



**Presented at the FIG Working Week 2023,
28 May - 1 June 2023 in Orlando, Florida, USA**

Geospatial and A.I. Technologies for cadastral mapping and Real Estate Registry

Tareq H. Hasosah

Chief Geospatial Officer at the Real Estate Registry- Saudi Arabia

Wednesday, May 31st, 2023



Table of Contents

- ❑ Real Estate Registry Introduction
- ❑ Geospatial Role in Real Estate Registration
- ❑ Technology Selection
- ❑ Parcel Creation Approach
- ❑ A.I. for Deed linkage
- ❑ A.I. for Feature Extraction
- ❑ Lesson Learned

Real Estate Registry Introduction

- The National Real Estate Registration Services Company (RER) was established on 24/05/2021.
- RER is fully owned by the Saudi Arabia Public Investment Fund (PIF)
- RER's mandate is to:
 - Conduct first registration activities that register all of the lands in the Kingdom by 2030
 - Maintain the real estate register to reflect subsequent transactions such as changes in ownership and changes in rights, restrictions or responsibilities
 - Maximize the value of real estate data for the benefit of both the wider economy and RER.

Company Strategic Goal:

- ✓ Increase the trust in Real Estate Market
- ✓ Increase transparency of the sector
- ✓ Attract Local, regional, and international investments

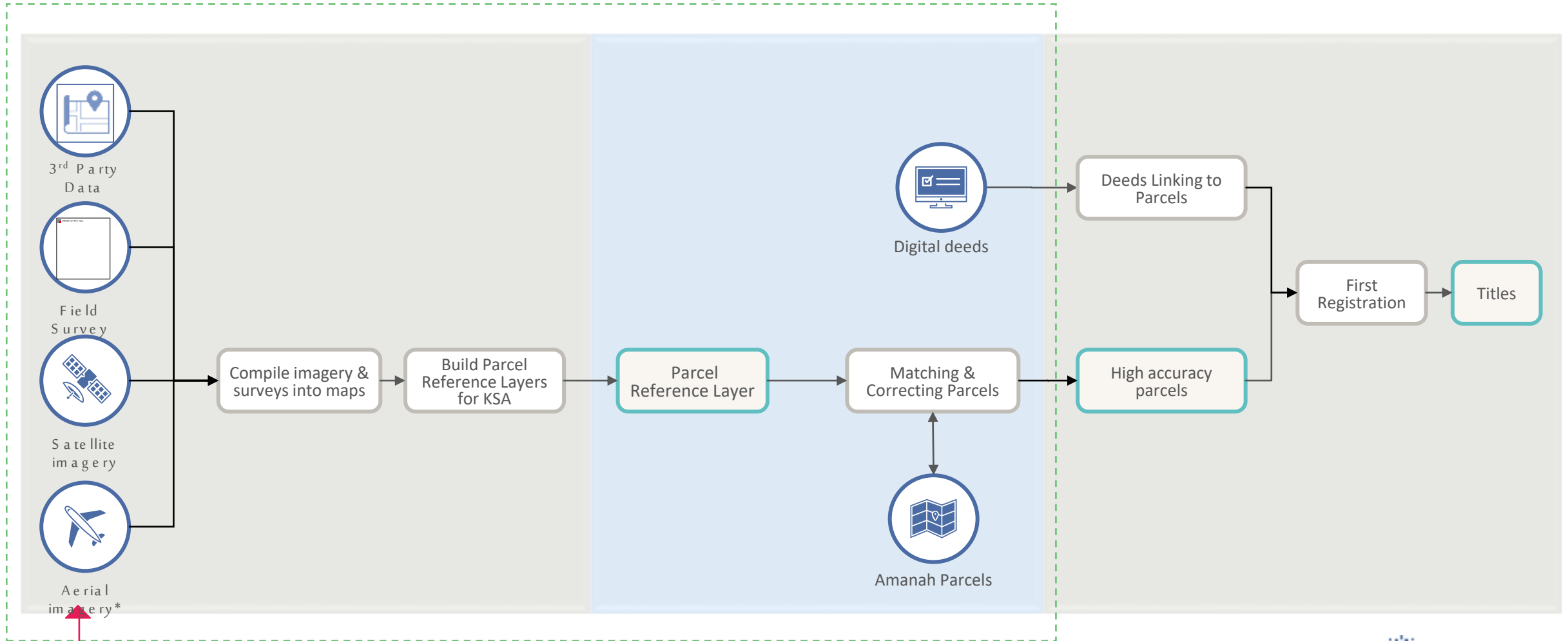
Geospatial Role in Real Estate Registration

1 Geospatial Operation

2 Geospatial Data management

3 Title registration

Geospatial Governance



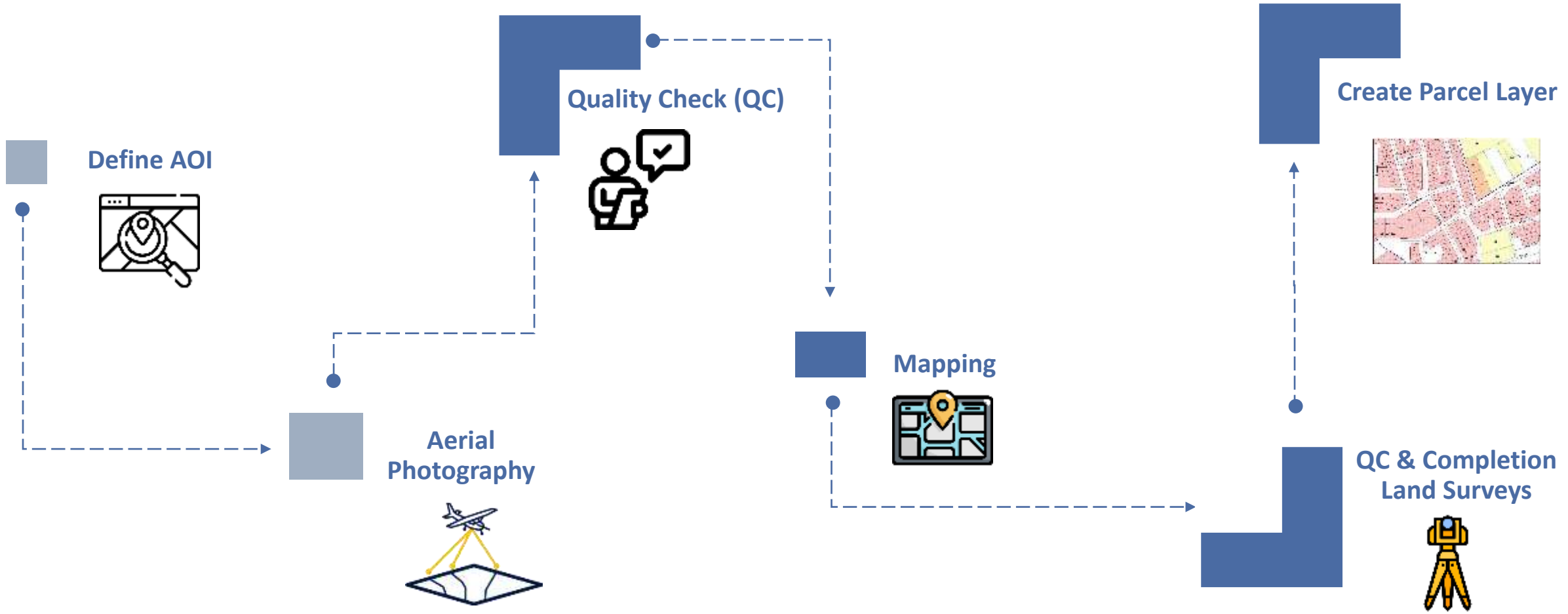
*Imagery and mapping must be high resolution and accuracy (25 cm) and based on the Saudi Arabia National Spatial Reference System (SANSRS) as per the approved regulations.

○ Data input □ Process ◻ Process Output

Technology used

	Tablet and Handheld GPS (Not survey grade)	Field Survey TS/RTK	MMS (incl Street based LIDAR)	UAV	Aerial Photo	Satellite Imagery
Compliant with Geospatial Regulations	No	Yes	Yes	Yes	Yes	Partial compliant (Only Rural Area)
Deployment	Rapid	Rapid	Rapid	Rapid	Moderate – seasonal timing	Moderate – clear skies required
Speed	Slow-Moderate	Slow - Moderate	High - MFE	Very High - AFE High - MFE	Very High - AFE High - MFE	Very High - AFE High – MFE
Spatial/Positional Accuracy	Low – doesn't meet regs 2 m – 5 m	Very High - cm Regulation - compliant 0.01 m – 0.03 m	High - cm Regulation - compliant 0.05 m – 0.15 m	High - cm Regulation - compliant 0.05 m – 0.15 m	High - cm Regulation - compliant 0.10 m – 0.25 m	Low – m Regulation Partial compliant (Only Rural Area) 1 m – 2m
Spatial Resolution	N/A	N/A	N/A	0.02 m – 0.05 m	0.07 m – 0.15 m	0.3 m – 1 m
Outputs	Low accuracy Marked up either non-rectified or rectified image map	Very accurate plan of full parcels - delineation Parcel demarcated	Mapping of land parcel front/building facade only	Accurate plan/map of full parcels -delineated	Accurate map of full parcels - delineated	Satisfactory Accurate map of (Only Rural Area) parcels - delineated
Areal Coverage	Parcel/Area	Parcel/Area	Area/District	Area/District	District/City/Region	District/City/Region
Unit Cost (per parcel)	Moderate	High	Moderate	Moderate	Low	Very Low
Comments	Useful for rapid check to clarify obstruction of boundary in aerial/satellite imagery Access to parcel required	For areas with no marked boundaries (occupation) Densely settled areas where buildings obscure boundaries Owner objections Access to parcel required	Limitations for Mapping of land parcel because only capture front/building facade, but still good for Future application like property valuation, building encroachment	FFP AFE success will be dependent on density of settlement and also spectral difference between building wall and parcel construction and ground material	FFP AFE success will be dependent on density of settlement and also spectral difference between building wall and parcel construction and ground material	FFP – Rural Areas only AFE success will be dependent on density of settlement and also spectral difference between building wall and parcel construction and ground material

Parcel Creation Approach



Parcel Creation Approach



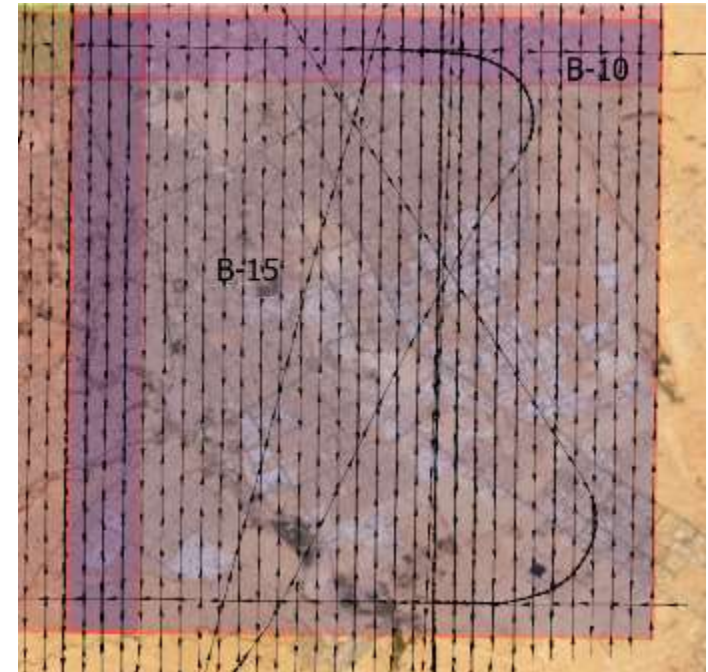
Defining the Area of Interest (AOI) for Precise Delineation to achieve greater accuracy in property ownership authentication over **100,000 KM²**



Parcel Creation Approach



This ambitious aerial mapping project will utilize 10 cm GSD resolution to cover 100,000 km² in Urban Areas. Approx. 2,000,000 km² will follow using Satellite Imagery.



Sample flight plan

Parcel Creation Approach



The positional accuracy of all geospatial products in this project will adhere to the standards set by ASPRS, specifically the "ASPRS Positional Accuracy Standards for Digital Geospatial Data, 2014" as follows:

- Ground Control Points: **2.5cms in XYZ**
- Aerial Triangulation: **½ (half) a pixel in XYZ**
- DSM **15cms** in elevation
- DTM **15cms** in elevation
- True Orthophotography: **10cm in XY**
- Ground Orthophotography: **10cm in XY.**
- 1:1000 Scale Topographic Database: **10cm in XY and 15cm in Z**

Parcel Creation Approach

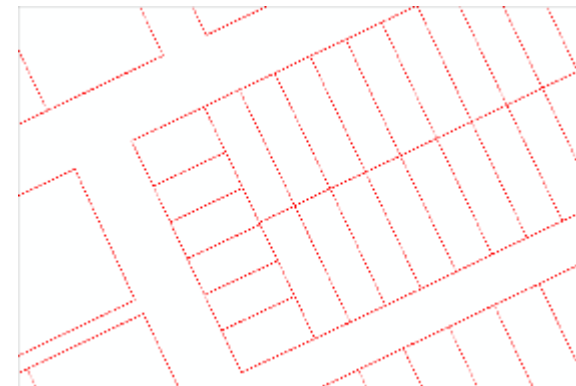


This process is to seamlessly convert raster data to vector data by digitizing vector objects from stereo images and for this project, we aim to focus on producing digital maps of the required features such as:

- Buildings: 3D buildings, shown to scale unless smaller than 1x1m.
- Parcel Boundaries: Visible boundaries forming preliminary parcels.
- Continuous Terrain: GCPs and continuous terrain.
- Transportation (2D): existing roads



Aerial Imagery



Land parcel output

Parcel Creation Approach



To ensure accuracy and completeness of land parcel data, we will utilize high accuracy surveying methods for field verification and land survey activities. This will capture any unclear or obstructed features that were not captured through stereo digitizing from the office.

Parcel Creation Approach



Upon completion of all parcel creation tasks, including aerial acquisition, quality checking, digitizing, and resolving any missing items, we will create a real estate geospatial data set that is authoritative, trusted, and easily accessible.



Final land parcel layer on top of Aerial Imagery



Final land parcel layer

Evaluation of A.I utilization opportunities:

1- Deed Linking

2- Automatic Feature Extraction

A.I. for Deed Linkage

The deed records contain errors and/or missing critical information. To overcome this, automatic data cleansing and preparation is required for successful linkage between deeds and their associated parcels.

ID	LAND_NO	PLAN_NO	AREA	NEIGHBORHOOD_NAME	CITY_AR	Serial
1996	528	3011	1625.95	اشبيلية	الرياض	144
1960	819	3183	600	اشبيلية	الرياض	145
2156	84	2683	810	اشبيلية	الرياض	146
1925	800	3183	500	اشبيلية	الرياض	147
1900	534	3011	811.9	اشبيلية	الرياض	148
1990	64	2733	625	اشبيلية	الرياض	149
1472	171 / 1	2935	500.15	اشبيلية	الرياض	150
1115	7/2	لا يوجد مخطط	830	اشبيلية	الرياض	151
1475		لا يوجد مخطط	875	اشبيلية	الرياض	152
1154	16	2888	650	اشبيلية	الرياض	153
1680	567	3183	487.5	اشبيلية	الرياض	154
1173	55	2888	700	اشبيلية	الرياض	155
7971	182 / 3	2495	318.57	اشبيلية	الرياض	11063
1843	75	2683	750	اشبيلية	الرياض	11064
1678	415	2979	500	اشبيلية	الرياض	11065
1842	26 / 3	2029	318.75	اشبيلية	الرياض	11066
1759	38	2495/أ	780	اشبيلية	الرياض	11067
1404	426	2979	825	اشبيلية	الرياض	11068
1423	150	2958	875	اشبيلية	الرياض	11069
1395	599	2979	600	اشبيلية	الرياض	11070
1379	139 / 2	3010	376.02	اشبيلية	الرياض	11071
1473	Oct-64	لا يوجد مخطط	184	اشبيلية	الرياض	13107
1479	Jun-66	لا يوجد مخطط	188	اشبيلية	الرياض	13108
1455	Sep-64	لا يوجد مخطط	208	اشبيلية	الرياض	13109
1172	13 / 64	لا يوجد مخطط	208	اشبيلية	الرياض	13110
1855	Dec-66	لا يوجد مخطط	208	اشبيلية	الرياض	13111

LAND_NO	PLAN_NO
7/2	لا يوجد مخطط
	لا يوجد مخطط

NEIGHBORHOOD_NAME
اشبيلية
اشبيلية
اشبيلية

A.I. for Deed Linkage - Result

Deeds count	Total deeds (units)	Units with issues	Total deeds without Issues	Direct linkage	linkage%	Enhanced model	Linkage count	linkage%
117,067	142,278	23,027	119,251	68,076	57%	12,899	80,975	67%

LAND_NO	PLAN_N	LAND_NO	PLAN_NC	LAND_NO	PLAN_NO	AREA	BORHOOD	CITY_AR	Serial
22 / 1	3010	22 / 1	3010	22 / 1	3010	400	اشبيليا	الرياض	1
302	2979	302	2979	302	2979	500	اشبيليا	الرياض	2
779	2979	779	2979	779	2979	600	اشبيليا	الرياض	3
1-Dec	2903	1-Dec	2903	1-Dec	2903	750	اشبيليا	الرياض	4
465 / 1	3011	465 / 1	3011	465 / 1	3011	1040	اشبيليا	الرياض	5
350	3011	350	3011	350	3011	660	اشبيليا	الرياض	6
720	2979	720	2979	720	2979	500	اشبيليا	الرياض	7
60 / 2	2877	60 / 2	2877	60 / 2	2877	364.5	اشبيليا	الرياض	8
54 / 1	2714	54 / 1	2714	54 / 1	2714	420	اشبيليا	الرياض	9
28	2979	28	2979	28	2979	500	اشبيليا	الرياض	10
30	2979	30	2979	30	2979	500	اشبيليا	الرياض	11
32	3159	32	3159	32	3159	616	اشبيليا	الرياض	12
106	3159	106	3159	106	3159	560	اشبيليا	الرياض	13
543 / 1	2979	543 / 1	2979	2-Jul	لا يوجد مخطط	350	اشبيليا	الرياض	151
33 / 2	3010	33 / 2	3010		لا يوجد مخطط	875	اشبيليا	الرياض	152
48 / 2	2958	48 / 2	2958	16	2888	650	اشبيليا	الرياض	153
436	3183	436	3183	567	3183	487.5	اشبيليا	الرياض	154
1 + 2 + 3 + 4	2683	1 + 2 + 3 + 4	2683	55	2888	700	اشبيليا	الرياض	155
175	2958	175	2958	90 / 1	2958	461.88	اشبيليا	الرياض	156

A.I. for Feature Extraction



Lesson Learned

- After testing A.I-based parcel digitizing against stereo digitizing methods, we have learned that while A.I can improve the process, the stereo digitizing methods are still necessary for ensuring accuracy.
- Traditional and A.I Hybrid approach to mapping.
- The traditional manual digitizing method is more time-consuming, yet it provides many more data that we could potentially take advantage of and commercialize.
- Data Fusion is a necessity.