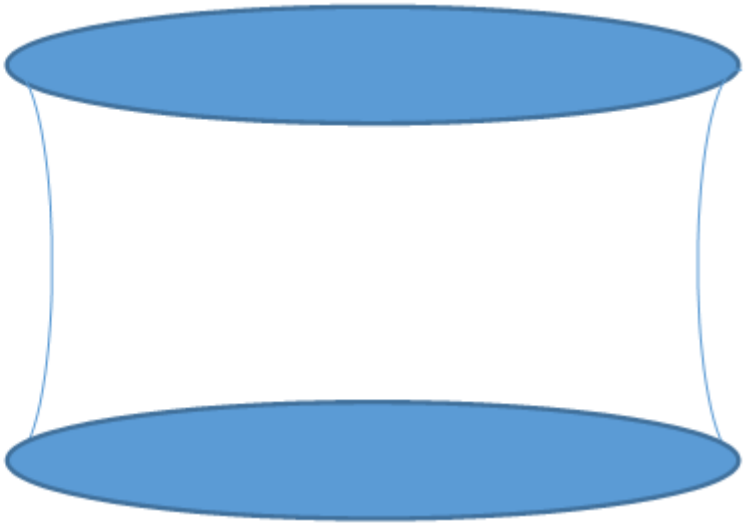
LandXML

- Exists, is supported by various tools and has been adopted in several jurisdictions
- It is fairly extensible – including to 3D
- Is not ideal as a transport format
  - Semantics are limited
  - Encoding of coordinates is incompatible with GML

Curved Surfaces in LandXML



A



B

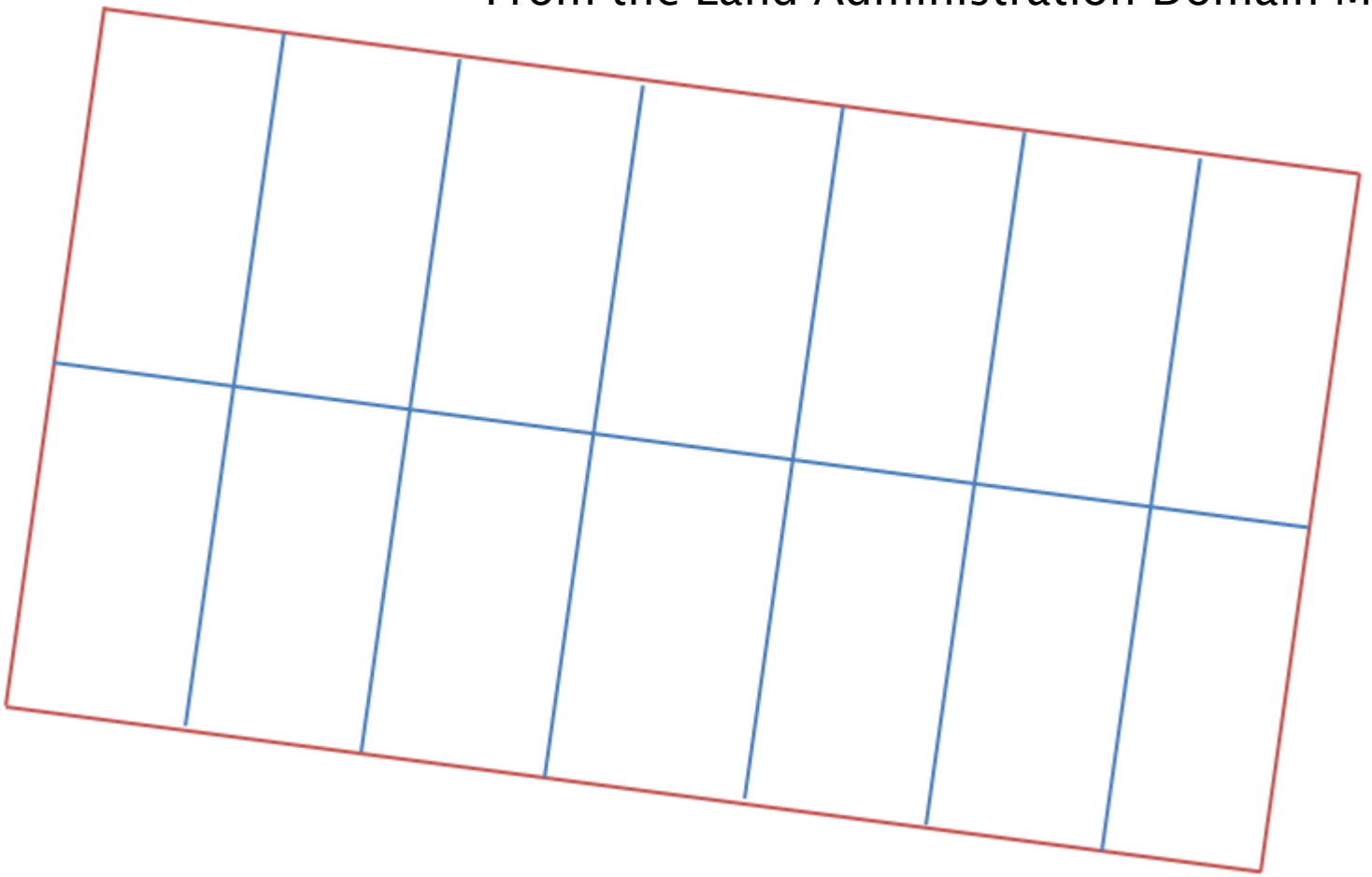
LandXML does have provision for some curved lines

It (bizarrely) does not actually have any way to define a surface
(It does have a way to define linear features and volumes)

So the surface can only be inferred from the bounding lines

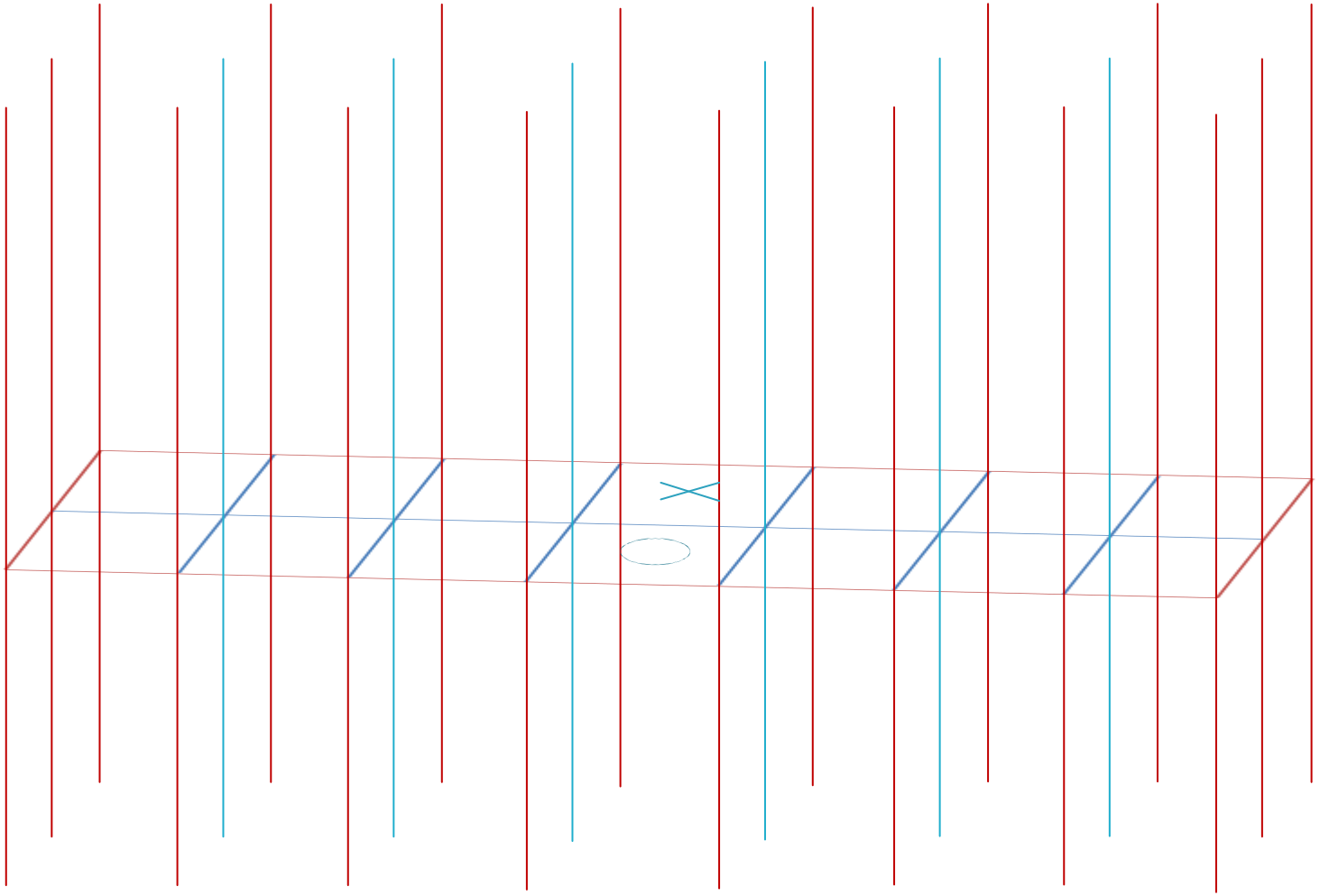
Recap of LA_BoundaryFaceString

From the Land Administration Domain Model



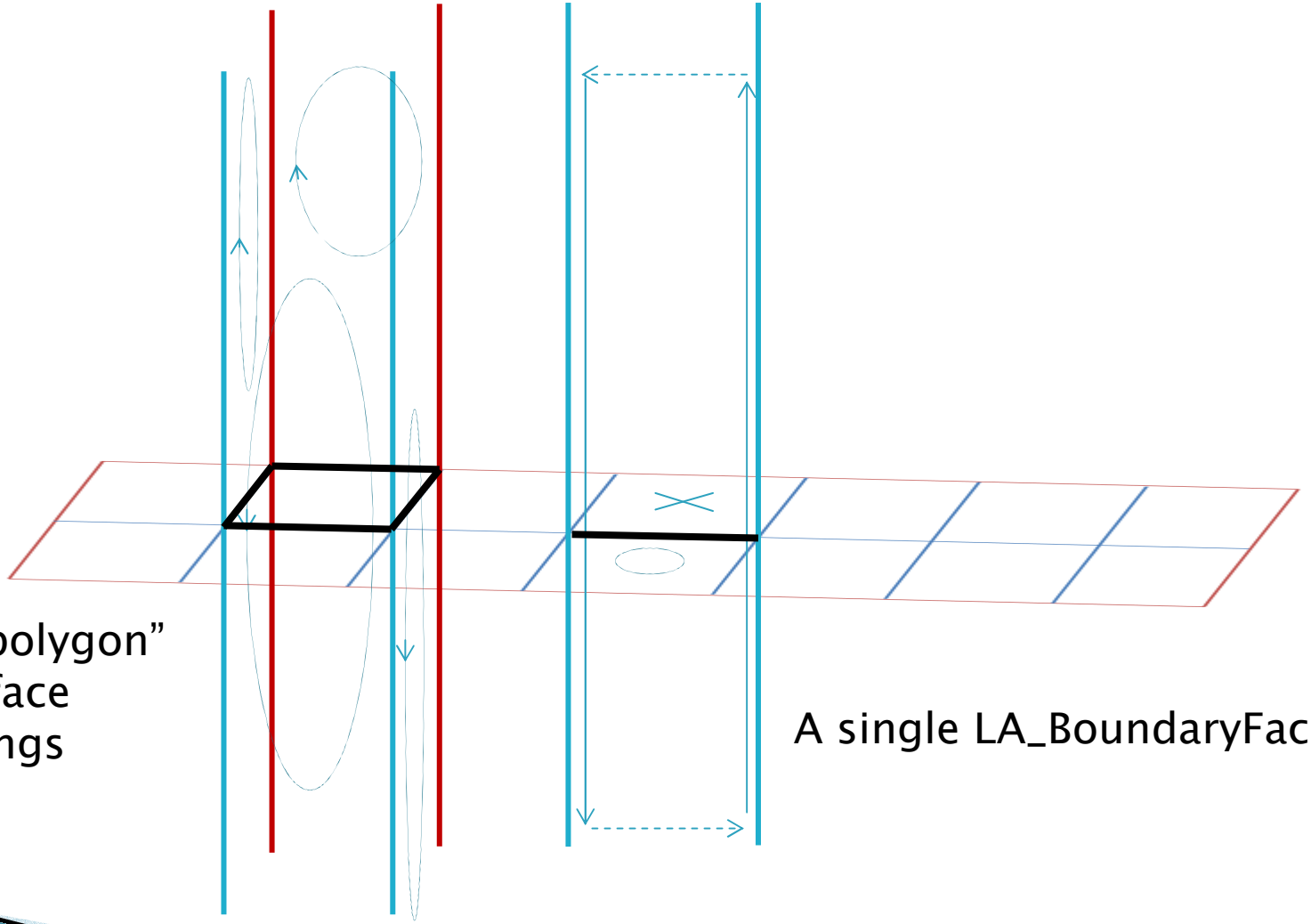
A 2D Cadastre

Recap of LA_BoundaryFaceString



A 2D Cadastre converted to 3D

Recap of LA_BoundaryFaceString

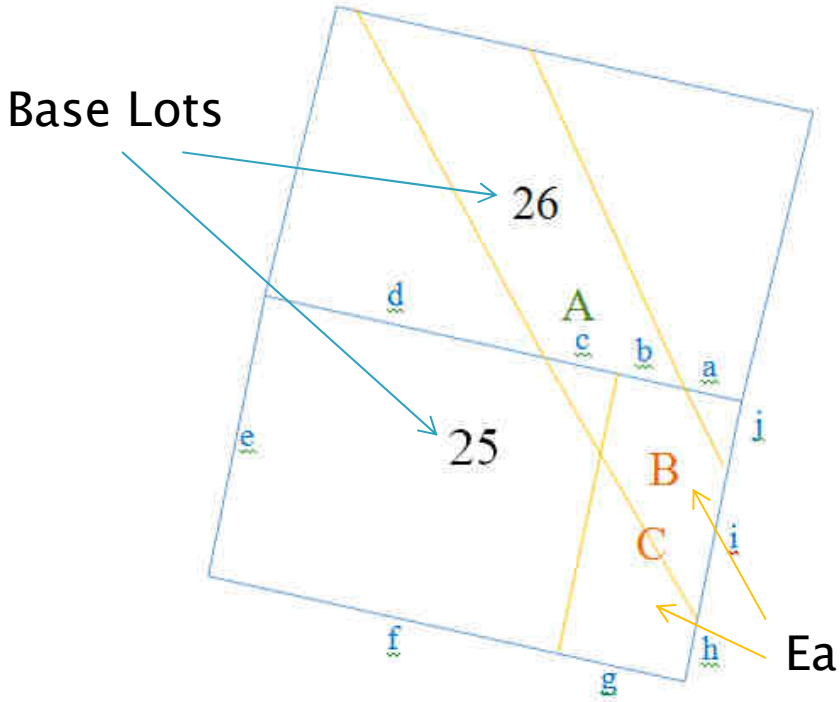


A “polygon”
Of face
strings

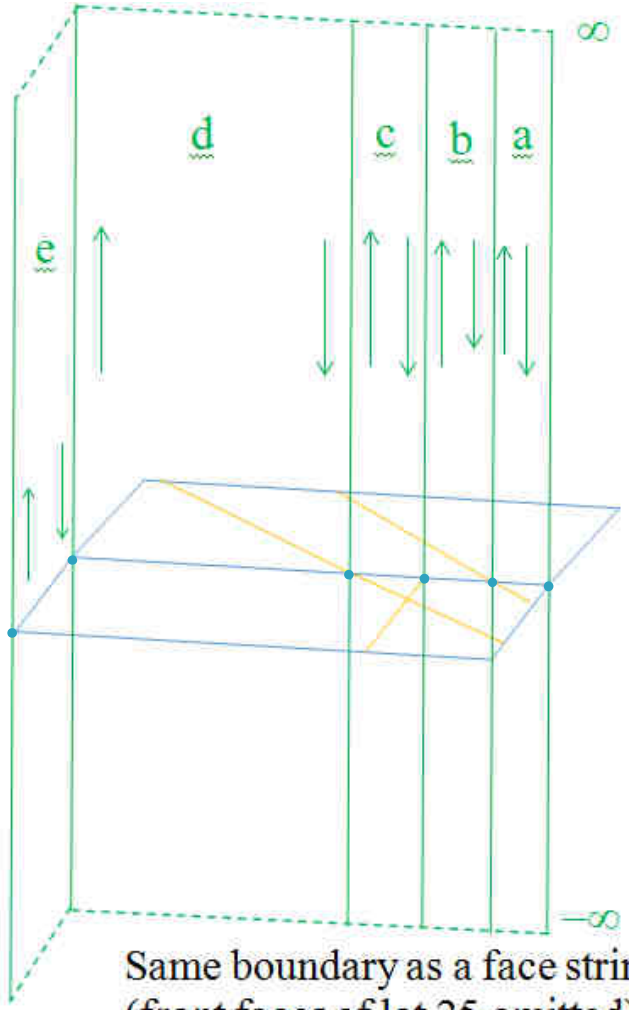
A single LA_BoundaryFaceString

More Complex Case

2D non-base parcels (Easements)

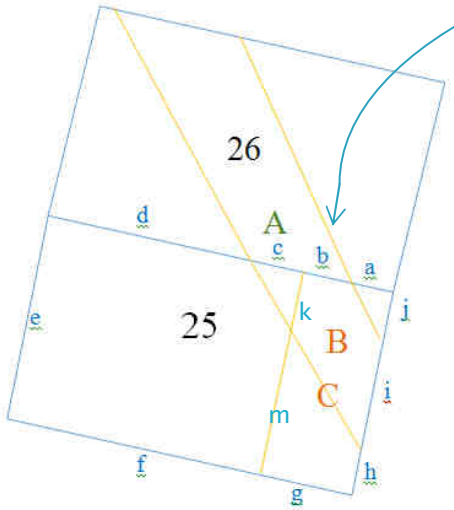


Boundary between Lots 25 and 26 as a linestring (a,b,c,d)

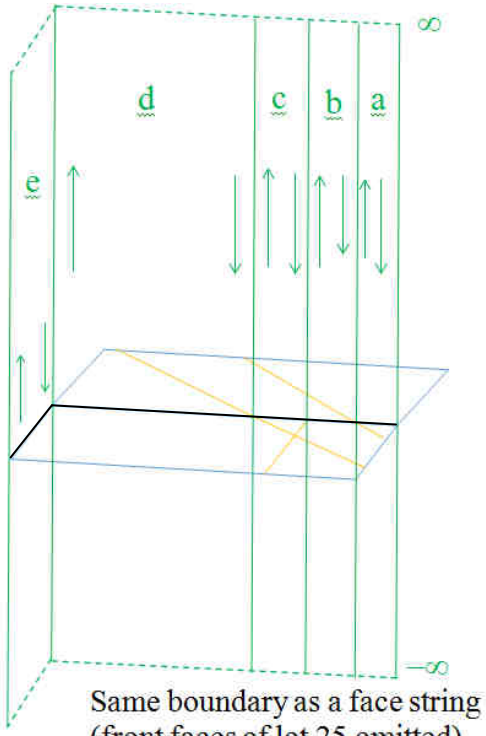


Same boundary as a face string (front faces of lot 25 omitted)

Topological Encoding



Boundary between Lots 25 and 26 as a linestring (a,b,c,d)



Same boundary as a face string (front faces of lot 25 omitted)

a has 25 and C on **left**;
26 on **right**;
b has 25, B and C on **left**;
26 and A on **right**;
c has 25 and B on **left**;
26 and A on **right**;
d has 25 on **left**,
26 on **right**;
e has 25 on **left**;

25 is defined by:
a,b,c,d,e,f,g,h,i,j
C is defined by:
a,b,k,m,g,h,i,j
26 by:
-d,-c,-b,-a, etc

Sharing of primitive by using references

Progress?

- So – now we have a topologically encoded 2D (quite ordinary) cadastral data structure – what's new?
- We think of it as "3D" now (and that doesn't cost anything)
- Now we can add true 3D spatial units

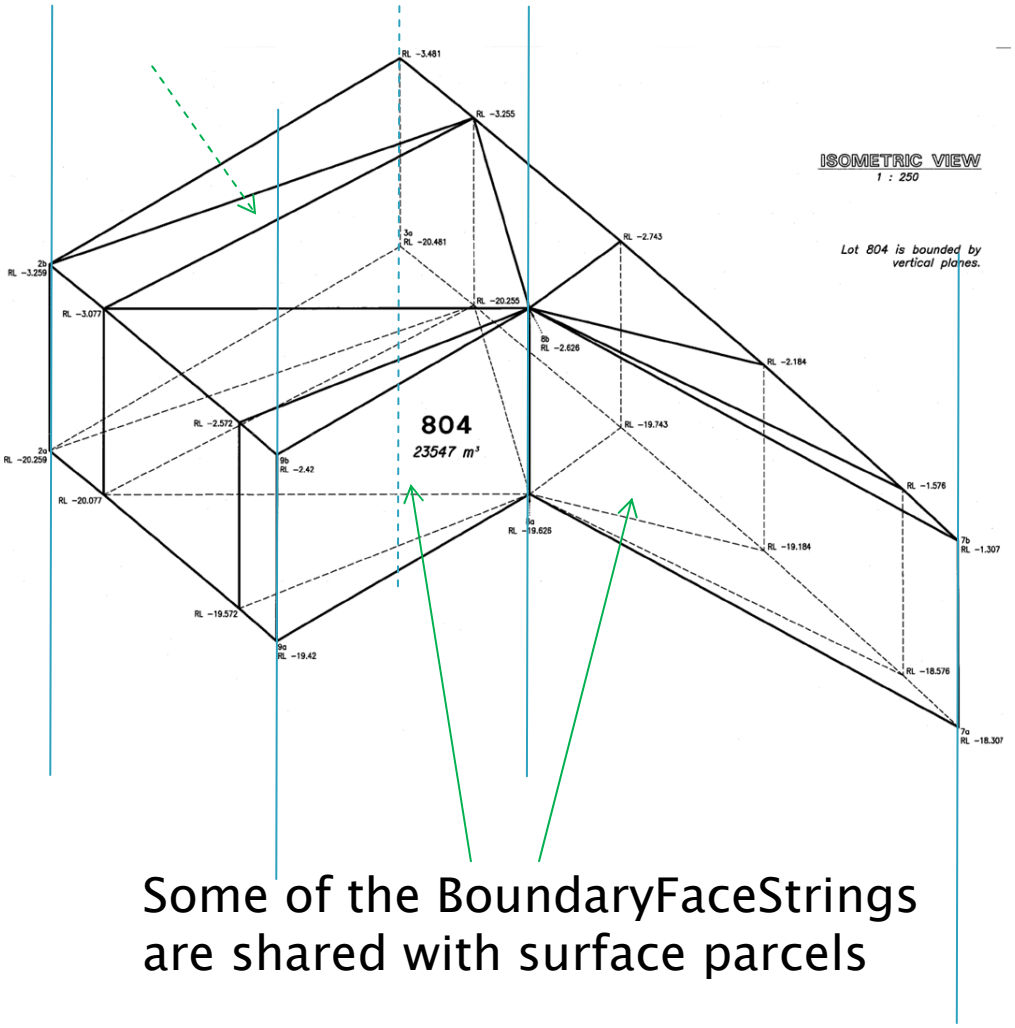
A 3D Spatial Unit

Part of a tunnel.

The sides are vertical, defined by the surface parcels above it.

The top and bottom are not horizontal, but triangulated by the designer to ensure planarity.

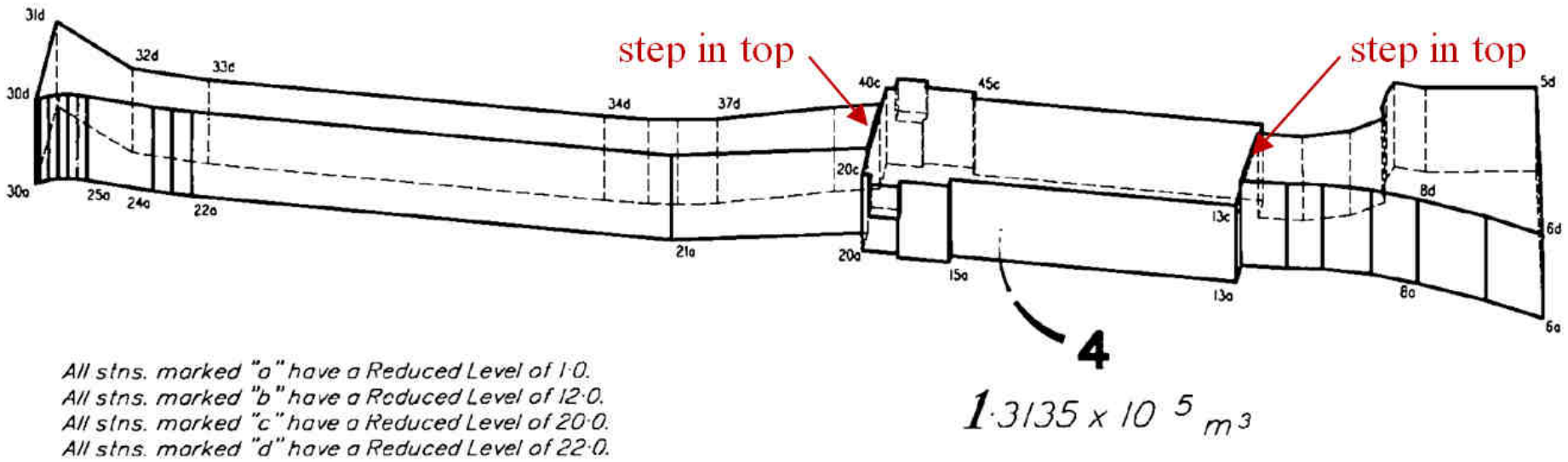
A set of (vertical) BoundaryFaceStrings, and a top and bottom will define it.



Some of the BoundaryFaceStrings are shared with surface parcels

Sharing of nodes and edges in BoundaryFaces

Another 3D Spatial Unit



Lot 4 is bounded by vertical & horizontal planes.

- Everything is horizontal or vertical
- The top and bottom are fairly simple
- Most complexity is in the BoundaryFaceStrings

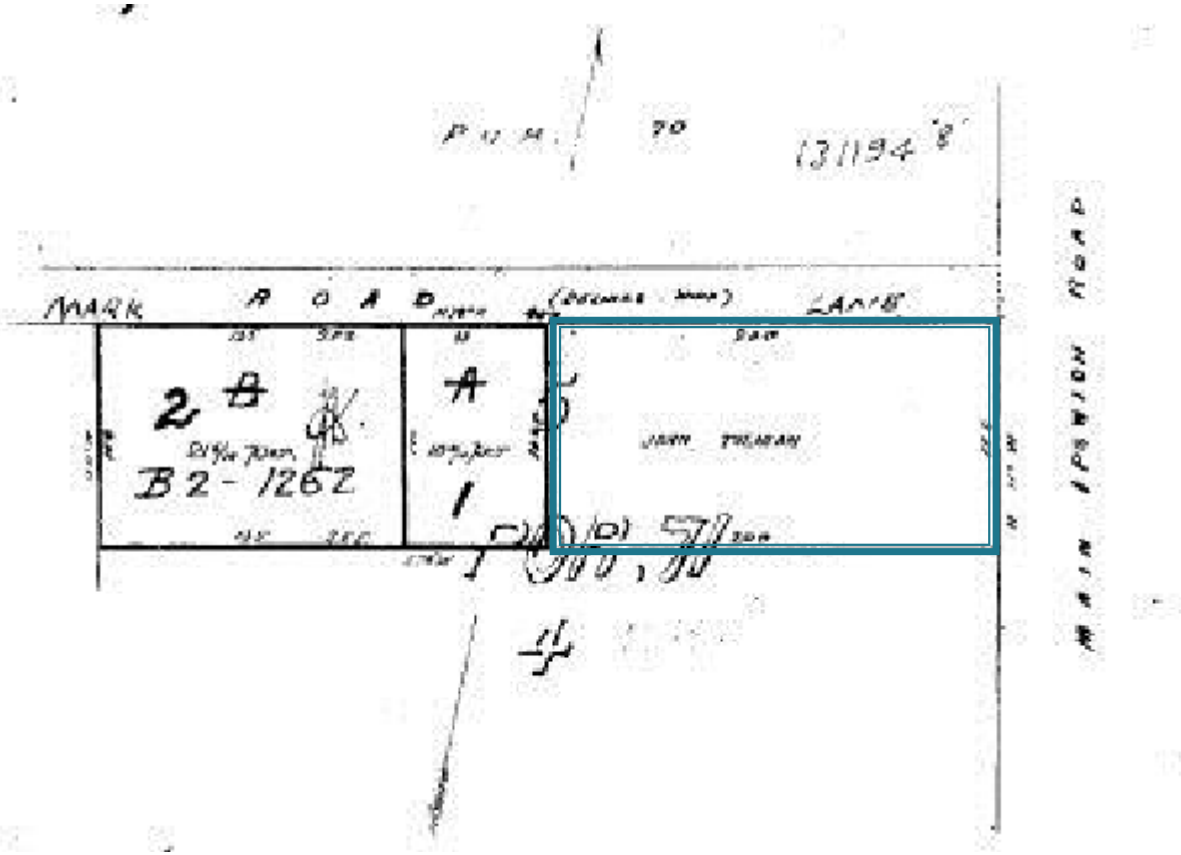
A Fairly Complex Real-world Case

History:

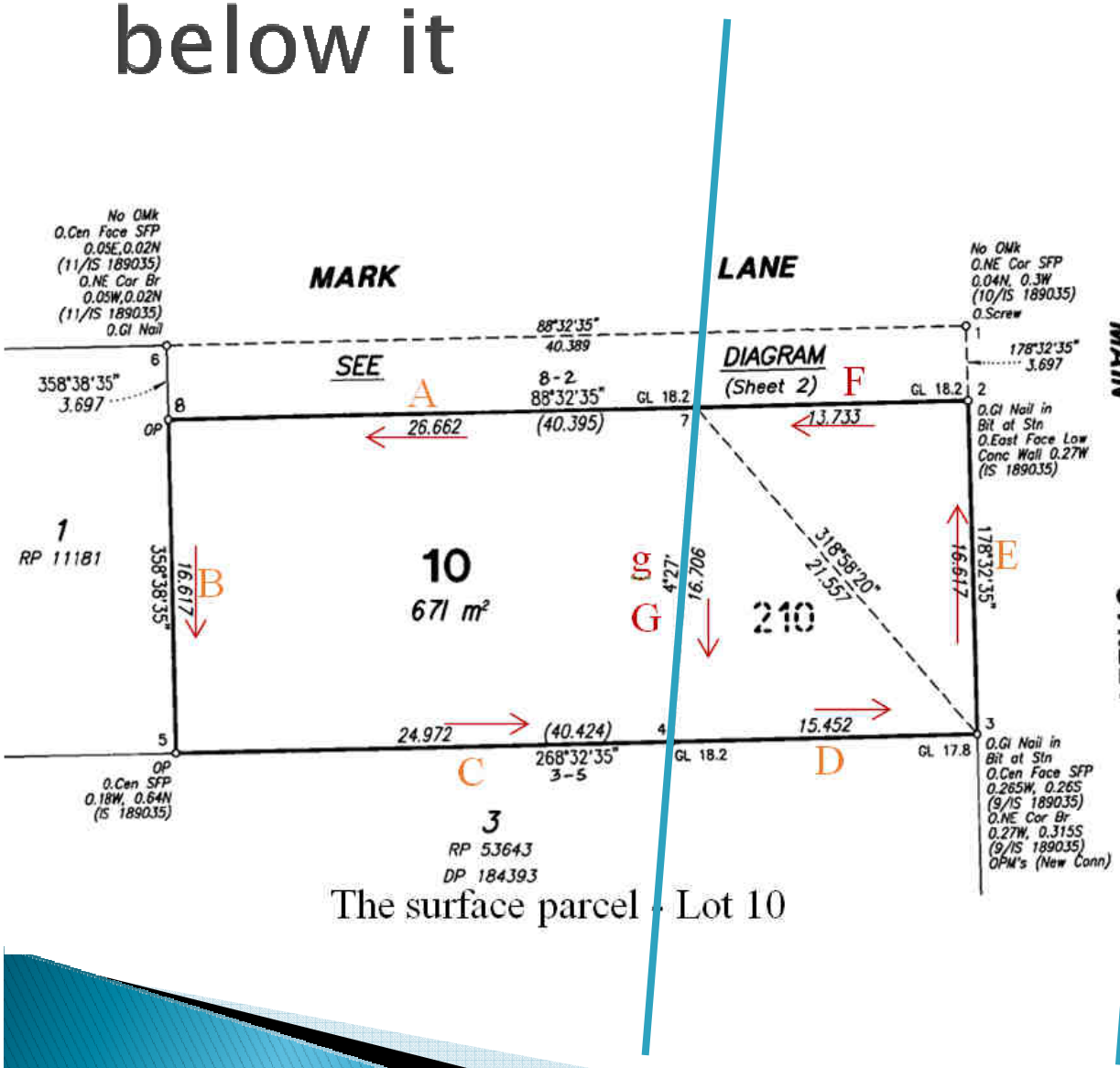
- Starting with a simple 2D parcel
- Part of a tunnel is put through below it
  - So that it becomes a 3D remainder spatial unit
- A 5 storey building is built on it
  - The corner is truncated to improve the traffic flow
  - The individual 3D building units are created

- Consider the chronological steps in the data structure:

As a simple 2D parcel



Part of a 3D tunnel is put through below it

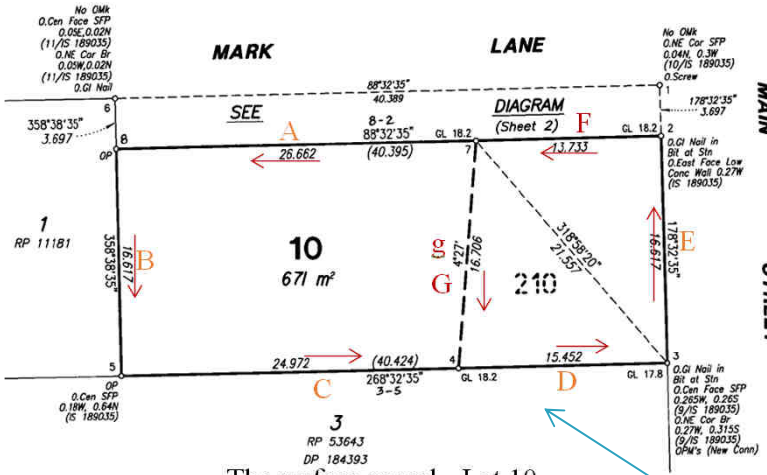


The surface parcel - Lot 10

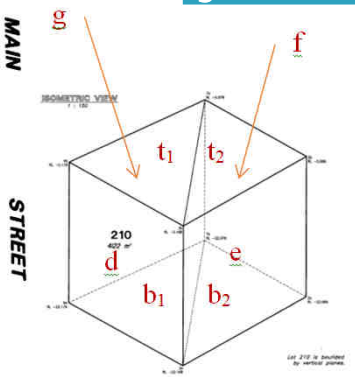
The tunnel parcel - Lot 210

Part of a tunnel is put through below it

Face	Inside spatial unit(s)	Outside spatial unit(s)
t_1	Lot 210	Lot 10
t_2	Lot 210	Lot 10
b_1	Lot 10	Lot 210
b_2	Lot 10	Lot 210
g	Lot 210	Lot 10



The surface parcel - Lot 10



The tunnel parcel - Lot 210

Add the faces

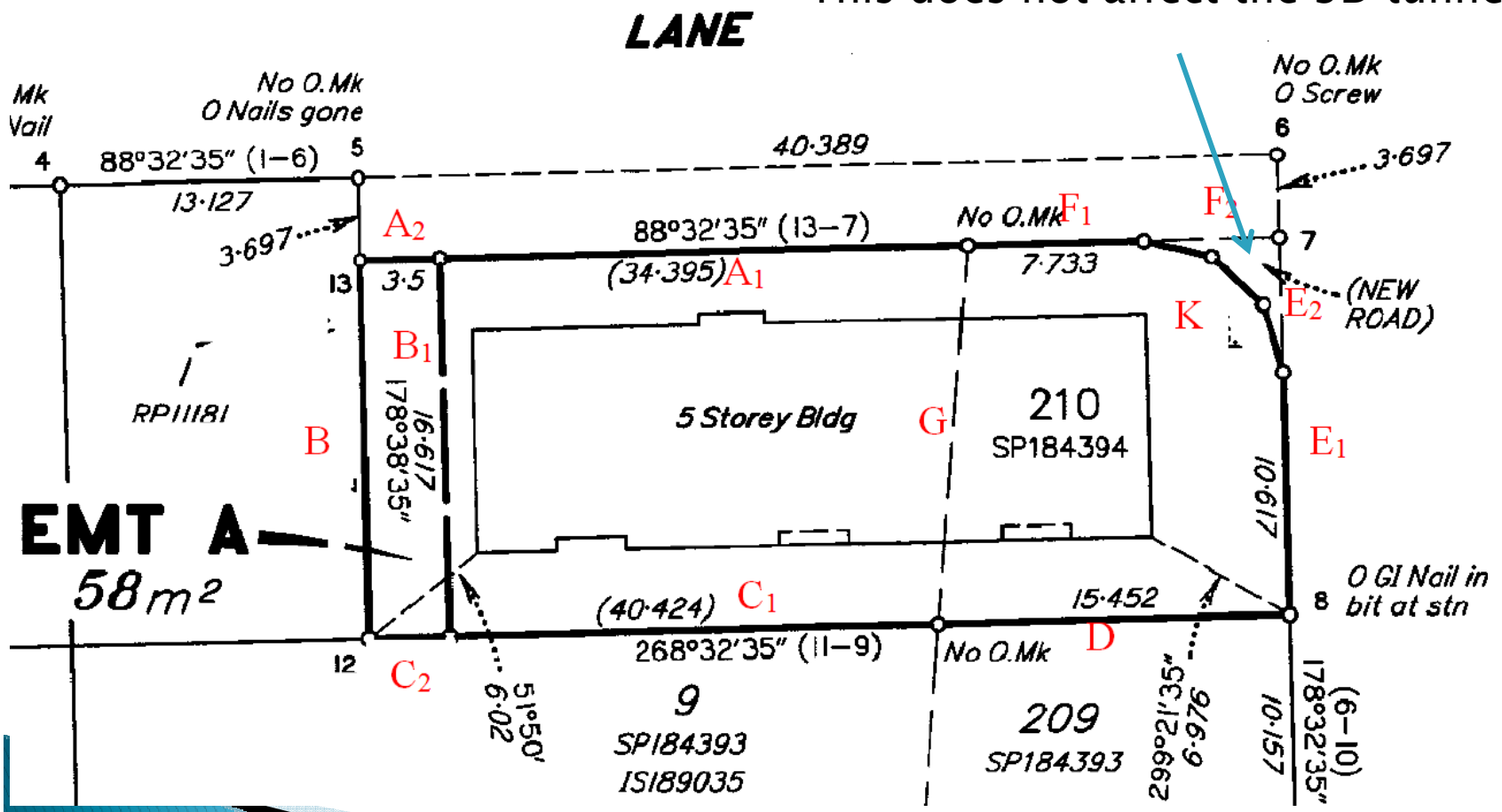
No need to add faces d ,e, f because they are within D, E, F

Break the lines
(as we did in 2D)
Encode the 3D lot
(as if it were 2D)

Line	Left spatial unit(s)	Right spatial unit(s)
A	Lot 10	Road
B	Lot 10	Lot 1/RP11181
C	Lot 10	Lot 3/RP53643
D	Lot 10, Lot 210	Lot 3/RP53643
E	Lot 10, Lot 210	Road
F	Lot 10, Lot 210	Road
G	Lot 210	

A 5 Storey Building is Built

Corner is truncated to improve traffic flow
This does not affect the 3D tunnel parcel

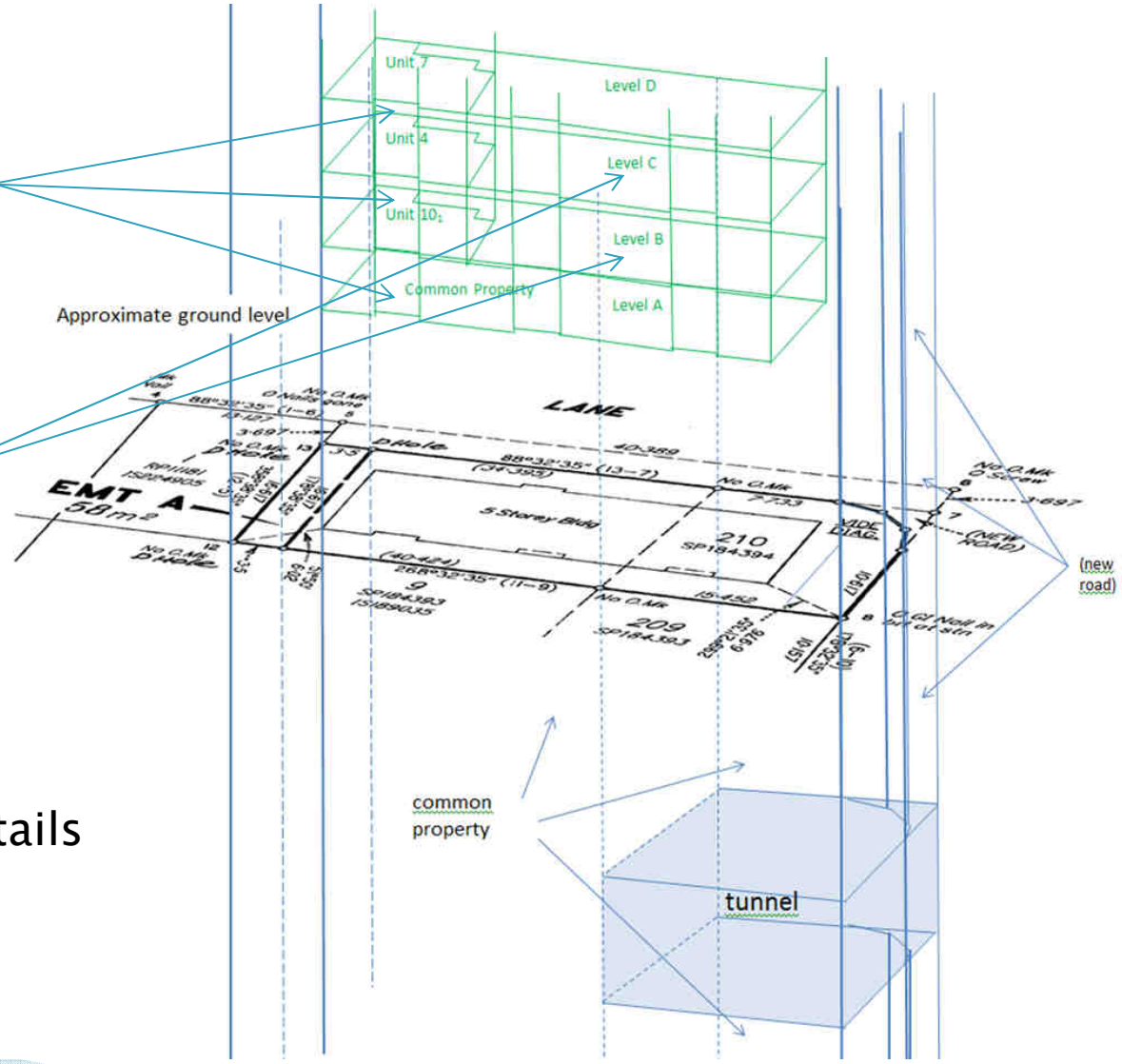


Units in the building are created

BoundaryFaceStrings are shared between units on different levels

Floors and ceilings are shared from units to the ones above / below them

More encoding details in the paper



LandXML fragment

BoundaryFaceStrings

BouddaryFaces

3D SpatialUnits

Points

```
<Parcel class="FaceString" name="B">
  <CoordGeom><Line><Start pntRef="13"/><End pntRef="12"/></Line>...</CoordGeom>
</Parcel>
<Parcel class="FaceString" name="C2">
  <CoordGeom>...</CoordGeom>
</Parcel>
<Parcel class="FaceString" name="N">
  <CoordGeom>...</CoordGeom>
</Parcel>
...
<Parcel class="Face" name="t2">
  <CoordGeom desc="Polygon3D">...</CoordGeom>
</Parcel>
<Parcel class="Face" name="Bottom Lot 10/1">
  <CoordGeom desc="Polygon3D">...</CoordGeom>
</Parcel>
...
<Parcel class="Easement" name="A" parcelFormat="Standard">
  <Parcels>
    <Parcel pclRef="B" /> <Parcel pclRef="C2" />
    <Parcel pclRef="B2" /> <Parcel pclRef="A2" />
  </Parcels>
</Parcel>
<Parcel class="LOT" name="4" parcelFormat="Volumetric">
  <Parcels>
    <Parcel pclRef="L" /> <Parcel pclRef="M" />
    <Parcel pclRef="N" /> <Parcel pclRef="P" />
    <Parcel pclRef="Q" /> <Parcel pclRef="-Bottom Lot 10/1" />
    <Parcel pclRef="Bottom Lot 4" />
  </Parcels>
</Parcel>
<Parcel class="LOT" name="10/1" parcelFormat="Volumetric">
  <Parcels>
    <Parcel pclRef="L" /> <Parcel pclRef="M" />
    <Parcel pclRef="N" /> <Parcel pclRef="P" />
    <Parcel pclRef="Q" /> <Parcel pclRef="Bottom Lot 10/1" />
    <Parcel pclRef="-Bottom Lot 7" />
  </Parcels>
</Parcel>
<CgPoint name="12" state="existing" oID="6636442" pntSurv="boundary">2000 1000</CgPoint>
<CgPoint name="13" state="existing" oID="6630143" pntSurv="boundary">1999.891 1016.617</CgPoint>
```

Conclusion

- Encoding in this form reduces the redundancy of the data
  - This reduces the possibility of gaps / slivers / overlaps
- The data can be viewed as if it were a 2D plan
  - Simply ignoring the faces allows any 2D software to be used
- The approach can be extended to create a full 3D cadastral data base
  - Which can similarly be viewed “as if” 2D

LandXML Encoding of Mixed 2D and 3D Survey Plans with Topology

Rodney James THOMPSON, Australia,
Peter VAN OOSTEROM, The Netherlands,
Kean Huat SOON, Singapore

5th INTERNATIONAL WORKSHOP ON 3D CADASTRES
October 2016 – Athens