



Sense.Lidar

Machine Learning Point Classification

Keith Owens

1

About Sense.Lidar

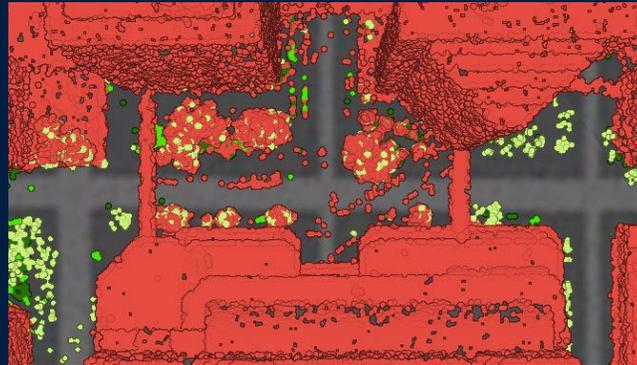
Using cloud processes and AI, Sense.Lidar™ accurately classifies clusters of lidar points which characterizes the details of our earth.

Sense.Lidar

Why it is necessary



Few classifications



Inaccurate classifications



Time consuming



Expensive



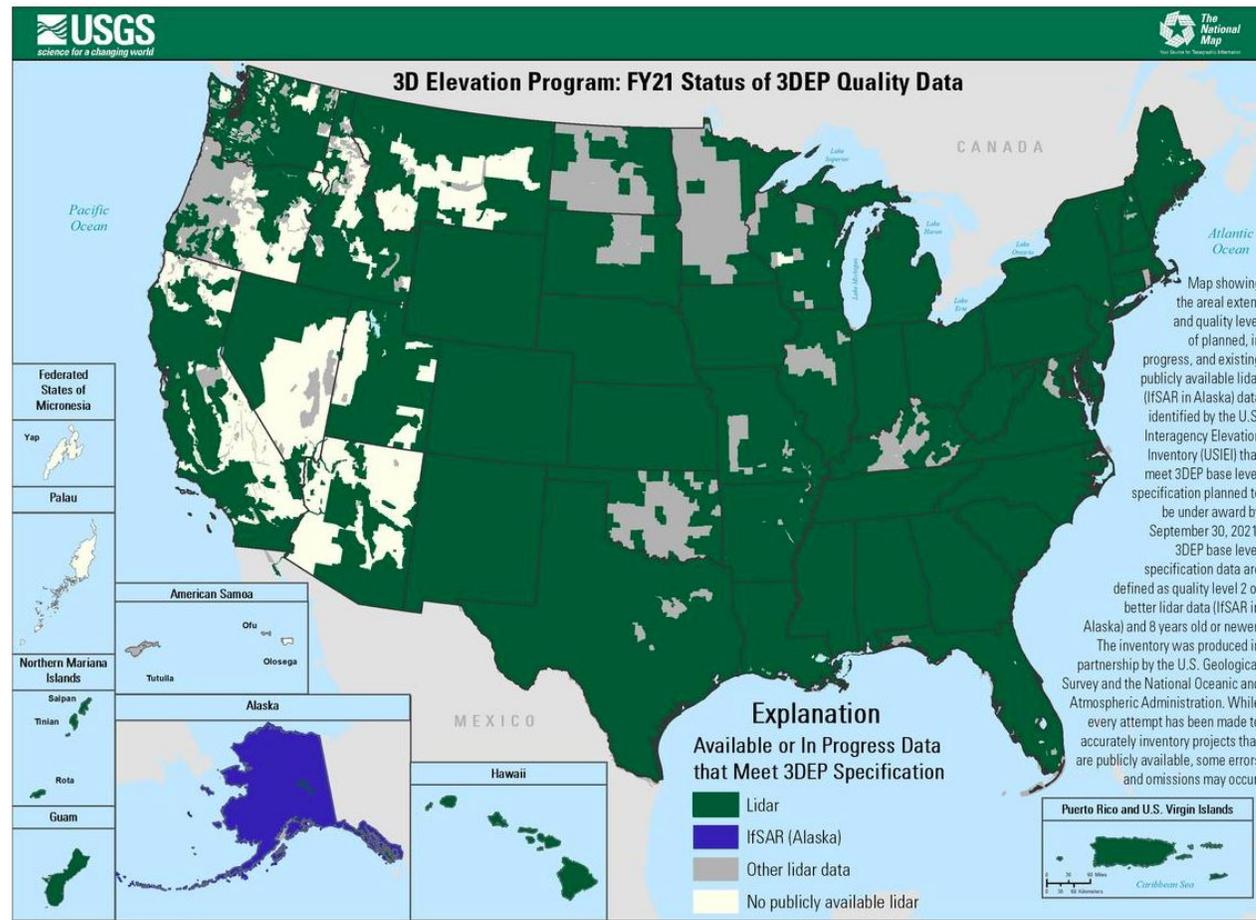
Minimal use-cases



Low quality at scale

Available Lidar

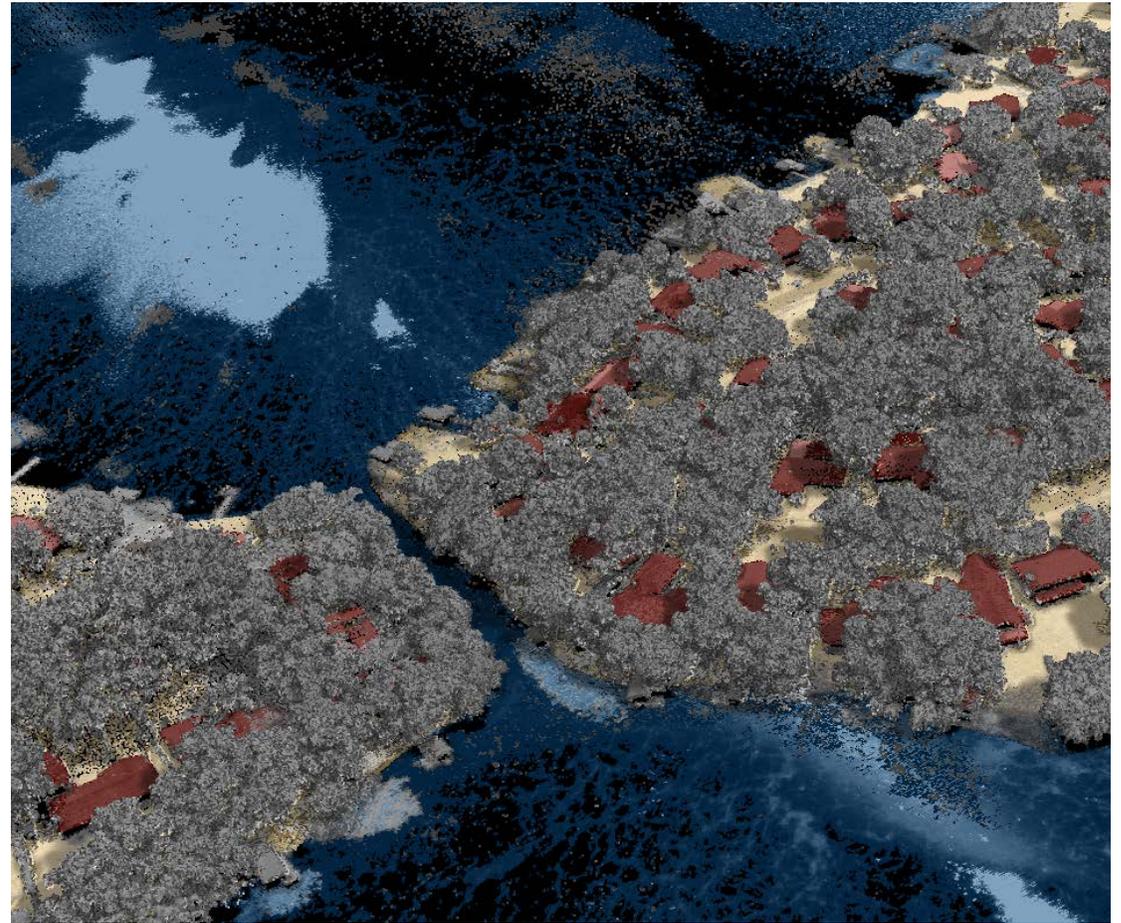
State and federal programs – not all data is created equal



- Abundance of existing lidar data
- Lidar data vintage (3+ years) considered for new collection
- Older datasets can be improved for better change analysis

Available Lidar

Local, state and federal programs – not all data is created equal



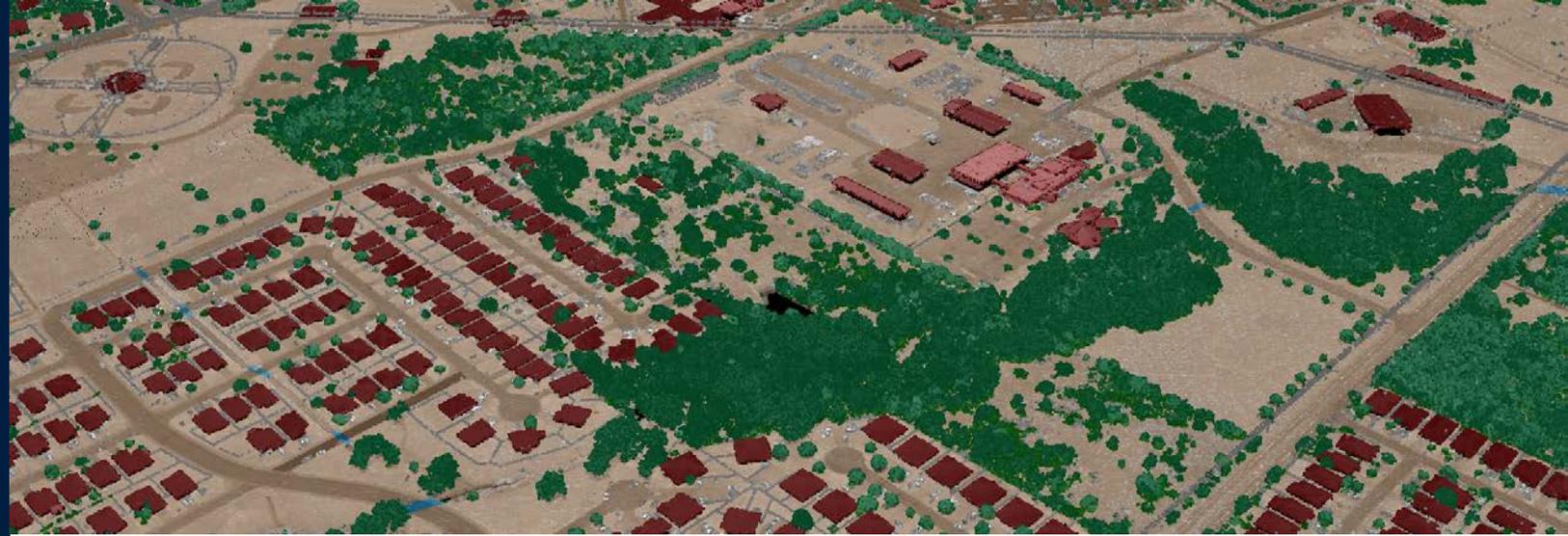
2

TNRIS Classification Project

Texas Enhanced Lidar Data

TWDB / TNRIS

North, Central, and East Texas



-  Enhance existing USGS Lidar
-  83,000 square miles
-  Accuracy to 99%
-  3rd party inspected and verified

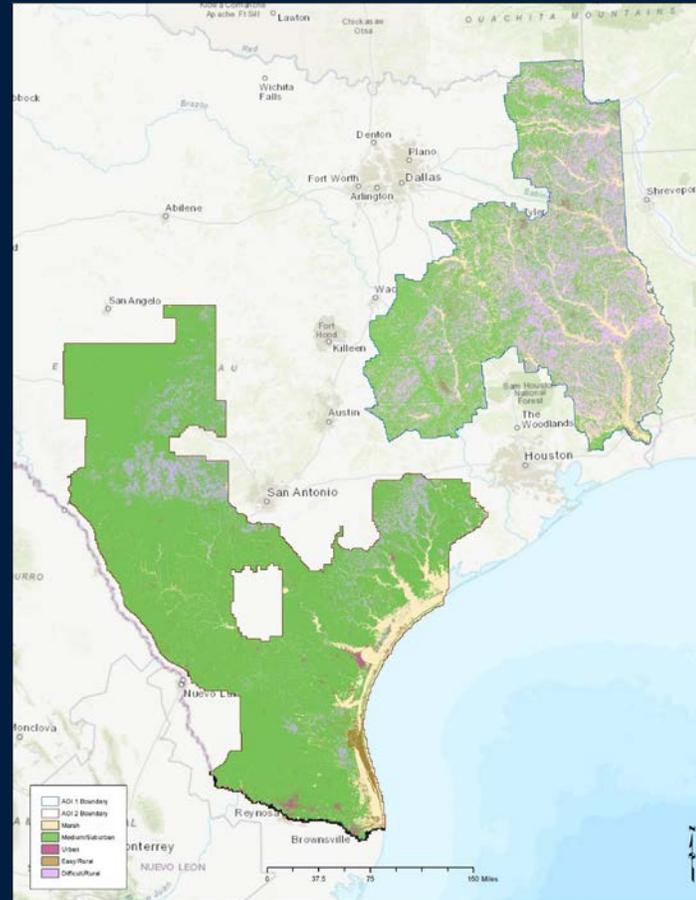
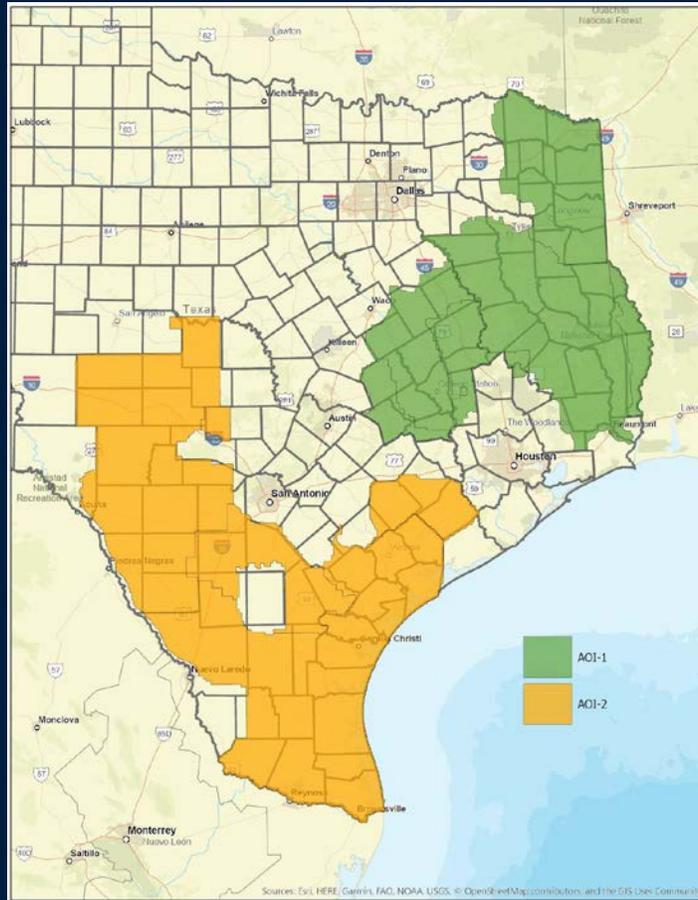
Sense.Lidar is Fugro's machine learning process for accurately classifying USGS lidar data.

The data is enhanced from the standard USGS classifications to include Buildings, Vegetation, and Culverts to a 99% accuracy.

Accessible at <https://data.tnris.org/>

Texas Enhanced Lidar Data

Texas Natural Resources Information System



Existing USGS QL2 lidar

- Class 1. processed, but unclassified
- Class 2. bare earth
- Class 7. low noise
- Class 9. water
- Class 10. ignored ground (near breakline)
- Class 17. bridge decks
- Class 18. high noise

97,836 national grid tiles

83,184.5 square miles

Lidar point cloud classified to TNRIS specifications from class 1

- Class 3. low vegetation
- Class 4. medium vegetation
- Class 5. high vegetation
- Class 6. building
- Class 14. culverts (from class 2. bare earth)

3

Production Workflow

Sense.Lidar Workflow

Automation with human assisted feature extraction



Data access, formatting, QC, and staging



Segment data by land cover category



Create training data sets based on land cover



Run cloud based auto classification



Human assisted QC, edit, and cleaning



QC data product and packaging for cloud delivery

Sense.Lidar Data Management

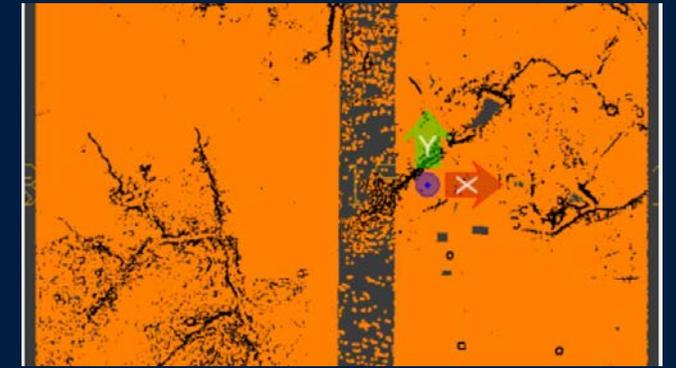
Managing data imperfections at ingest



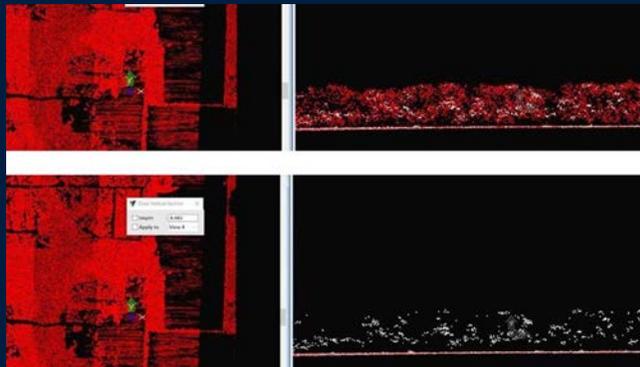
Data gaps in Class 1 & 2



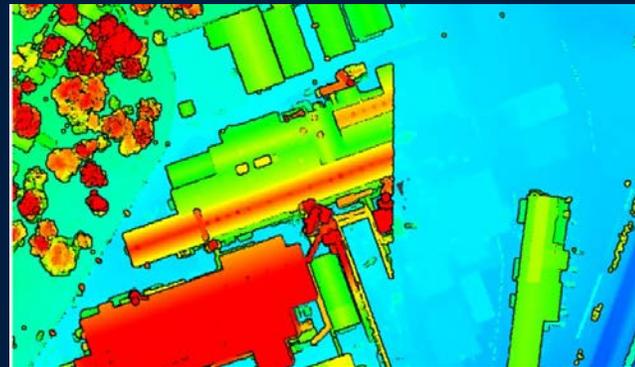
Low point density in Class 1 & 2



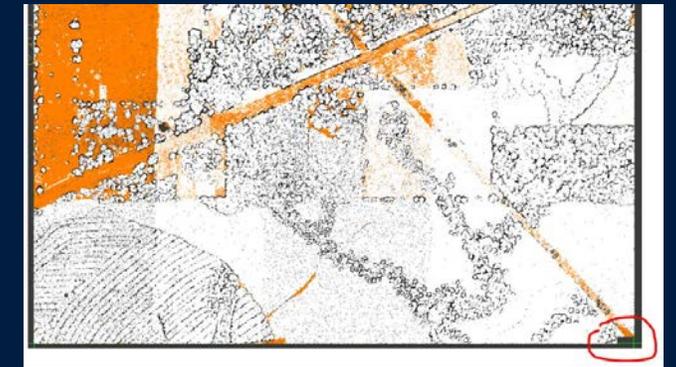
Data gaps and low point density in class 2



Improper class 7



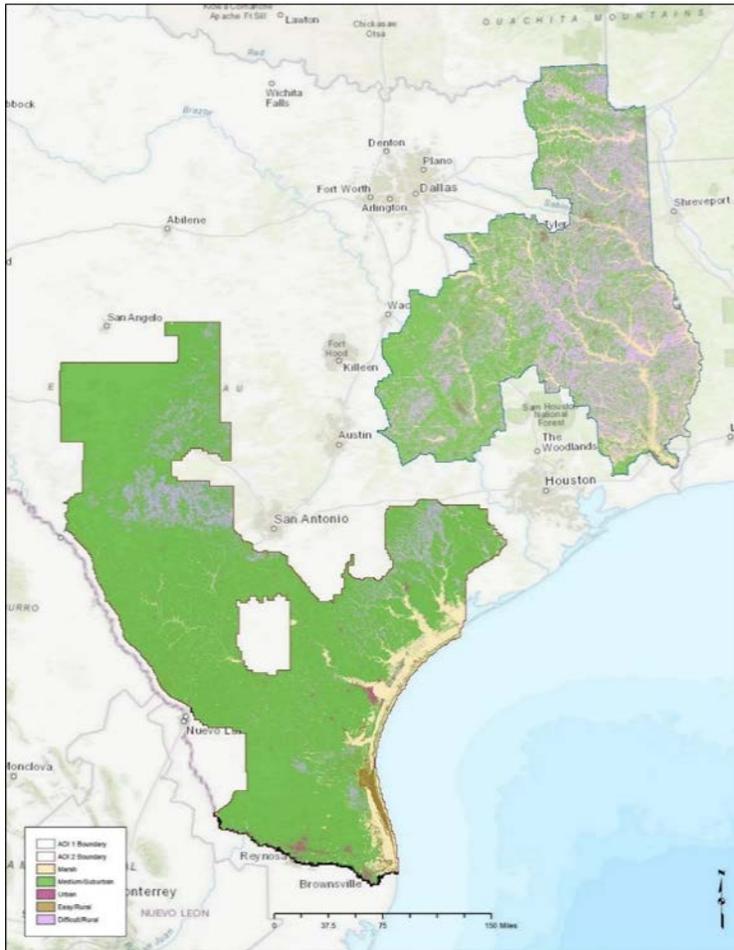
Missing partial buildings



Data gap

Sense.Lidar Land Cover

Segment lidar AOI by land cover for training



Area and Land Cover Type

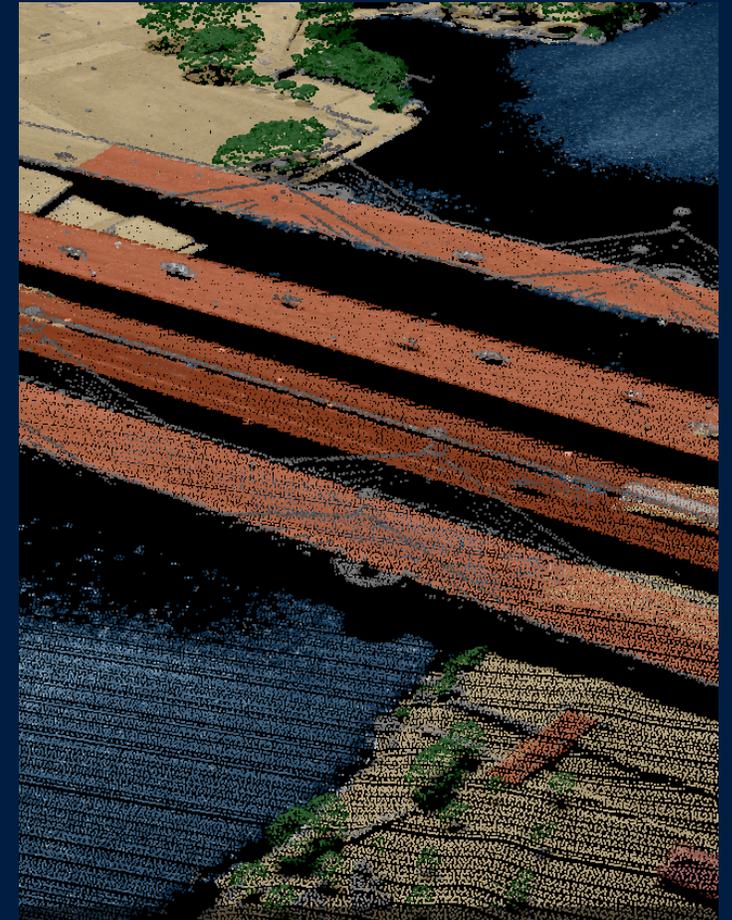
1. 97,836 national grid tiles
2. 15 NLCs
 1. Open water
 2. Developed Open space
 3. Developed Low intensity
 4. Developed Medium intensity
 5. Developed High intensity
 6. Barren land
 7. Deciduous forest
 8. Evergreen forest
 9. Mixed forest
 10. Shrub/scrub
 11. Herbaceous
 12. Hay/pasture
 13. Cultivated crops
 14. Woody wetlands
 15. Emergent herbaceous wetlands

Project Specifications

1. USGS QL2
 1. Processed (1)
 2. Bare earth (2)
 3. Low noise (7)
 4. Water (9)
 5. Bridge deck (17)
 6. High noise (18)
 7. Ignored ground (20)
2. Sense.Lidar classifications
 1. Low vegetation (3)
 2. Medium vegetation (4)
 3. High vegetation (5)
 4. Building (6)
 5. Culverts (14)

Sense.Lidar Training

Create lidar training datasets based on land cover type





4

Accuracy

Sense.Lidar Accuracy

Accuracy is key for performing analysis



1. Create near-perfect accuracy check lidar tiles
2. Run comparison between near perfect tiles and auto classification tiles

Adding classifications

1. Low vegetation (3)
2. Medium vegetation (4)
3. High vegetation (5)
4. Building (6)
5. Culverts (14)

[usgs17-70cm_15sts985840_confusion_matrix.txt] Confusion Matrix:

Total number of points: 9489026.
Total number of points changed: 653.

	1	2	3	4	5	6	7	9	10	# points
1	99.94	0.20	0.20	0.10	-	-	-	-	-	466998
2	-	100.00	-	-	-	-	-	-	-	4439365
3	0.30	-	99.97	-	-	-	-	-	-	309889
4	0.10	-	-	99.99	-	-	-	-	-	580740
5	-	-	-	-	100.00	-	-	-	-	3656889
6	2.90	-	-	-	-	97.91	-	-	-	671
7	-	-	-	-	-	-	100.00	-	-	18
9	-	-	-	-	-	-	-	100.00	-	31147
10	-	-	-	-	-	-	-	-	100.00	3309

[usgs17-70cm_15sur330985_confusion_matrix.txt] Confusion Matrix:

Total number of points: 7930516.
Total number of points changed: 63669.

	1	2	3	4	5	6	7	9	10	11	14	17	18	# points
1	99.26	-	0.34	0.31	0.80	0.10	-	-	-	-	-	-	-	1010661
2	-	100.00	-	-	-	-	-	-	-	-	-	-	-	3482296
3	4.44	-	95.56	-	-	-	-	-	-	-	-	-	-	248641
4	3.97	-	-	95.87	-	0.16	-	-	-	-	-	-	-	245783
5	1.60	-	-	-	98.90	0.40	-	-	-	-	-	-	-	2159001
6	1.10	-	0.10	0.60	0.25	98.57	-	-	-	0.10	-	-	-	777226
7	-	-	-	-	-	-	100.00	-	-	-	-	-	-	110
9	-	-	-	-	-	-	-	100.00	-	-	-	-	-	714
10	-	-	-	-	-	-	-	-	100.00	-	-	-	-	1606
11	-	-	-	-	-	-	-	-	-	100.00	-	-	-	1009
14	-	-	-	-	-	-	-	-	-	-	100.00	-	-	2967
17	-	-	-	-	-	-	-	-	-	-	-	100.00	-	501
18	-	-	-	-	-	-	-	-	-	-	-	-	100.00	1

[usgs17-70cm_15sur525580_confusion_matrix.txt] Confusion Matrix:

Total number of points: 8022756.
Total number of points changed: 6842.

	1	2	3	4	5	6	7	9	10	14	# points
1	99.97	-	0.20	0.10	-	-	-	-	-	-	1341811
2	-	100.00	-	-	-	-	-	-	-	-	3742523
3	1.14	-	98.86	-	-	-	-	-	-	-	339496
4	0.37	-	-	99.63	-	-	-	-	-	-	328725
5	0.50	-	-	-	99.95	-	-	-	-	-	2256754
6	1.90	-	-	0.20	0.16	98.73	-	-	-	-	12952
7	-	-	-	-	-	-	100.00	-	-	-	4
9	-	-	-	-	-	-	-	100.00	-	-	161
10	-	-	-	-	-	-	-	-	100.00	-	64
14	-	-	-	-	-	-	-	-	-	100.00	266

[usgs17-70cm_15sur690805_confusion_matrix.txt] Confusion Matrix:

Total number of points: 8291293.
Total number of points changed: 999.

	1	2	3	4	5	6	7	9	10	14	# points
1	99.97	-	0.20	0.10	-	-	-	-	-	-	792765
2	-	100.00	-	-	-	-	-	-	-	-	2462248
3	0.60	-	99.94	-	-	-	-	-	-	-	689586
4	0.30	-	-	99.96	-	-	-	-	-	-	323141
5	-	-	-	-	100.00	-	-	-	-	-	3959024
6	1.29	-	-	0.80	0.12	98.51	-	-	-	-	2488
7	-	-	-	-	-	-	100.00	-	-	-	218
9	-	-	-	-	-	-	-	100.00	-	-	56950
10	-	-	-	-	-	-	-	-	100.00	-	4843
14	-	-	-	-	-	-	-	-	-	100.00	30

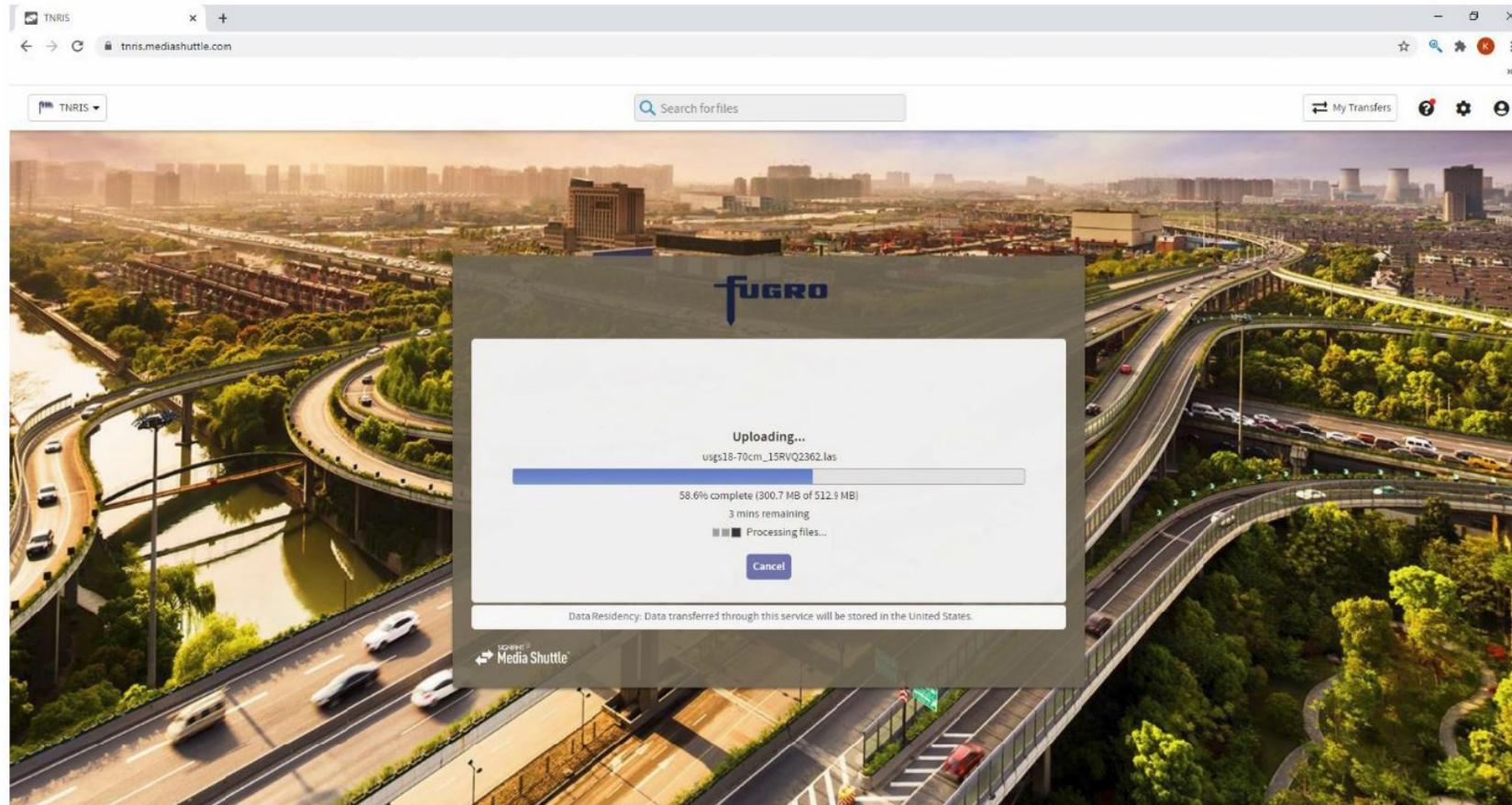
Project Specifications

- USGS QL2
 - Processed (1)
 - Bare earth (2)
 - Low noise (7)
 - Water (9)
 - Bridge deck (17)
 - High noise (18)
 - Ignored ground (20)
- Sense.Lidar classifications
 - Low vegetation (3)
 - Medium vegetation (4)
 - High vegetation (5)
 - Building (6)
 - Culverts (14)



Sense.Lidar Edit and Delivery

Human-assisted edit and cloud delivery



5

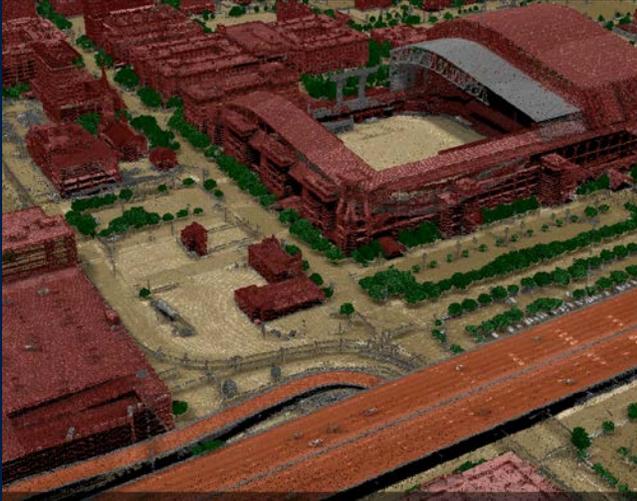
USGS to State Specifications Results

Sense.Lidar Results

Enhanced USGS Lidar to include Buildings, Vegetation, and Culverts



Key features



Accurately classifies lidar point clouds to best represent the feature to 95%-99% accuracy.



Efficiently and accurately assists with creating lidar-derived 3D digital twins of natural and built assets.



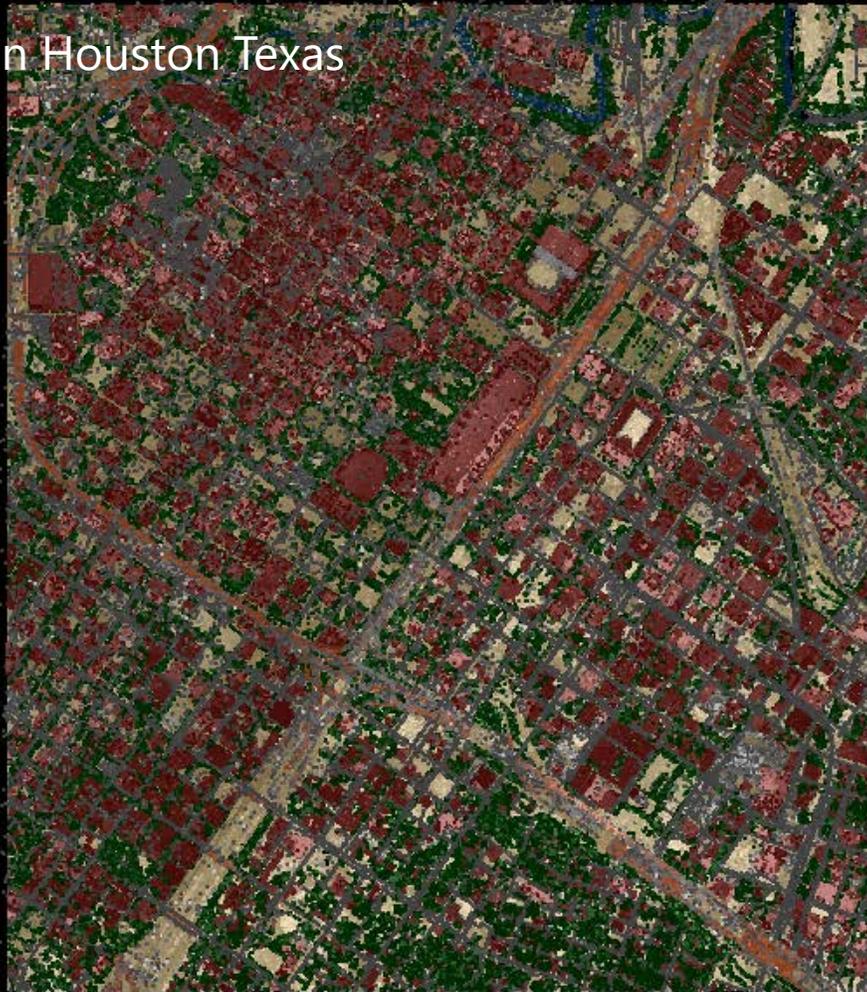
Can be localised or scaled to city, state or country-wide analyses through cloud-based processing.

6

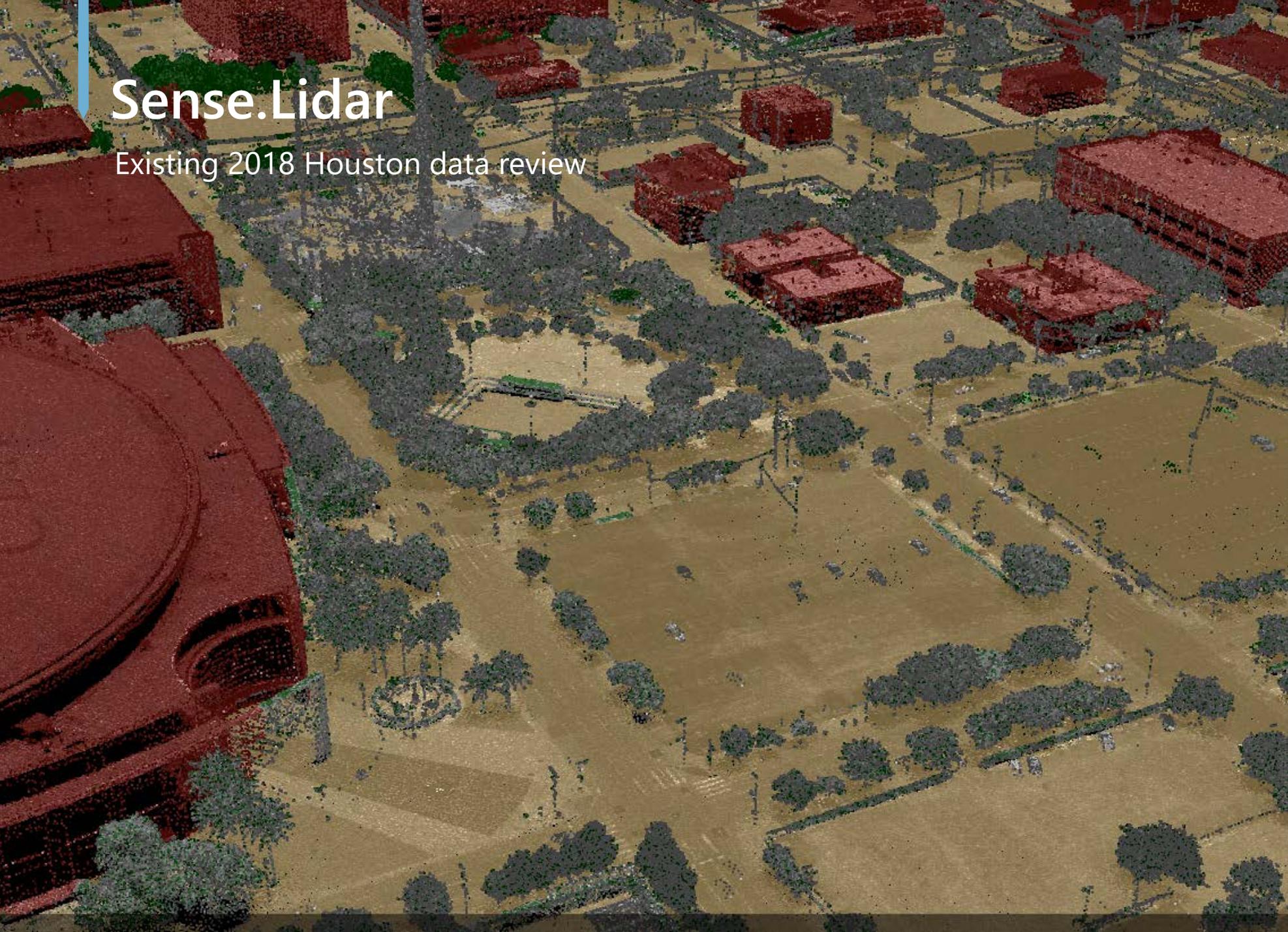
Enhancing Existing Texas Data

Sense.Lidar

Urban area test in Houston Texas



- Using Fugro-developed 2018 topographic lidar to TNRIS specifications
- Sense.Lidar used to determine the accuracy of enhancing legacy data
- Fugro removed the lidar classification and ran the tiles through Sense.Lidar to reclassify the vegetation and buildings from the 4ppsm data



Sense.Lidar

Existing 2018 Houston data review

- Existing/vintage data used macros combined with manual techniques for classifying lidar data
- This required a production workflow that was labor intensive and expensive
- Projects often sacrificed quality to fit budgets and schedules.
- Many points in unclassified or misclassified from COTS Macro development and human assisted editing



Sense.Lidar

Existing 2018 Houston data review

- Unclassified removed to visualize existing/vintage data classification imperfections
- Powerlines, poles, buildings and other utility features show up in veg class



Sense.Lidar

Existing 2018 Houston data review

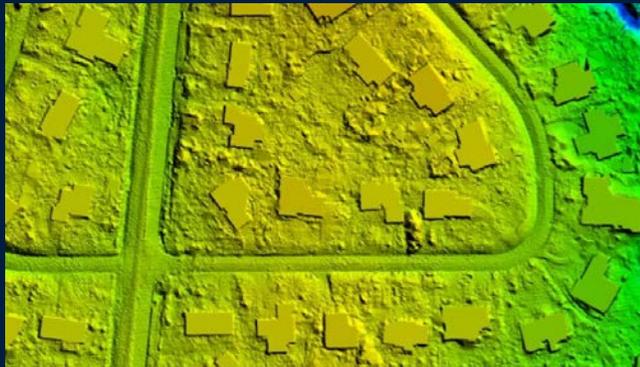
- Sense.lidar machine learning outperforms COTS software macros and human editing
- The automated process achieves, on average, a 95% accuracy
- This provides opportunity for human-assisted feature extraction (HAFl) to focus on the fine details to achieve 99% accuracy

7

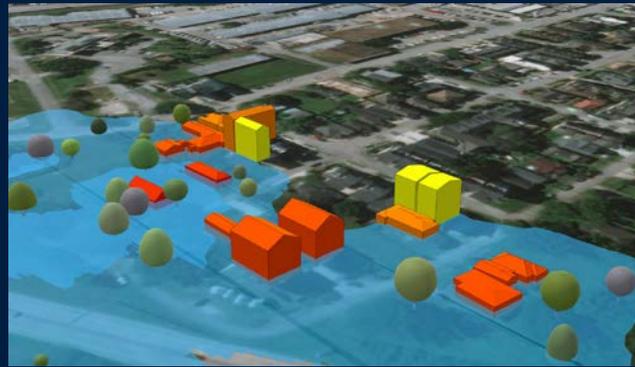
Expanded use of Sense.Lidar

Better Data with Sense.Lidar

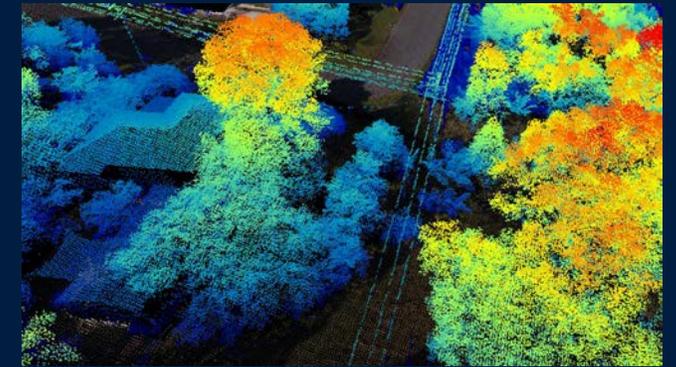
Better point classifications assist in created better data



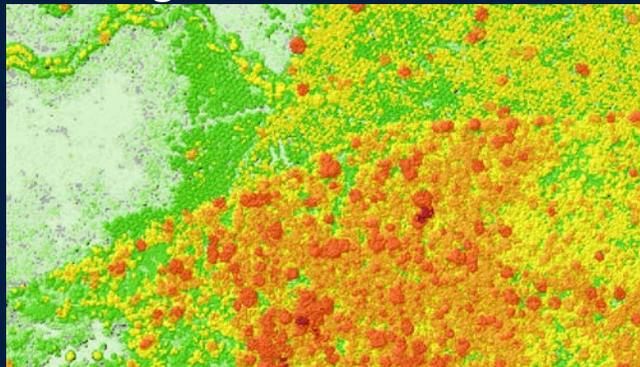
Building footprints and building flattened DEM



Improved LOD1 and LOD2 building models



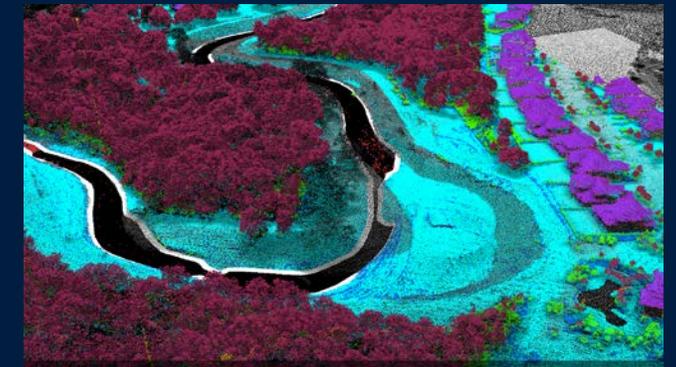
Improved asset identification



Accurate vegetation geolocation and density



Accurate vegetation height



Accurate and efficient change analysis

Expanding the Use of Lidar

With more classifications, more analysis can be done!



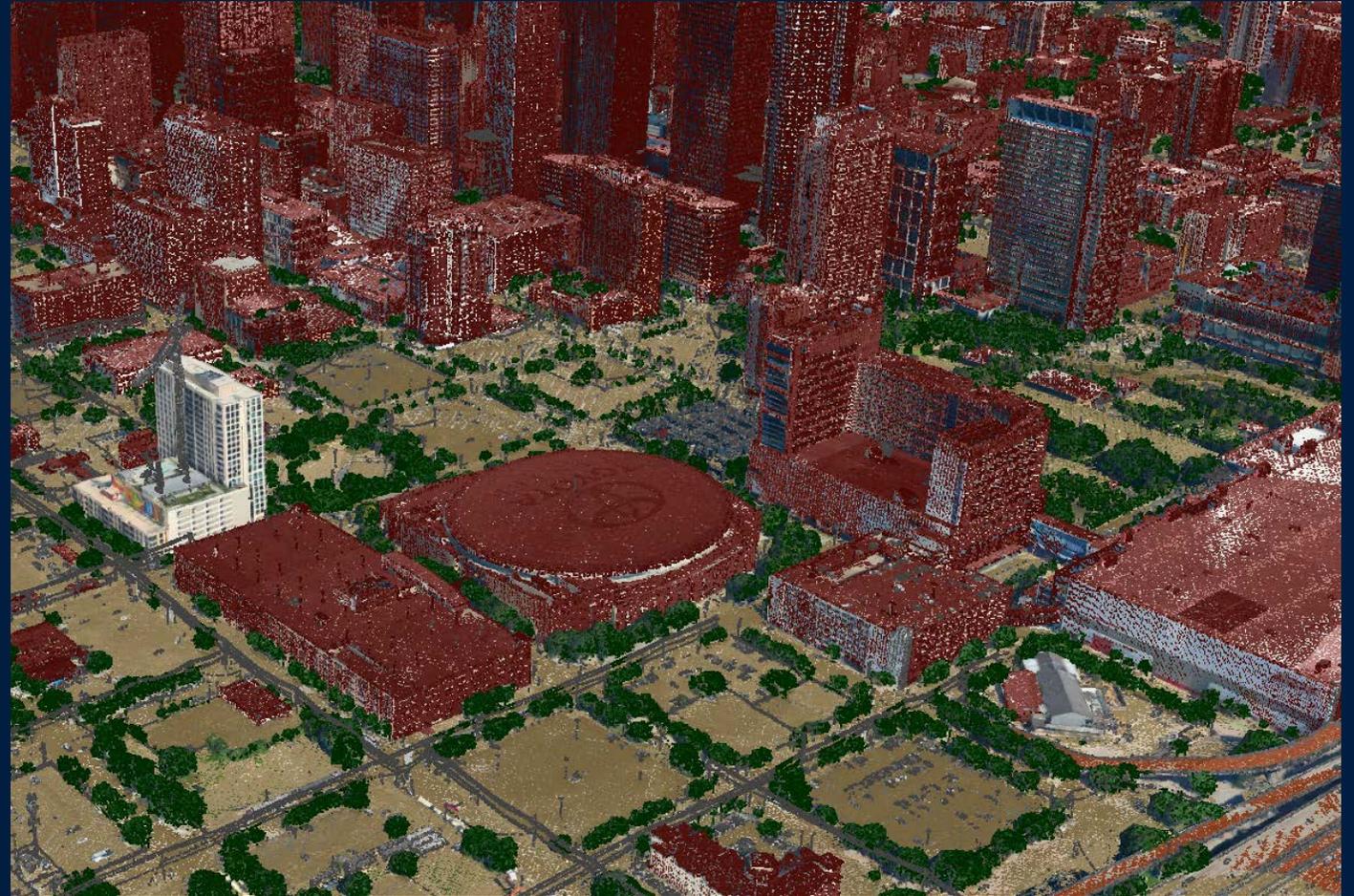
Helping Improve 3D Models

Using better classified lidar data to improve 3D model output



Combining Accuracy and Visualization

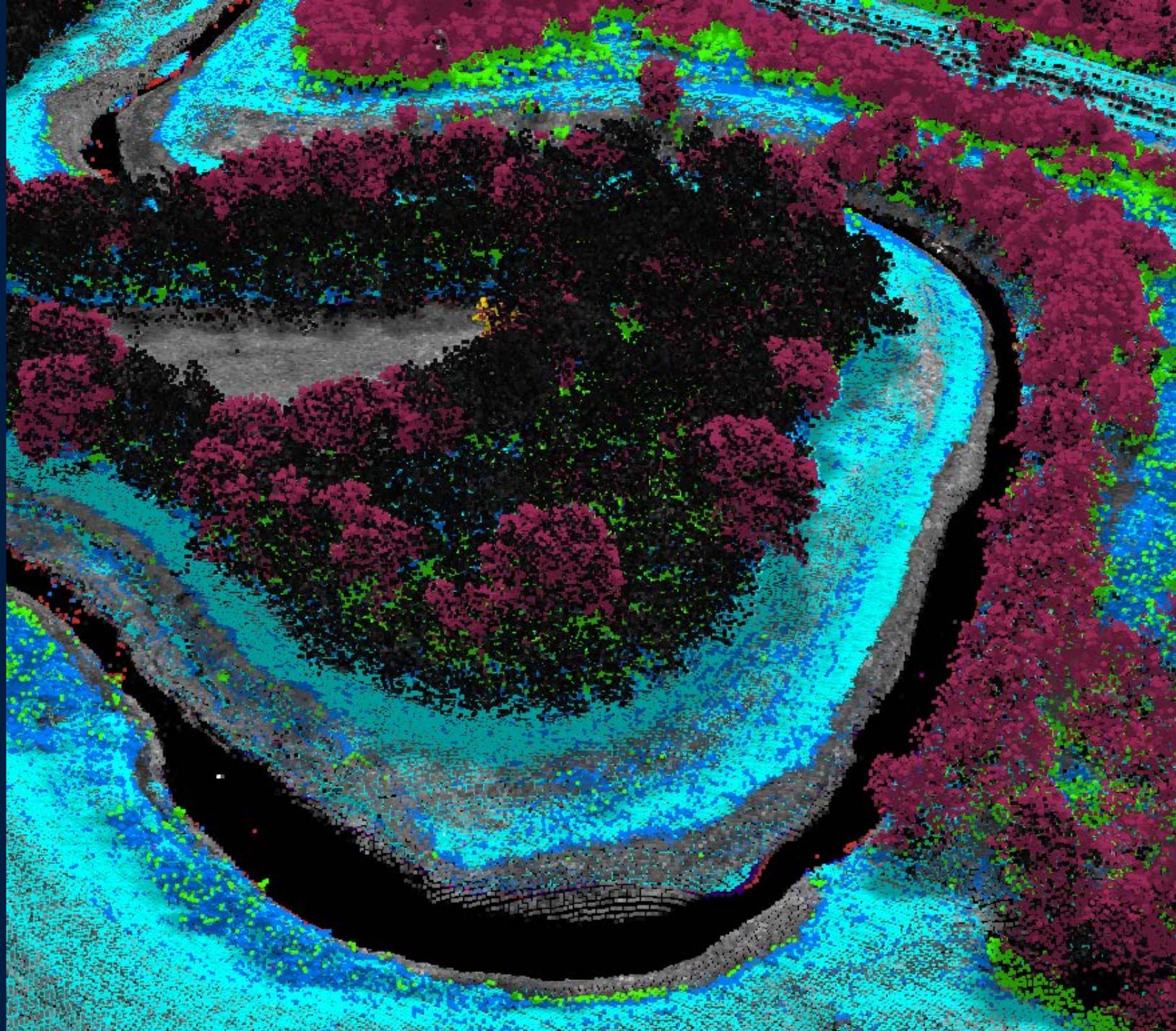
Merging Sense.Lidar results with 3D model processing expands options for product output



Sense.Lidar Roadmap

Roadmap of Sense.Lidar

- Continue creating land category machine learning datasets
- Build programs for 2, 4, 8, 16, 32, 64+ ppsm lidar data input
- Add classifications to support transportation, facilities, water management, forestry and agriculture
- Improve existing data to support more accurate change analysis



8

Sense.Lidar Today

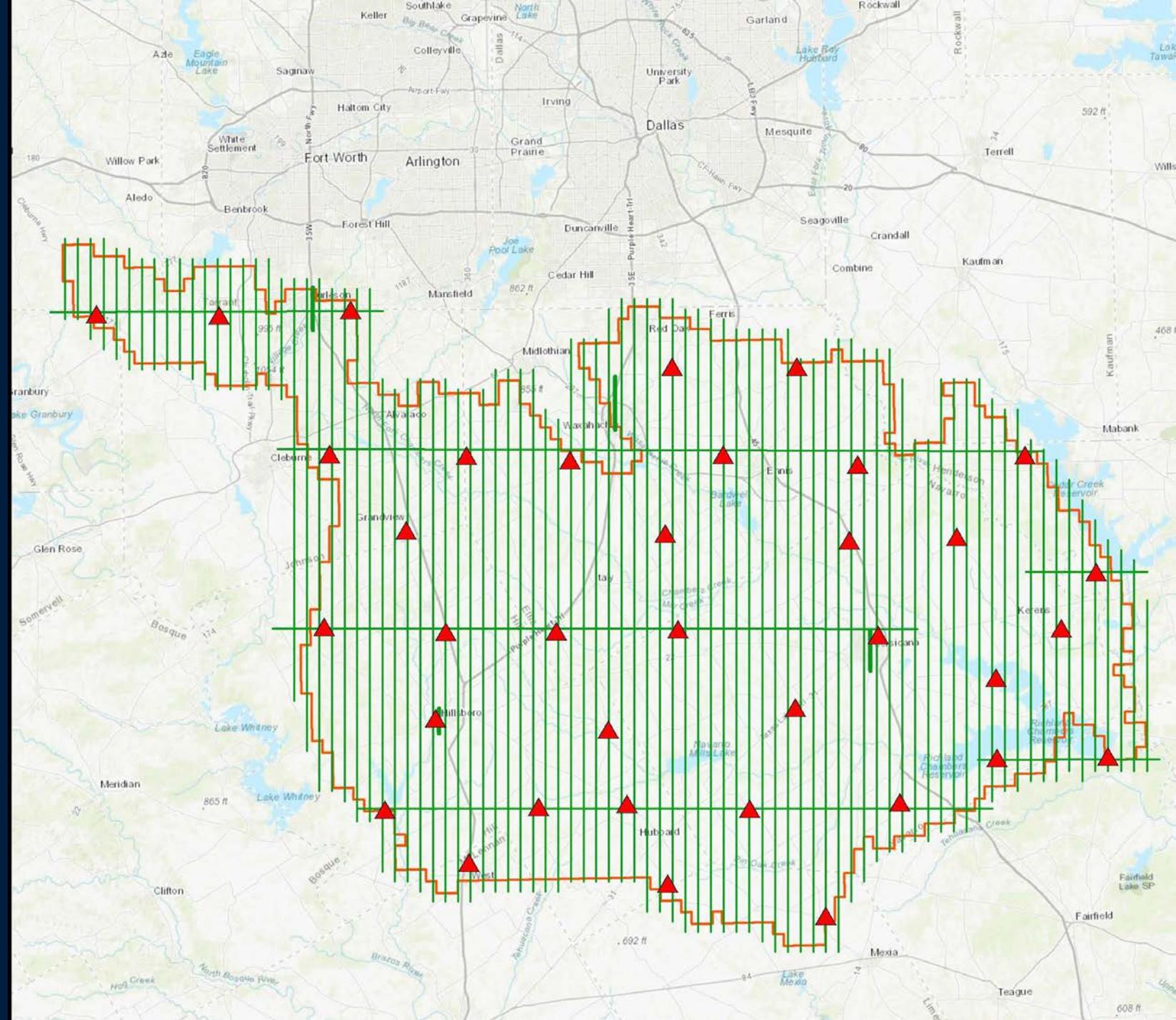
JHEN

2022 TNRIS Lidar 4ppsm

Through our Texas DIR contract with the Texas Natural Resources Information System (TNRIS)

Portions of:

- Ellis County
- Hill County
- Johnson County
- Navarro County



JHEN Statistics and Status

Project details



8,000ft AGL



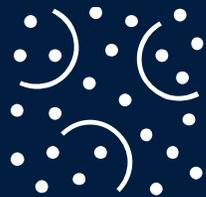
96 Fli Li
3,461 Li Mi



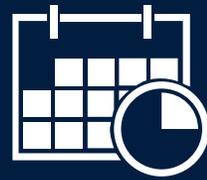
Leaf off
Jan/Feb22



3,223 sq. mi.



4ppsm



On
schedule
July 8, 2022

Deliverables

Classified point cloud:

- Class 1 Unclassified
- Class 2 bare-earth ground
- Class 3 Low veg
- Class 4 Med veg
- Class 5 High veg
- Class 6 Building
- Class 7 Low point (noise)
- Class 9 Water
- Class 14 Culverts
- Class 17 Bridge decks
- Class 18 High noise
- Class 20 Ignored ground

Bare-earth DTM
Intensity Image
Hydro breaklines
Metadata
Project reports

NCTCOG Lidar

Burleson



Sense.Lidar

JHEN



NCTCOG Lidar

Burlison



Sense.Lidar

JHEN



NCTCOG Lidar

Burleson



Sense.Lidar

JHEN



NCTCOG Lidar

Burleson



Sense.Lidar

JHEN



NCTCOG Lidar

Burleson



Sense.Lidar

JHEN



NCTCOG Lidar

Burleson



Sense.Lidar

JHEN



Contact



Keith Owens

Technical and Business
Development Manager

k.owens@fugro.com

(775) 287-2661

www.fugro.com



The logo for FUGRO features a large, stylized white letter 'F' on the left. The vertical stem of the 'F' is a long, downward-pointing arrowhead. To the right of the 'F', the word 'FUGRO' is written in a bold, white, sans-serif font.

FUGRO

Unlocking Insights
from **Geo-data**