

# 3D Cadastres: 30 years back, 30 years ahead.

Rod Thompson  
FIG 3D Cadastres workshop  
2-4 October 2018, Delft NL.

# Looking back 30 years

# 1988

- ▶ 1988 was the year the world came to Brisbane



## WORLD EXPO 88

### Leisure in the Age of Technology



# Looking back 30 years

# 1988

- ▶ 1988 was the year the world came to Brisbane
- ▶ 1788 was the year a bunch of convicts arrived in Australia



Not everyone  
agreed that this  
was a good idea

But we celebrated  
anyway in 1988

# Looking back 30 years

# 1988

- ▶ 1988 was the year the world came to Brisbane
- ▶ 1988 was the bi-centenary of a bunch of convicts being transported to [Australia](#)
- ▶ In 1988, the data capture for the Queensland Digital Cadastral Data Base (DCDB) was about half complete

# What was a Cadastre Prior to Digitization?

- ▶ A collection of plans of survey that defined the spatial extents
- ▶ A collection of title documents that made the connection between the spatial extent and the owner (or interested party)
- ▶ A collection of records of transaction

All on paper

# What was a Cadastre Prior to Digitization?

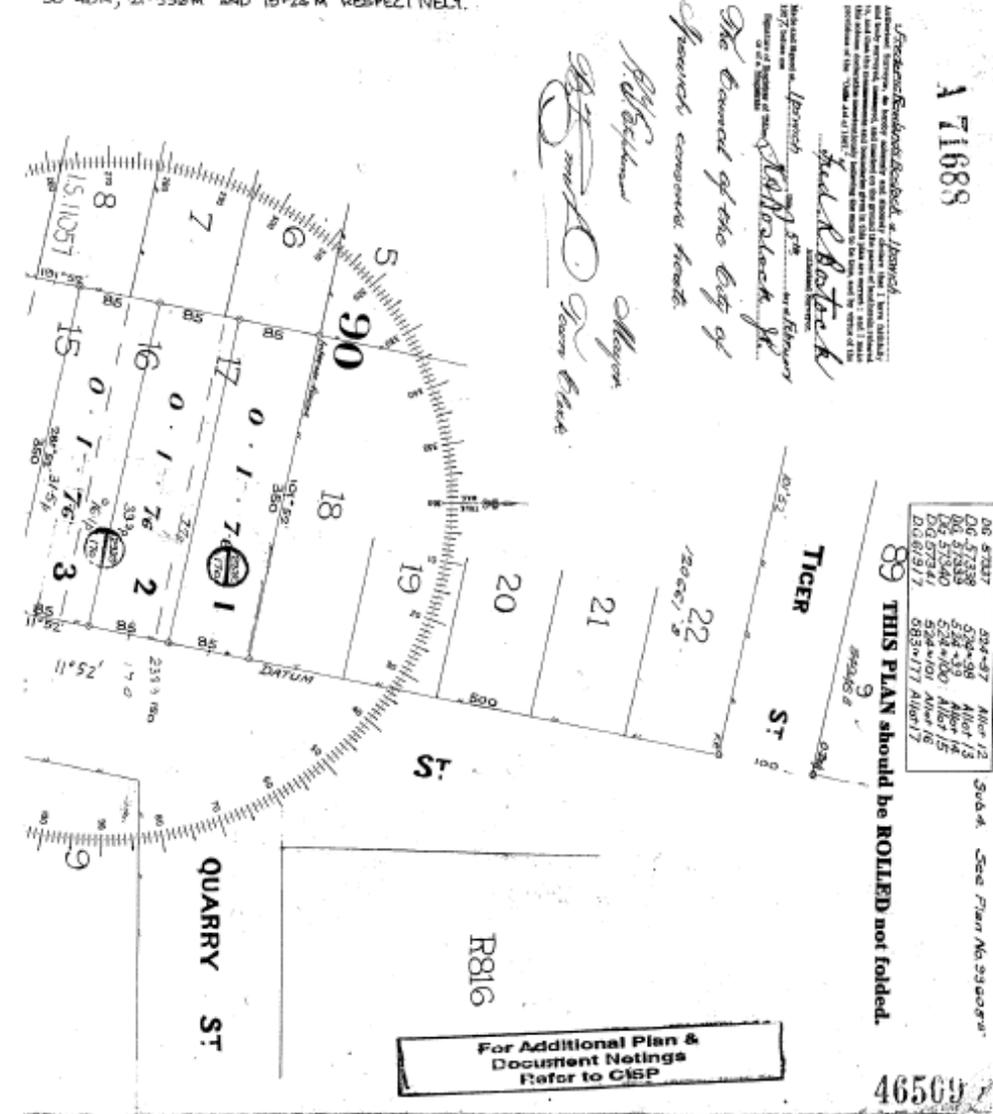
- ▶ Data from the plans was copied to make “working maps”
- ▶ Printed cadastral maps were created from the plan data (by cartographers and draftsmen).
- ▶ Important information that could affect tenure was pencilled onto the working maps

All manually

# 3D Cadastre in Queensland Prior to 1988

- ▶ Land parcels “to the depth of” – this plan from 1927
- ▶ The concept of Strata Titles arrived in the late 1980’s
- ▶ Timeshare Apartments

LOT 3 IS TO THE DEPTH OF 30.48 M  
 LOT 5 " " " " " " 21.336 M  
 LOT 6 " " " " " " 15.24 M  
 LOTS 13, 15 & 16 ARE BELOW LOTS 3, 5 & 6  
 RESPECTIVELY AND ARE BELOW THE DEPTHS OF  
 30.48 M, 21.336 M AND 15.24 M RESPECTIVELY.



46509

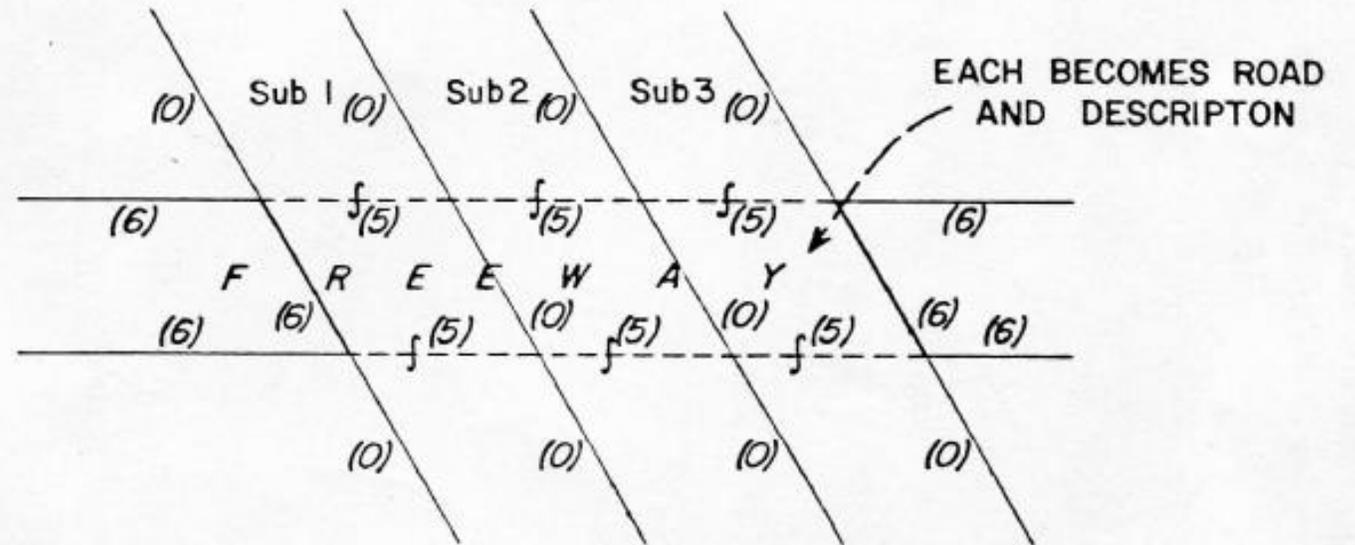
46509

# Early 3D Cadastral Issues

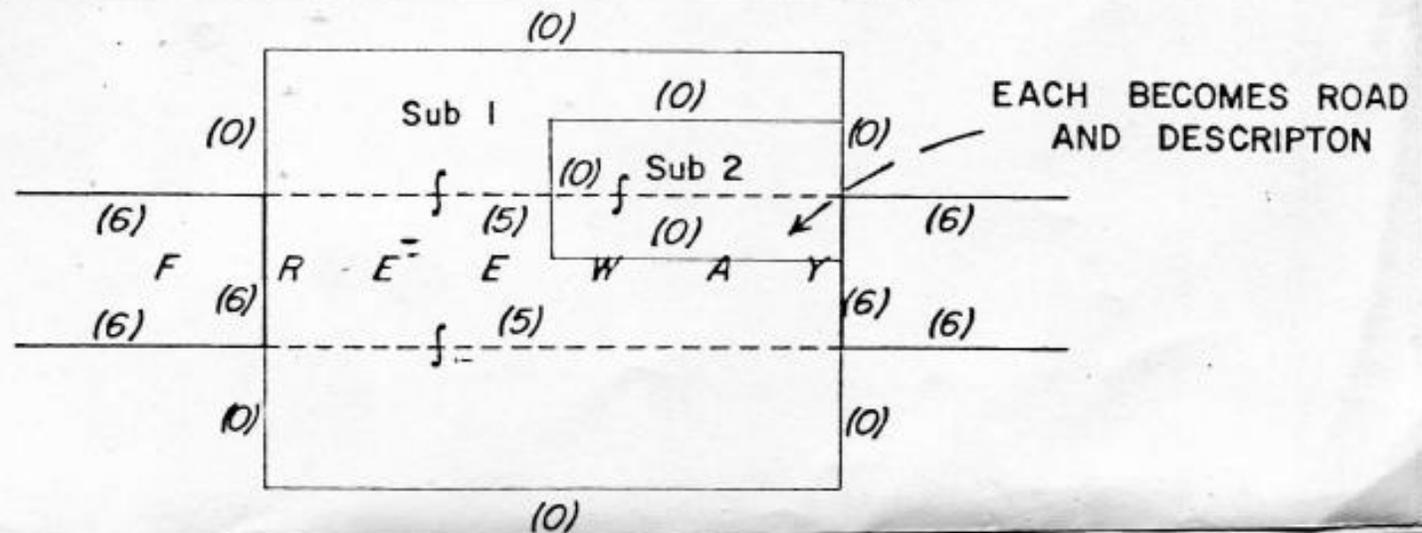
- Land over/under freeways

## MULTILAYER SITUATIONS :

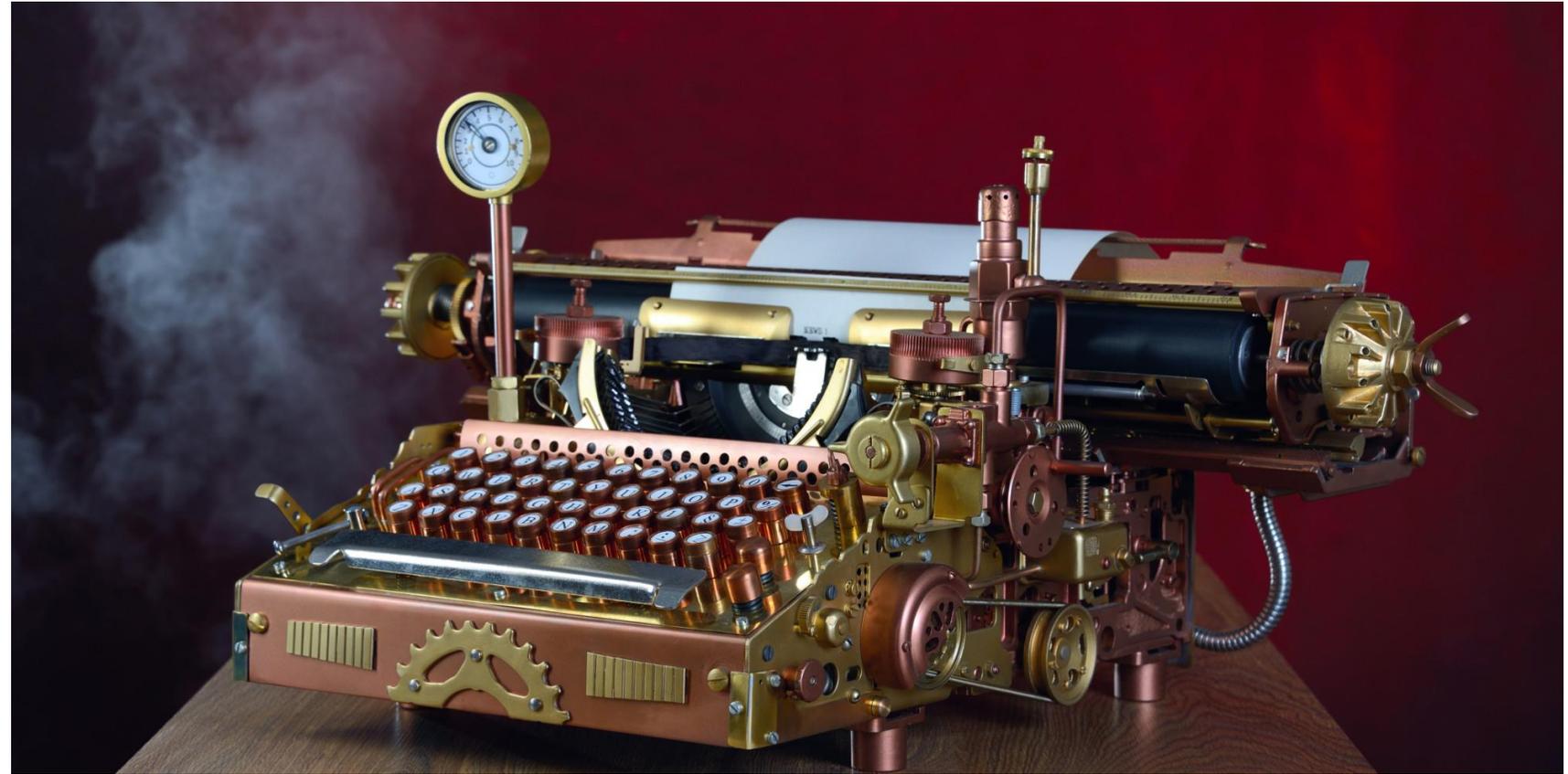
### FREEWAY PASSING OVER SURVEYED BLOCKS



### FREEWAY PASSING UNDER SURVEYED BLOCKS



# Technology – Then, Now, and in the Future



# Technology in 1988

## Leisure in the Age of Technology (Expo 1988)



The Mobile Phone was new technology (very expensive)  
Two robot arms doing a “Lion Dance” in the Japan Pavilion  
Floppy discs

BBC Domesday Project

# Technology in 1988

## What we Didn't Have

No Google Earth (no Google even)

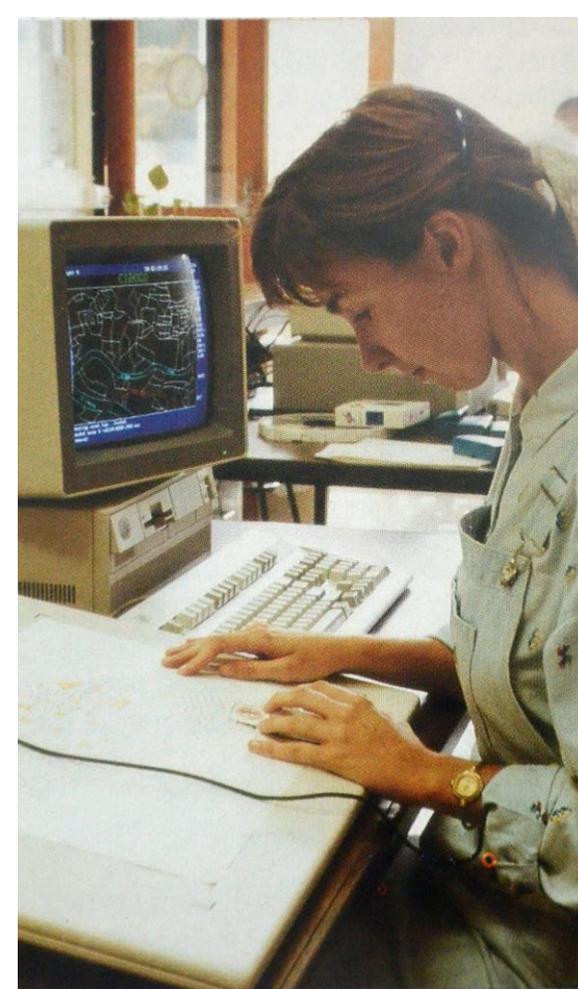
Internet existed, but was for specialised users

Personal computers were expensive and bulky

Who could ever need more than 640k of memory?

WWW (not until 1989), HTML, HTTP, URL

“a clear case for  
a digital  
approach”



# The Digital Cadastre Project in 1988

Divett, N. G. and J. de Lange (1983). Queensland's Digital Cadastre, A Challenge for Land Information Collectors. The Digital Cadastre 1983 Seminar. Qld University of Technology, Brisbane, Australian Institute of Surveyors.

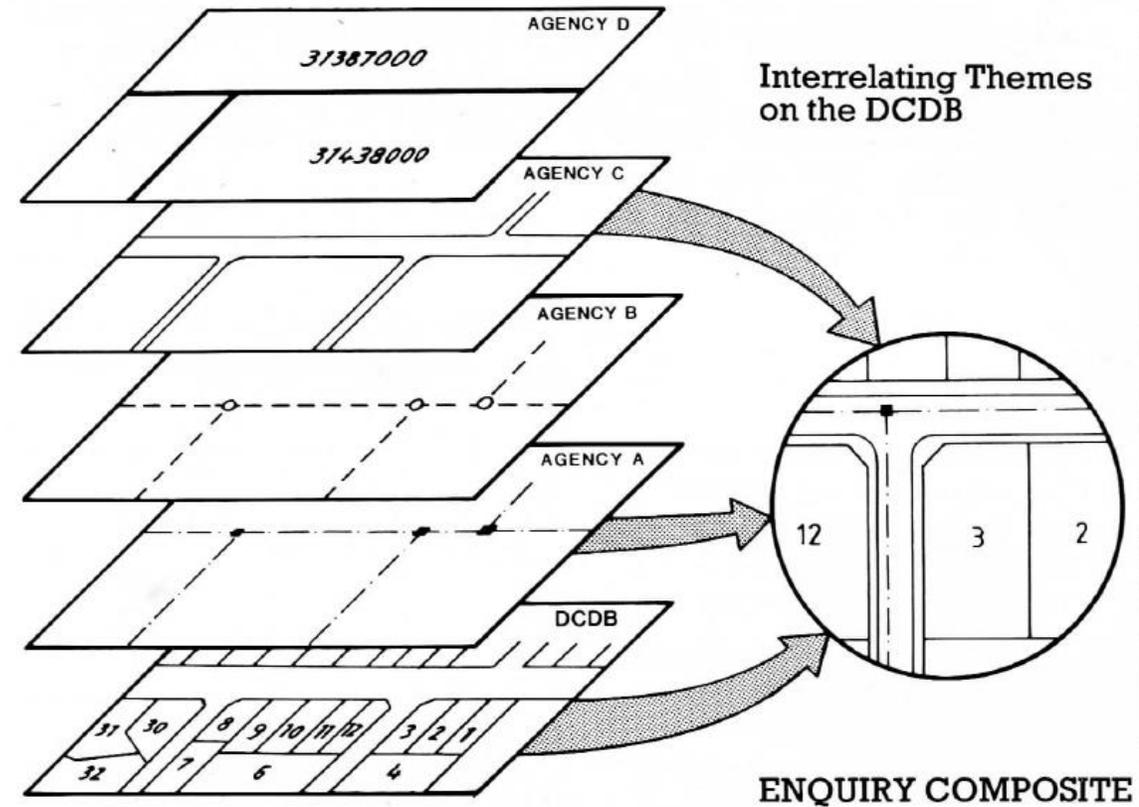
# The Digital Cadastre in 1988

Still to be decided (in 1988)

- ▶ What to Capture
- ▶ How to store the data we were capturing
- ▶ How to distribute it to the many other users

# 1988

The Digital Cadastral Database was the largest scale and most accurate data available over large areas, so other authorities were desperate to use it – Electricity, water, telecom etc.

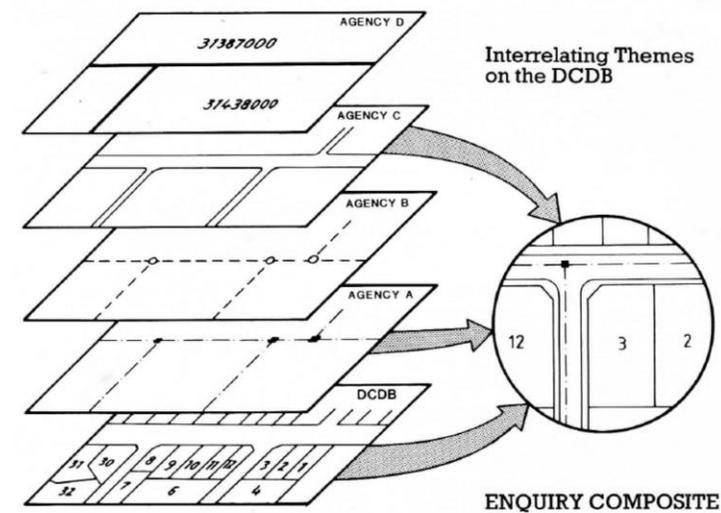


From a "Computer Information Sheet" of the time.

# Underground Assets

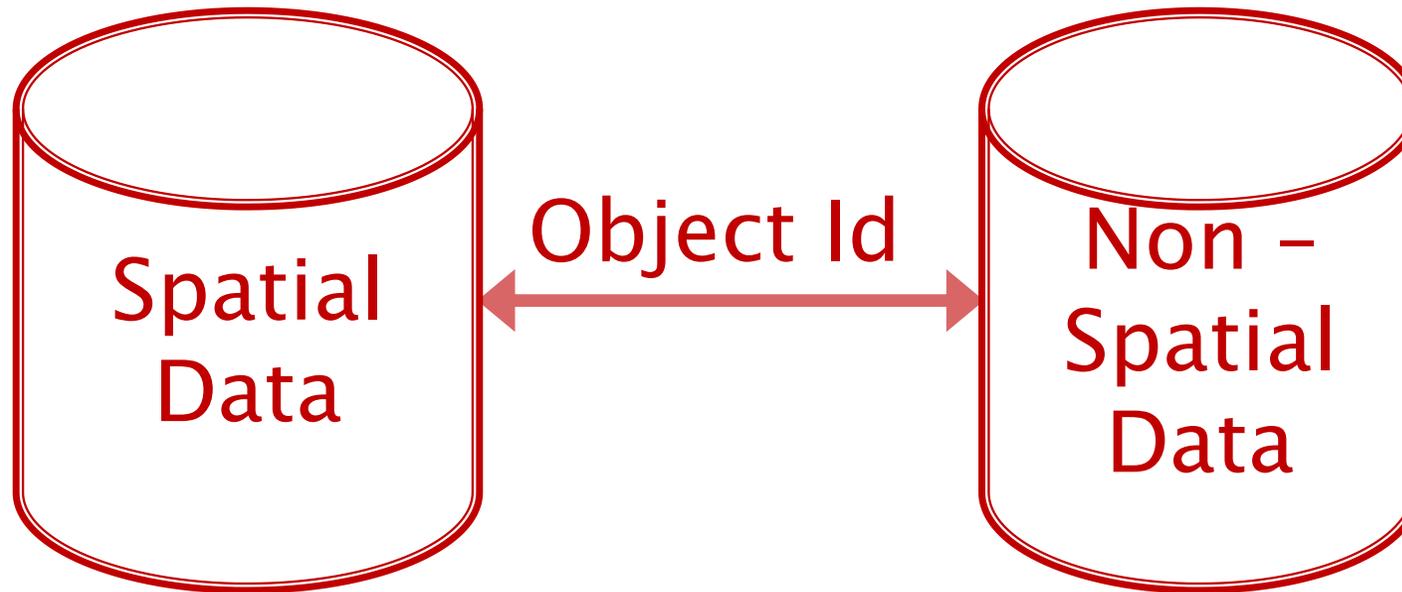


Need a good base map to record what's below ground



# Database Technology in 1988

Quite expensive  
textural terminal



Very expensive  
graphics terminal

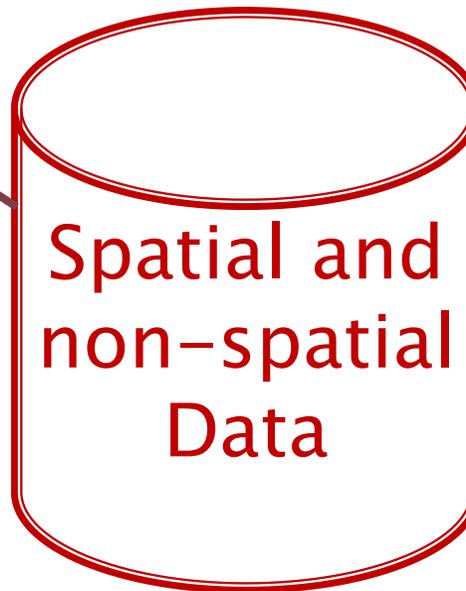
# Technology in 1988

Under  
Development



Expensive PC with a graphics adapter (CGA, EGA or VGA)

Enquiry  
only



Spatial and  
non-spatial  
Data

# 3D Cadastre Today

- ▶ 2D parcels with depth/height restrictions
- ▶ Strata Title Units and Timeshare
- ▶ Volumetric Spatial units
- ▶ Utility Networks
- ▶ Public Law Restrictions
- ▶ Development applications
- ▶ **But the Cadastral Databases are 2D or 2D+t**

# Why include extra “Layers” of information?

- ▶ Certainly the public authorities are not keen on spending money to do so!
- ▶ Why change the current situations?

Because we are good at this sort of thing! \*

Why set up new infrastructures, and re-invent the wheel?

# 3D Cadastre Today

Restricted 2D parcels (to the depth of)

## Strata Title Units

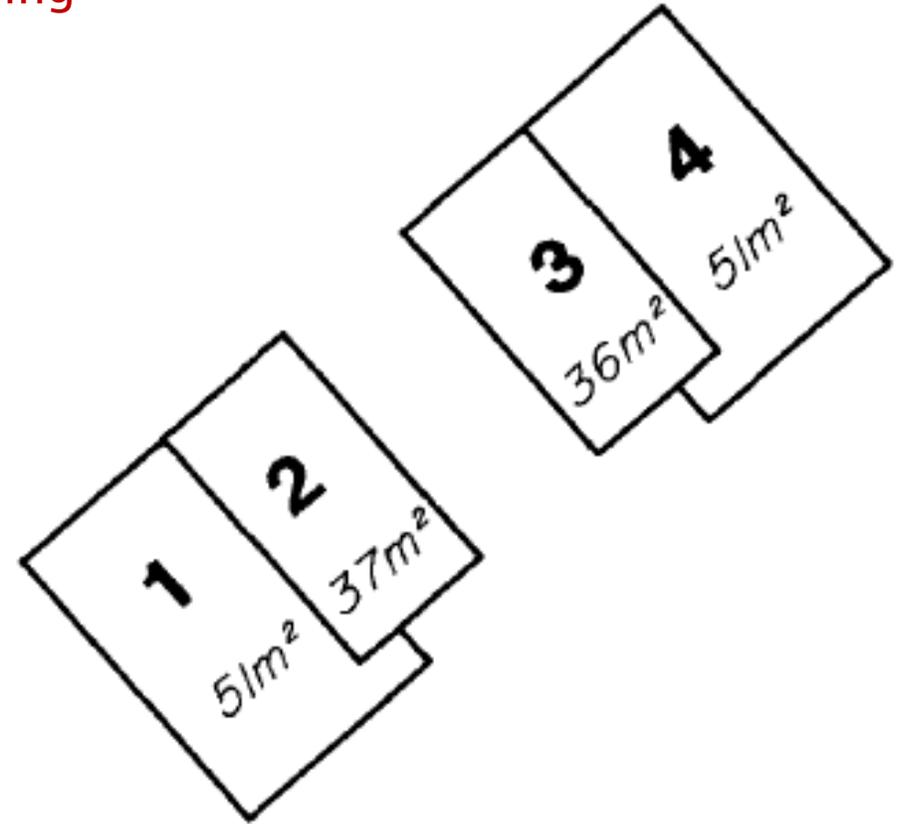
Volumetric Spatial Units

Utility Networks

Public Law Restrictions

Development Applications

Extents are defined by the walls of the building



# 3D Cadastre Today

Restricted 2D parcels (to the depth of)  
Strata Title Units

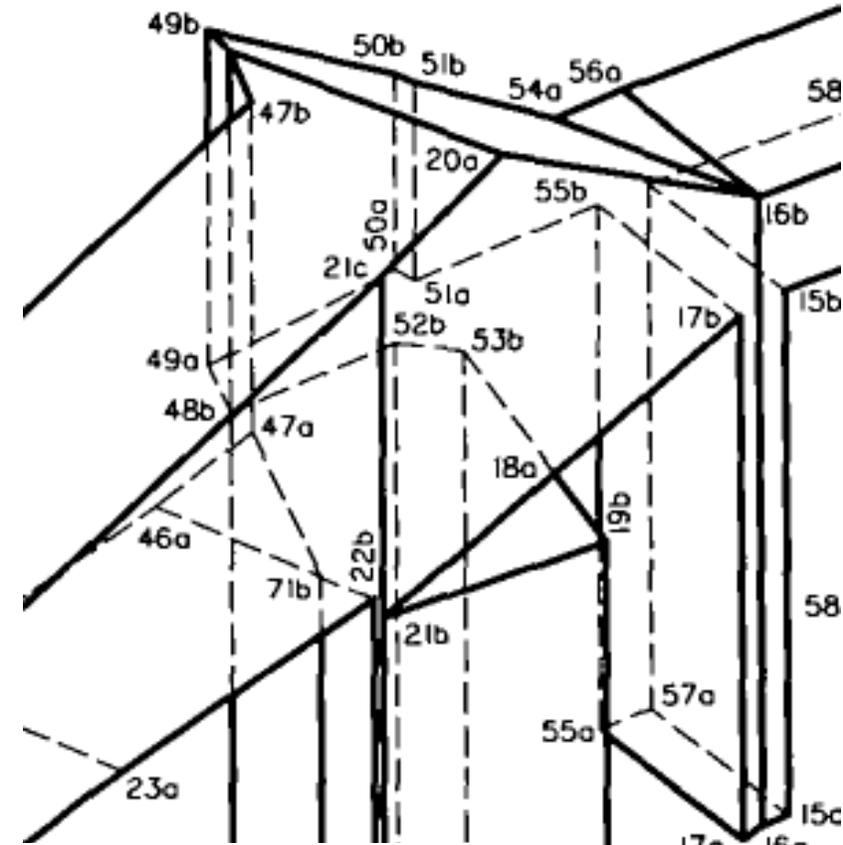
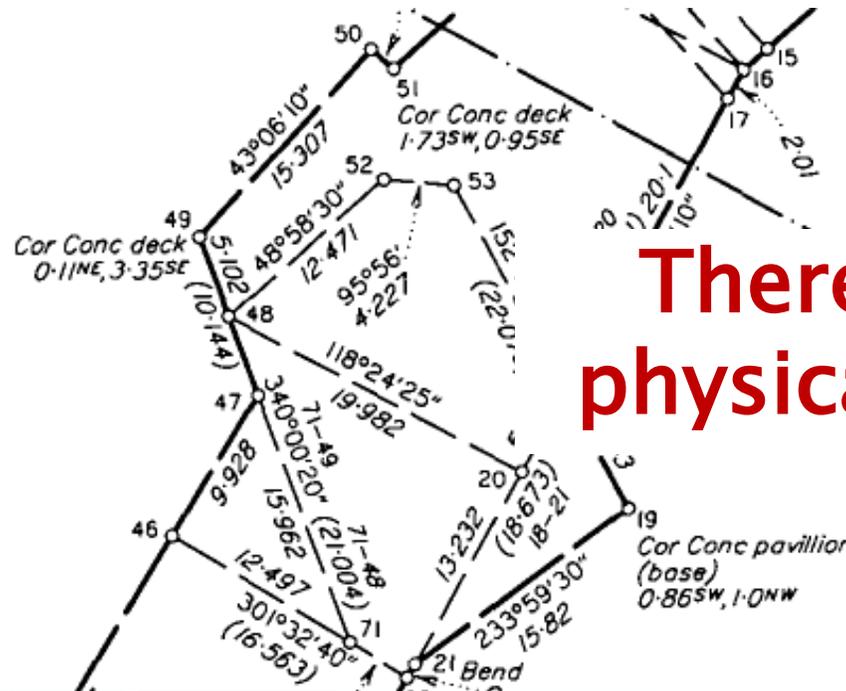
## Volumetric Spatial Units

Utility Networks

Public Law  
Restrictions

Development  
Applications

Extents are defined by measurements



There may be no  
physical object (yet)

17  
17m<sup>3</sup>

# 3D Cadastre Today

Restricted 2D parcels (to the depth of)

Strata Title Units

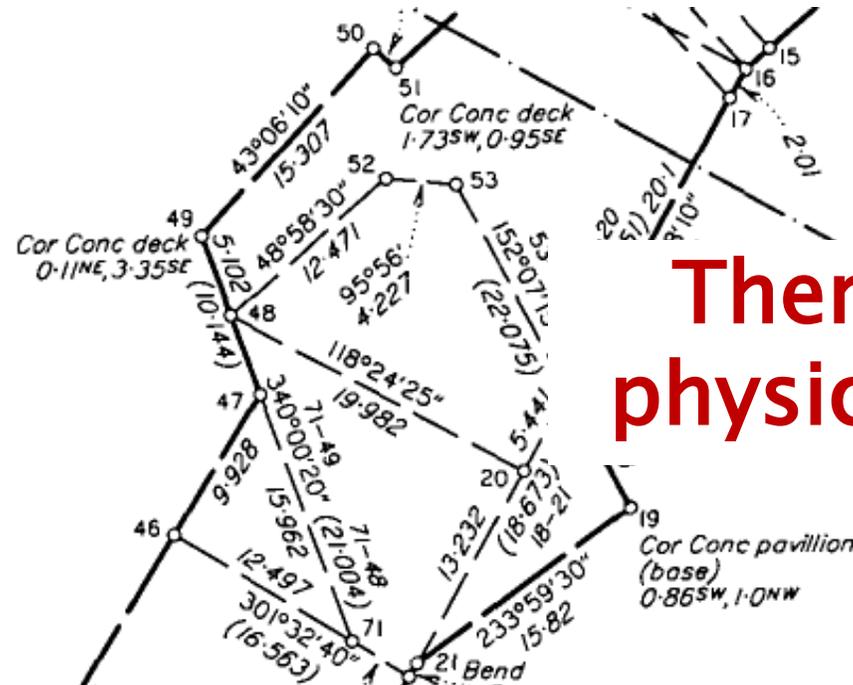
## Volumetric Spatial Units

Utility Networks

Public Law Restrictions

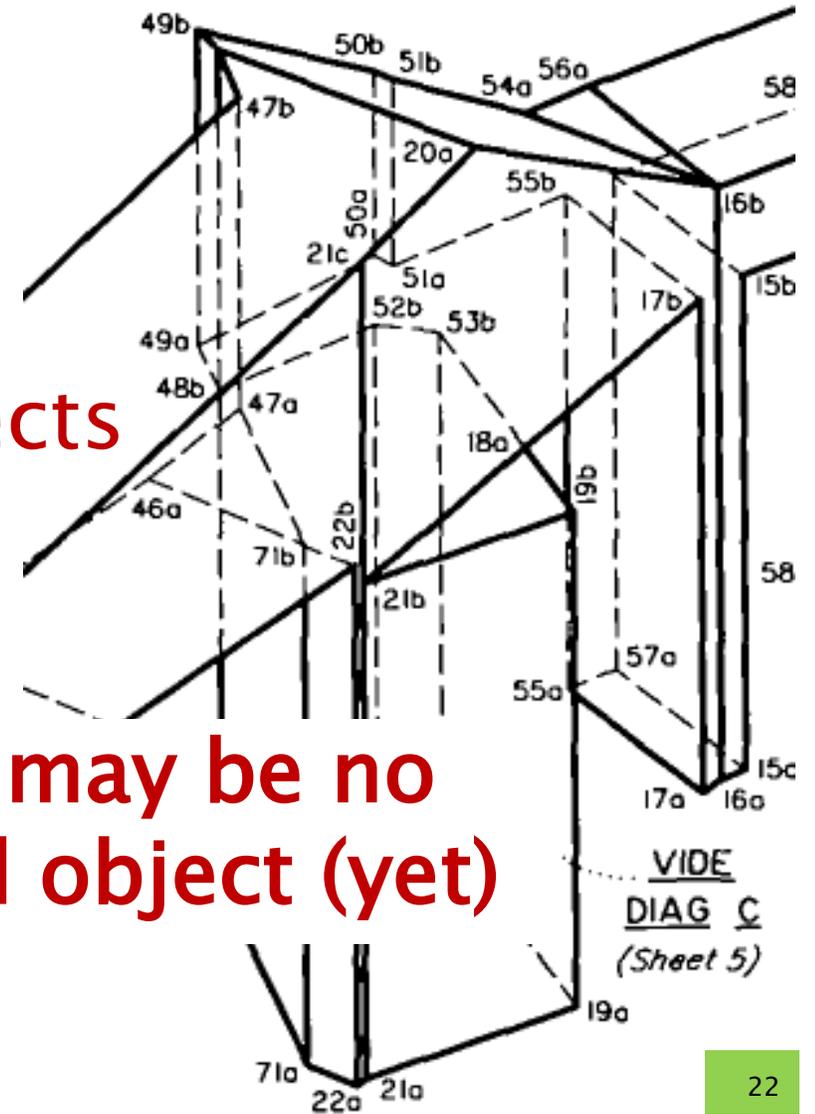
Development Applications

Extents defined by measurements



*Fiat Objects*

There may be no physical object (yet)



VIDE  
DIAG C  
(Sheet 5)

# 3D Cadastre Today

Restricted 2D parcels (to the depth of)

Strata Title Units

Volumetric Spatial Units

## Utility Networks

Public Law Restrictions

Development Applications

Transportation tunnels  
Cable conduits  
Water, Sewerage ...  
Microwave link airspace

Very limited in Queensland Cadastre



First class Cadastral Objects in The Netherlands

# 3D Cadastre Today

Restricted 2D parcels (to the depth of)

Strata Title Units

Volumetric Spatial Units

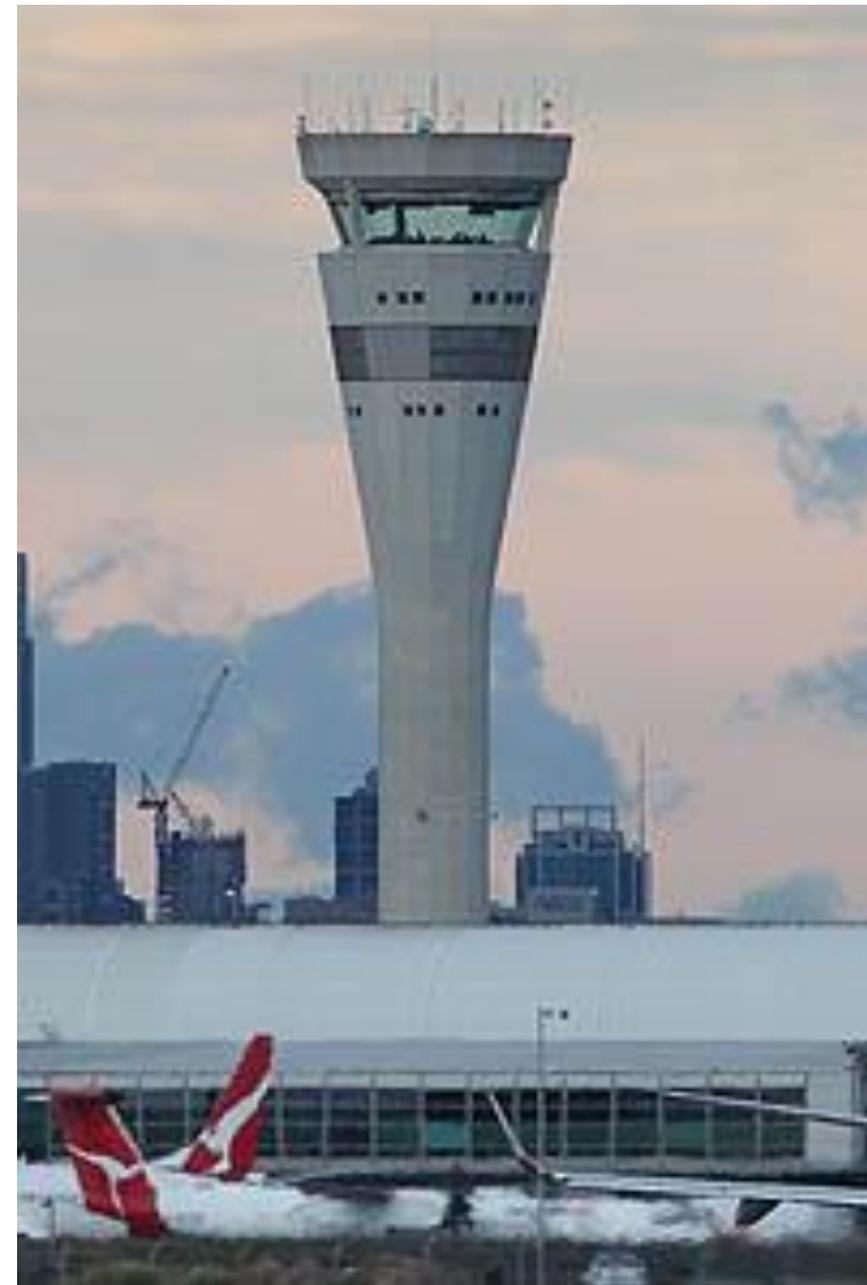
Utility Networks

## Public Law Restrictions

Development  
Applications

**Often  
considered “Not  
Cadastre”**

Air traffic lanes,  
Contaminated sites,  
Groundwater protection,  
Noise ...



# 3D Cadastre Today

Restricted 2D parcels (to the depth of)

Strata Title Units

Volumetric Spatial Units

Utility Networks

Public Law Restrictions

## Development Applications

Identified as desirable  
because:

- They are available earlier than conventional cadastre
- They are a fairly simple data source to use

But they introduce a new  
dimension of “time”  
(tentative time)

# 3D Cadastre Today

We must consider not 3D, but 3D+time

Most current databases record 3D spatial units

But 3D parcels are stored “flattened” to 2D

2D+t is not uncommon

Queensland DCDB has been 2D+t for 20 years now, and has 20 years of history

# 3D Cadastre Today – Technology

What we lack is an agreed approach to storing 3D cadastral objects

This will be solved soon

It is not a difficult technical problem.

Visualisation is a big issue

# Database Management



# The DBMS

- ▶ Thirty years ago, the big decision was between the “academically pleasing” relational model and the “more practical” Codasyl model
- ▶ Clearly, the RDBMS won
- ▶ Almost simultaneously, we programmers were discovering O-O programming.
- ▶ These were and are very different ways of thinking

# O-O

Loved by programmers  
and software engineers

Allows for relatively easy  
future modifications of  
programs

Just add “Persistence” to  
make a OODBMS

# The RDBMS

Loved by database designers  
and the people with the  
chequebooks

Passes the ACID\* test with  
flying colours

\* Atomicity, Consistency, Isolation, Durability

# O-O TECHNIQUES

Class Diagrams

UML

The simplicity of the “Persistence” model is not so evident in multi user databases

Software Engineers and Programmers typically don't understand the Relational Algebra

# RDBMS Techniques

Normal Form Analysis

Entity / Relationship

“Pure”, highly normalised relational databases won't do for spatial data

# O-O TECHNIQUES

# RDBMS Techniques

OODBMS

OR \*

RDBMS

**O**-R Mapping

OR

**O**RDBMS

OO programs  
accessing a RDBMS

**Not  
Compatible**

OO techniques within  
a RDBMS

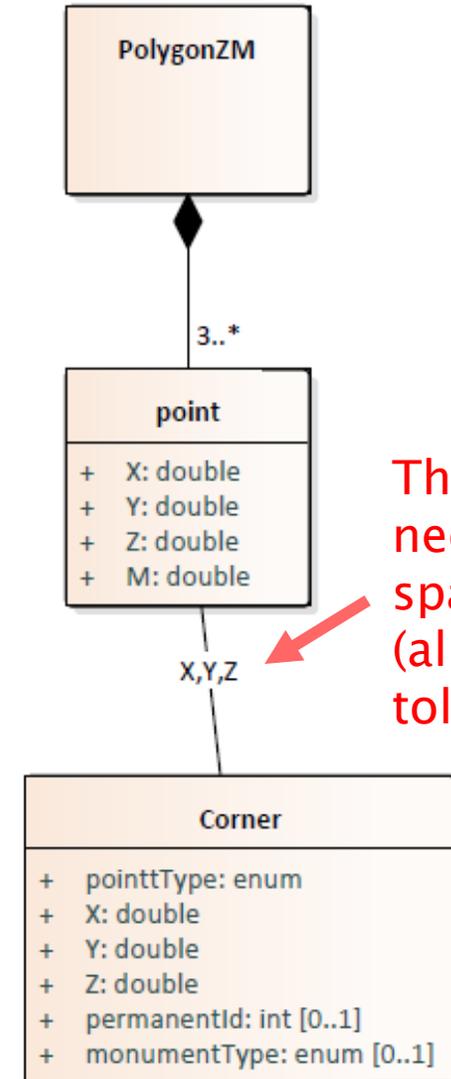
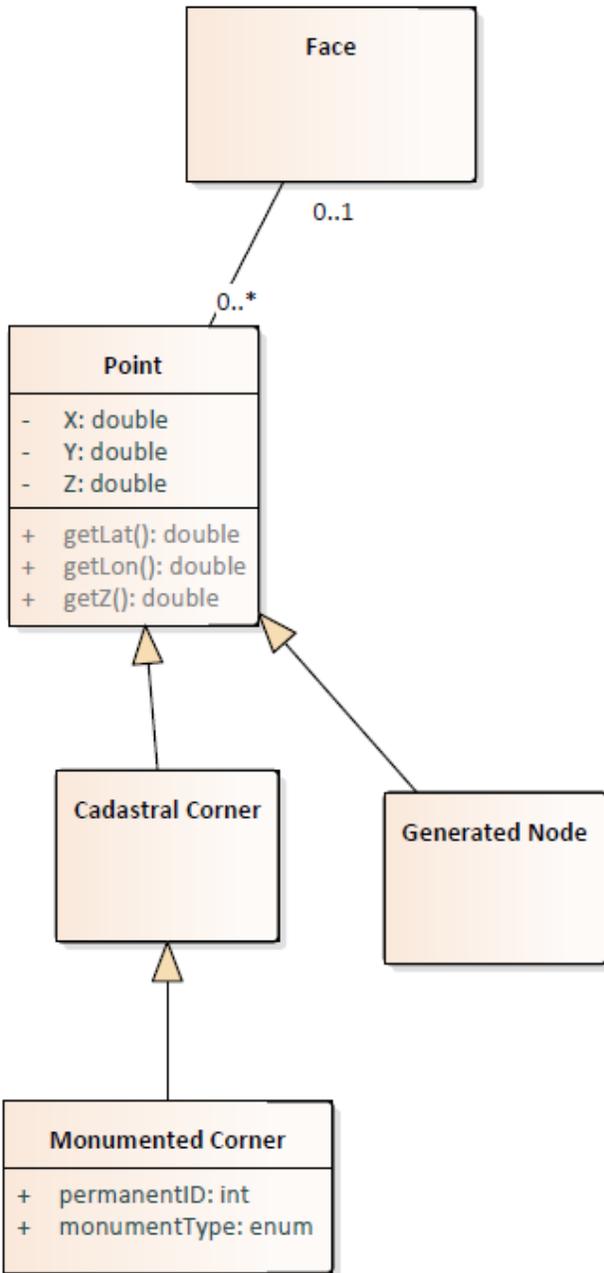
“Best Practice” for  
non-spatial data

“Best Practice” for  
spatial data

\* Pun intended

# How it Affects Us

A leading cadastral database implementation stores cadastral corner x,y values about 14 times for each actual corner (by my count)



This link needs a spatial search (allowing tolerance?)

# 3D Cadastre 2048

## Forecasting v/s Fortune-Telling

For example a nuclear war, or a run-away greenhouse effect will make all forecasts invalid.

So let's limit the discussion to forecasts.



Would we have predicted 30 years ago that we would now have a mobile phone with a complete mapping system, that we can watch movies on?

# Database Management in 2048

- ▶ The Clouds will have cleared
- ▶ Blockchain and subsequent technologies will be subsumed into the distributed database
- ▶ A consistent object technology will be adopted

OR

- ▶ Confusion will continue and get worse

# 3D Cadastre 2048 – the easy predictions

The technological issues will have been solved

A cadastral database will combine 2D+t with 3D+t (in the same schema)

Queensland will have moved more than 2 metres (roughly North East)

# 3D Cadastre 2048 – the easy predictions

Globalisation has been an issue for many years  
(since 1524\*) (Brotton 2012)

Brotton, G. (2012). [A History of the World in Twelve Maps](#), Penguin Books.

⇒ Tendency towards consistency in the practices  
of land administration.

⇒ The LADM (Land Administration Domain Model)  
is an enabler for this.

\* The date of the meeting on the River Guadiana to determine the meridian  
between the western and eastern hemispheres, and specifically, which  
hemisphere contained the Molucca Islands.

# 3D Cadastre 2048 – What will it Contain?

**Cadastre 2014 will show the complete legal situation of land including **public rights and restrictions!****

Kaufmann J, Steudler D, 1998. CADASTRE 2014 – A Vision for a Future Cadastral System (p15)

Sea Floor, Oceanic Volumes  
(Including international waters)

Lunar Spatial Units?  
Martian Spatial Units?

# 3D Cadastre 2048 – What will it Contain?

Input from Building Information Models

For building format units

But also, the BIM themselves will contain survey data

Input from other engineering projects

e.g. when a road is built, the necessary surveys can be used to improve the quality of cadastral information nearby

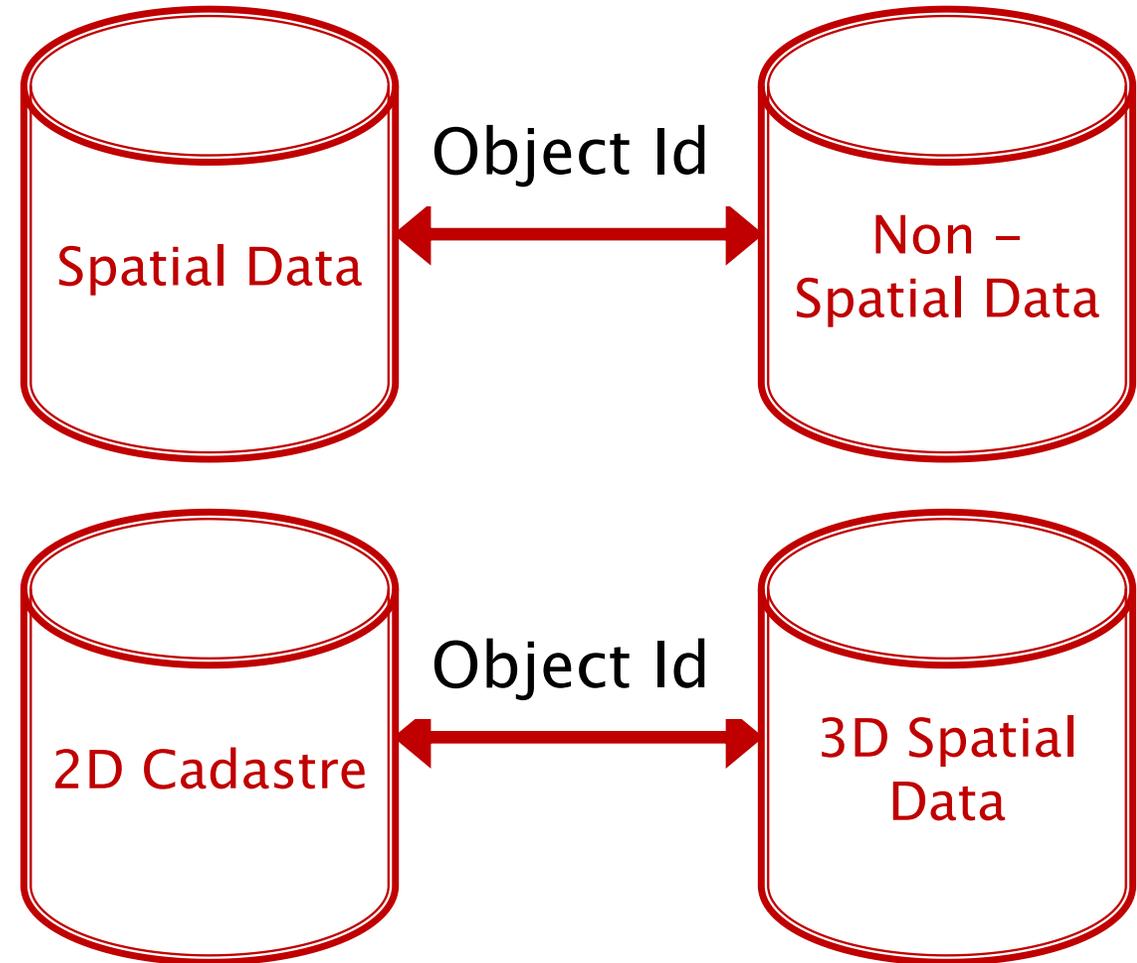
# 3D Cadastre 2048 – How to get there

## “Best Practice” 30 Years ago

Argument: Spatial data is too complex for a textual database model such as a Relational DBMS. Specifically designed spatial data technology is needed.

## Being suggested now (in certain quarters)

Argument: **3D** Spatial data is too complex for a **2D spatial** database model such as a Relational DBMS. Specifically designed **3D** spatial data technology is needed.



Splitting information between databases, will always be more trouble-prone than expected!

# 3D Cadastre 2048 – How to get there

“Best Practice” in 30 Years time



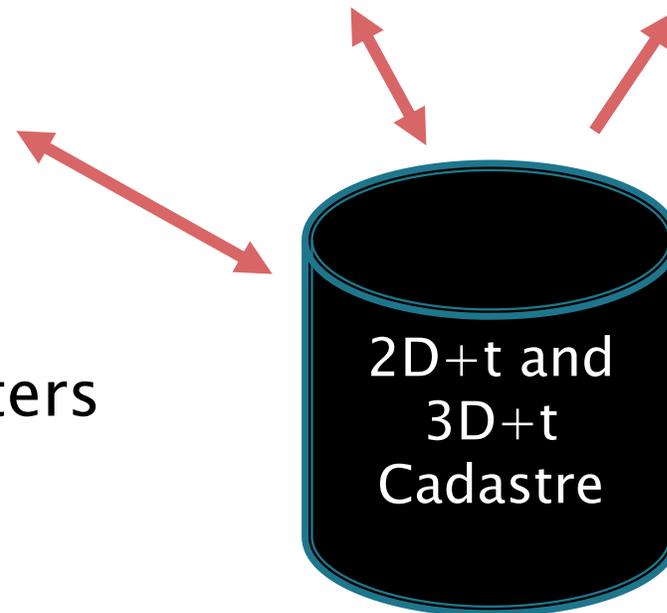
2D  
Enquiry  
Update



3D  
Enquiry  
Update



2D/3D  
Temporal  
Enquiry



But probably not using laptop computers

# Easing Gently into 3D

- ▶ Queensland legislation

3D is “Just Like” 2D – Own, Buy, Sell, Mortgage ...

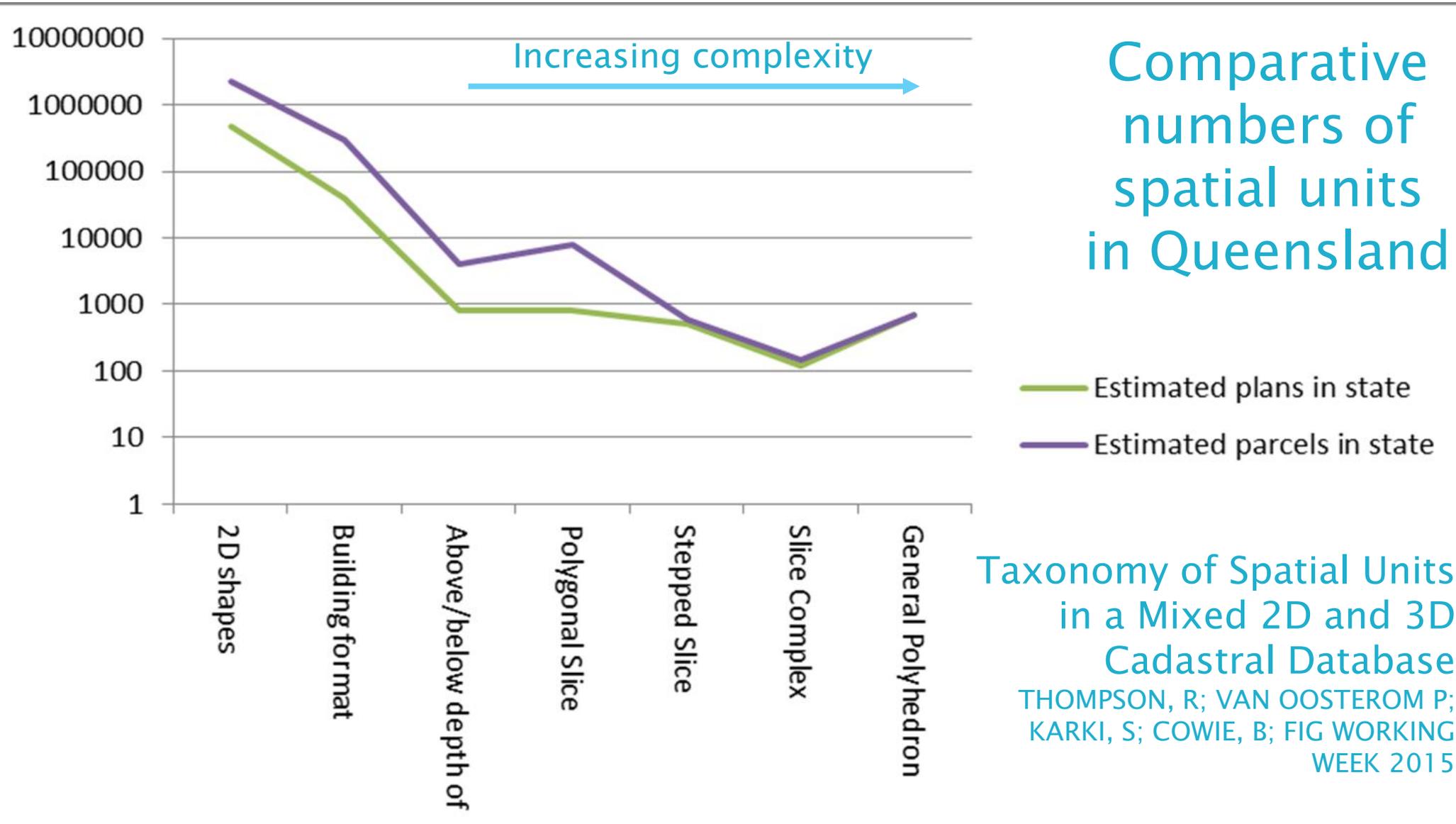
- ▶ Surveying Regulations

A 3D Survey plan looks like 2D, but with isometric diagrams...

- ▶ Now – Including 3D into the database

Suggestion: – just add 3D faces to the existing 2D database...

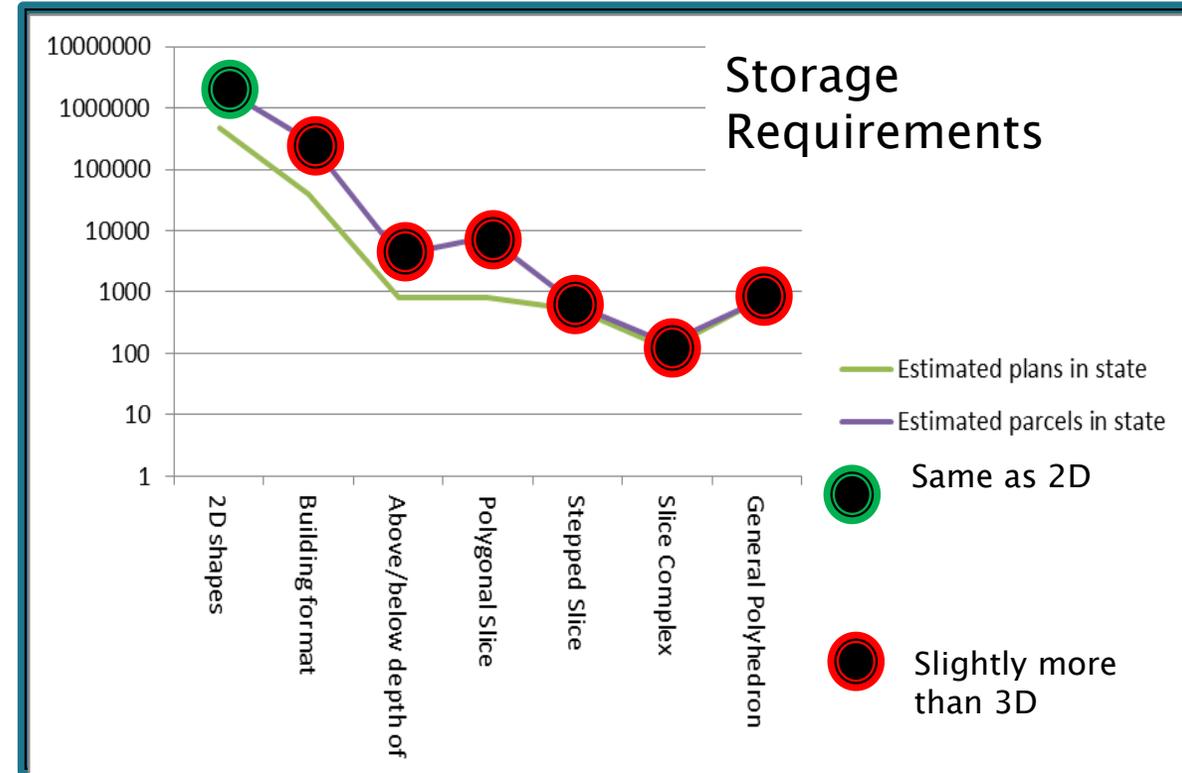
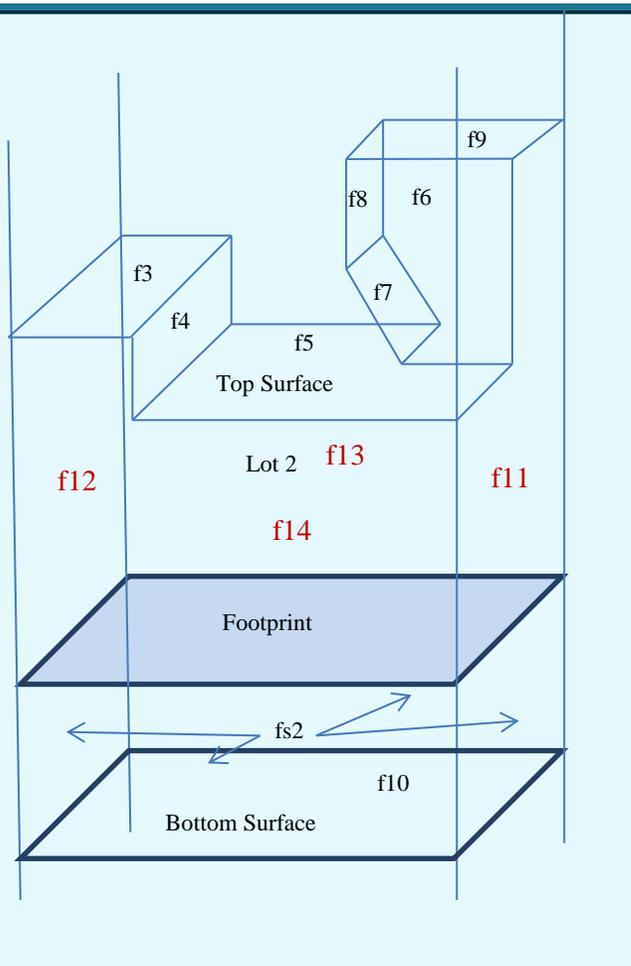
# 3D Cadastre 2048 - How to get there



# Polygon Soup Approach\*

Store a 2D parcel as a 2D parcel (but interpreted as 3D)

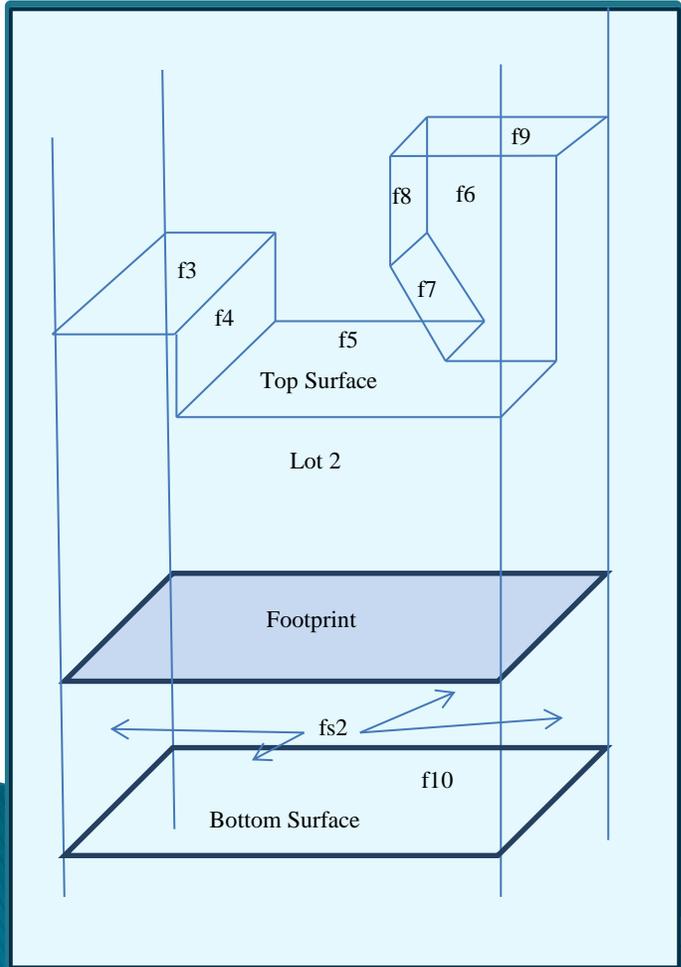
For a 3D Parcel, store the footprint, with enough faces to make a closed polyhedron



\*R. Thompson, P. van Oosterom, B. Cemellini, and M. de Vries. Developing an LADM compliant dissemination and visualization system for 3D Spatial Units. In 7th International FIG workshop on the Land Administration Domain Model – Zagreb, Croatia, 2018.

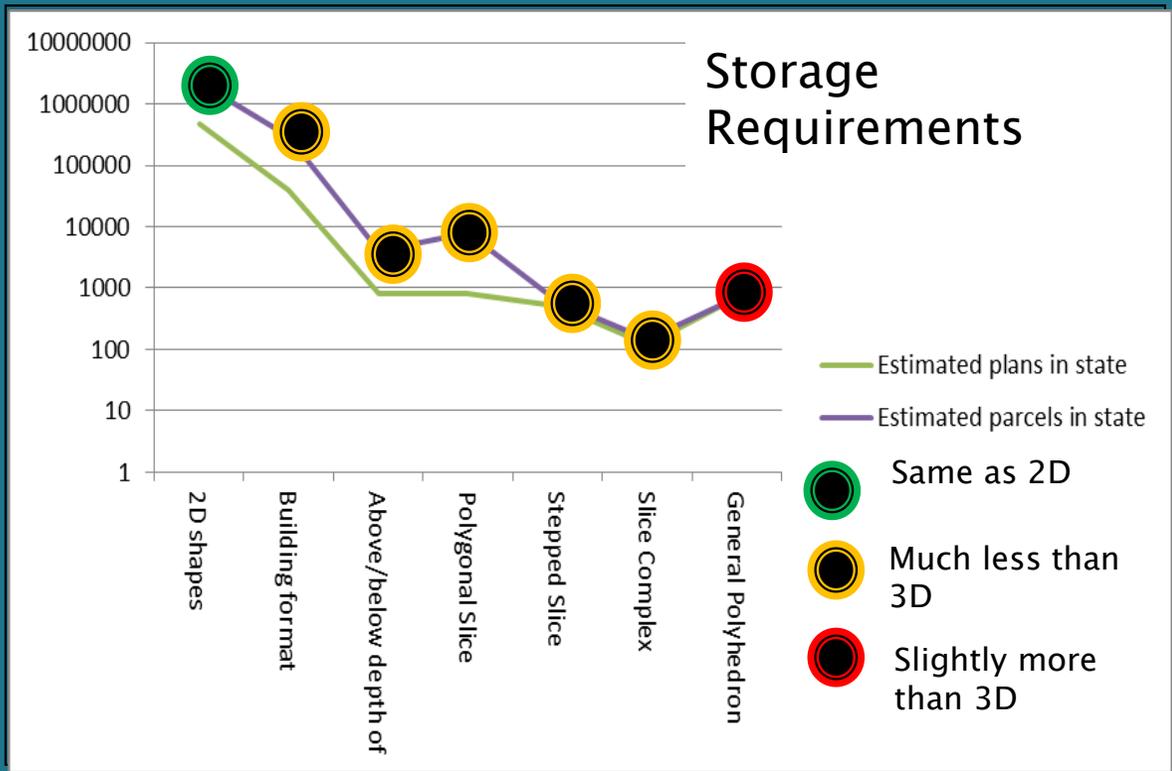
# Boundary Face String Approach\*

Store a 2D parcel as a 2D parcel (but interpreted as 3D)



For a 3D Parcel, store the footprint, with a top and a bottom

Top and bottom surfaces can be as complex as necessary



\*A Conceptual Model Supporting a Range of 3D Parcel Representations through all Stages: Data Capture, Transfer and Storage  
 Rodney James THOMPSON, Australia  
 Peter VAN OOSTEROM, The Netherlands  
 Kean Huat SOON, Singapore  
 Russell PRIEBBENOW, Australia

# 3D Cadastre 2048 – Disruptive Technologies

Now – if we are all convinced that by 2048, the technology issues will be solved, and we have a 3D+t cadastral database containing all imaginable RRRs



What could possibly go wrong?

# Will our Cadastral Databases be Accurate in 2048?

- ▶ Confident answer “NO”

Large tracts of the world haven't ever been surveyed  
Survey techniques are constantly improving so “old” surveys  
are seen as inaccurate

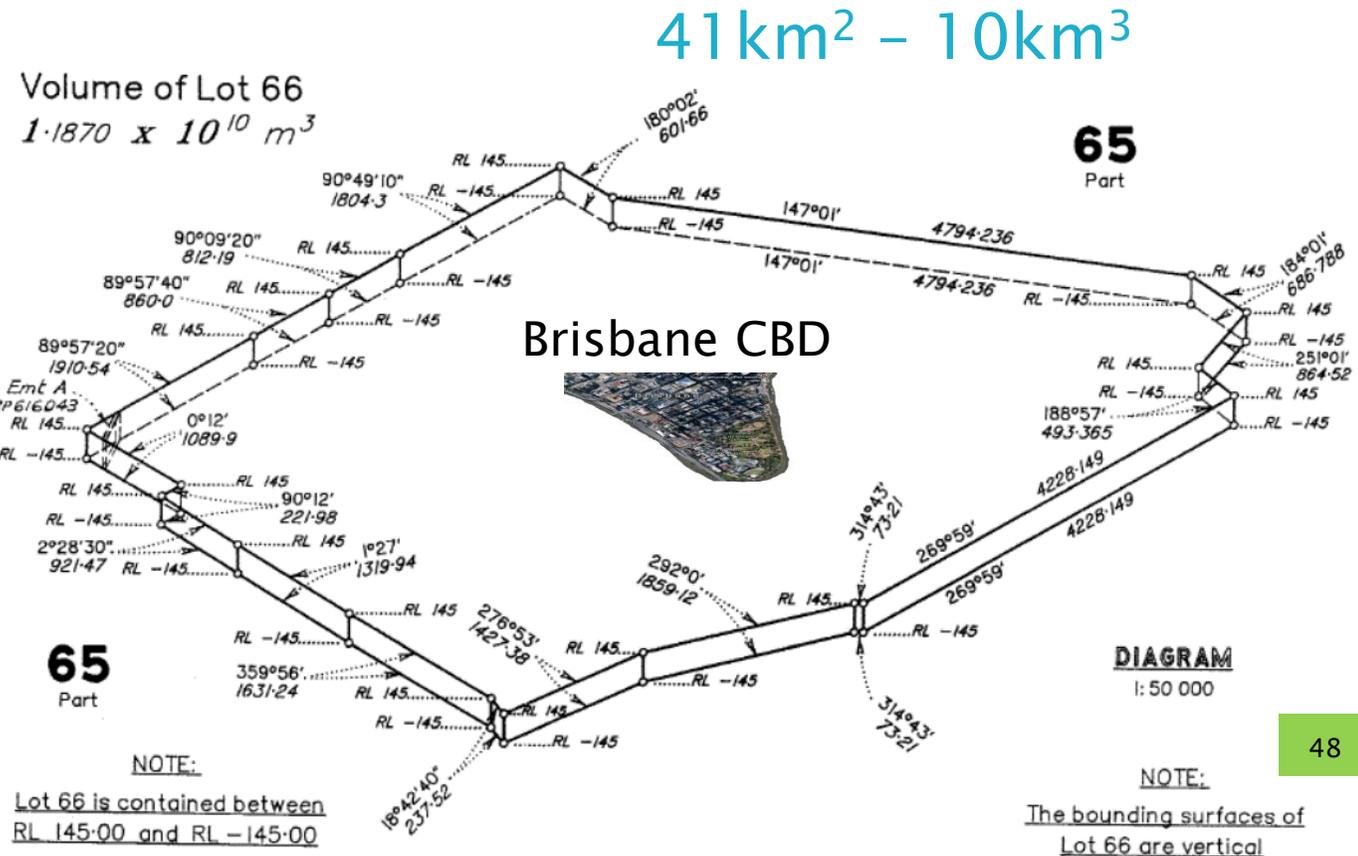
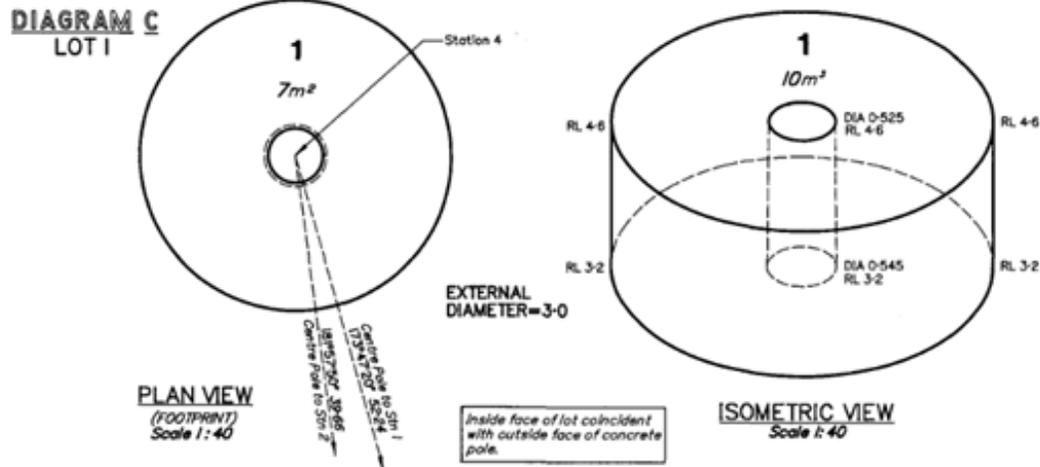
We have learned to work with different accuracy levels

# Will our Cadastral Databases be Accurate in 2048?

Do we have to wait for high accuracy before we include 3D spatial units?

No – we can work with what we've got

3m Diameter – 7m<sup>2</sup>



# What will the “Registering Authority” become?

- ▶ Will “Blockchain” or similar technology make the Registering Authority redundant?

The hardest thing about registering land transactions is keeping consistency between versions of documents\* and ensuring that all interested parties are kept informed of ALL actions on a particular property.

\* This means documents in the broadest sense  
- including for example an XML file

# What will the “Registering Authority” become?

**Geodata Enabled Hierarchical Blockchain Architecture for Resolving Boundary Conflicts in Cadastre Surveys and Land Registration**  
**(FIG article of the month May 2018 - Abdulvahit Torun)**

**Is Blockchain a major disruptive technology?**

# Blockchain and the “Registering Authority”

Bitcoin was a kind of “demo application” for Blockchain

The banks have had to react, and look hard at it

Could we see a “International Cadastral Database” coming about in the next 30 years?

Whether we like it or not!

# Quantum Computing

- ▶ Could possibly “blow away” all current encryption techniques
  - In public key / private key schemes, it makes the private key public!
- ▶ Replace with “quantum encryption”?

# Drones and Flying Cars



- ▶ Anything heavier than air that flies makes noise!
- ▶ The heavier, the noisier.

The answer? Defined traffic lanes – another 3D Cadastral Spatial Object.



**“the real roadblock to a drone-filled future for the retail industry is government regulation.”**

<http://www.web-strategist.com/blog/2017/03/13/these-ten-delivery-drones-that-will-change-retail-and-logistics/>

# Volunteered Information

- ▶ Fast maturing
- ▶ Has potential in Cadastre
- ▶ Fits the “Hierarchy of Evidence” principle

# Development / Planning Approval Information

- ▶ Include survey data from development requests
- ▶ Long before a current “cadastral” database sees it
- ▶ Comprises another “dimension” of time

# Temporal Data

- ▶ Naturally we need history – no argument, but:
  - We need “Valid Time”
  - We need “Transaction Time”
  - We need to be able to correct errors in history
  - We need “future cadastre” (planning approvals)
    - This could be called “Tentative Time”
  - In 2038 we will have been using Dynamic Datums for 28 years.

# In Summary – in 2048

Cadastral Databases will support 3D+*t*

They will be “all in together”: 2D + 3D + time, all in the one schema

Most spatial units will still be “2D” (standard format)

There will be Public Law Rights, Responsibilities and Restrictions in the Cadastre,

These will be Development Approvals in the Cadastral database

# In Summary – in 2048

Utility networks will be considered to be cadastre

Databases will take on a very new look (not just cadastral or even spatial databases, but all DBMS)

Blockchain and subsequent technologies will be subsumed into the distributed database

We will still be citing “Cadastre 2014”

# In Summary – in 2048

If I'm wrong about any of these predictions, remind me in 2048!

(at the 21<sup>st</sup> International FIG Workshop on 3D Cadastres)

# 3D Cadastres: 30 years back, 30 years ahead.

“If this ... seems completely reasonable and all my extrapolations convincing, I shall not have succeeded in looking very far ahead, for the one fact about the Future of which we can be certain is that it will be utterly fantastic”

Arthur C Clark 1964 “Profiles of the Future”

- ▶ Rod Thompson
- ▶ FIG 3D Cadastres workshop
- ▶ 2–4 October 2018, Delft NL.