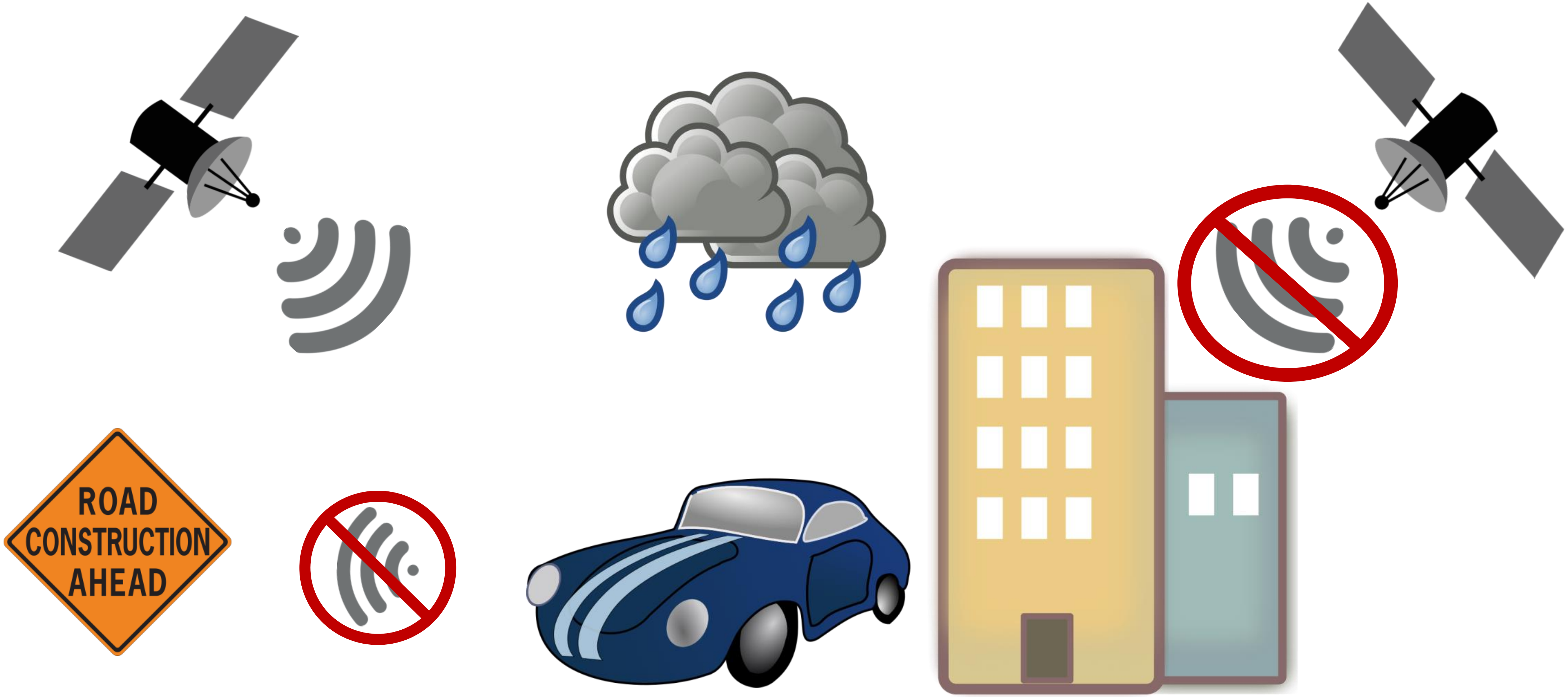
Exploring Optimal GPS Signals for Autonomous Vehicles

Christopher Miller


ROAD
CONSTRUCTION
AHEAD

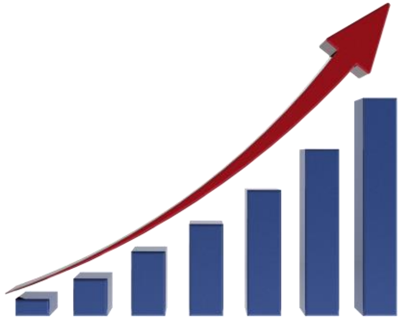
Overview

I. Background
   - *I. Motivation*
   - *II. Autonomous Vehicle (AV) Requirements*

II. Methodology
   - *I. Area of Concentration*
   - *II. Data Inputs*
   - *III. Workflow*

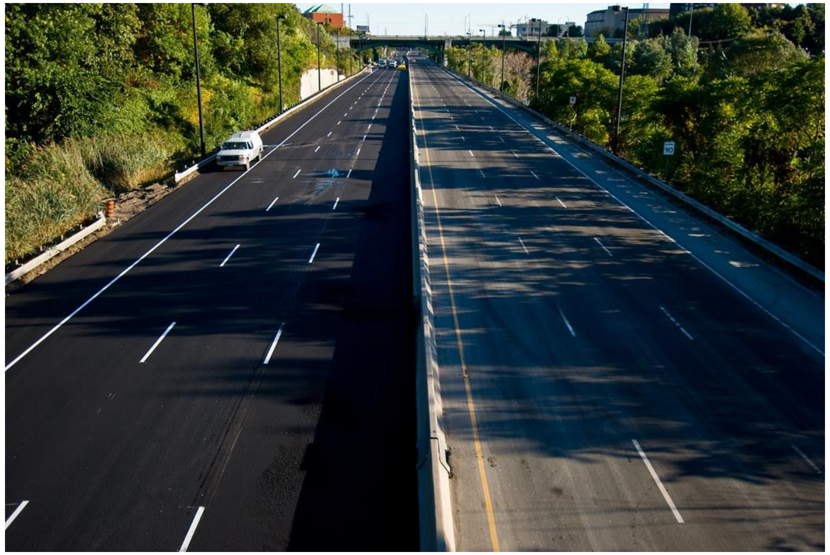
III. Tentative Results

Background: *Motivation*

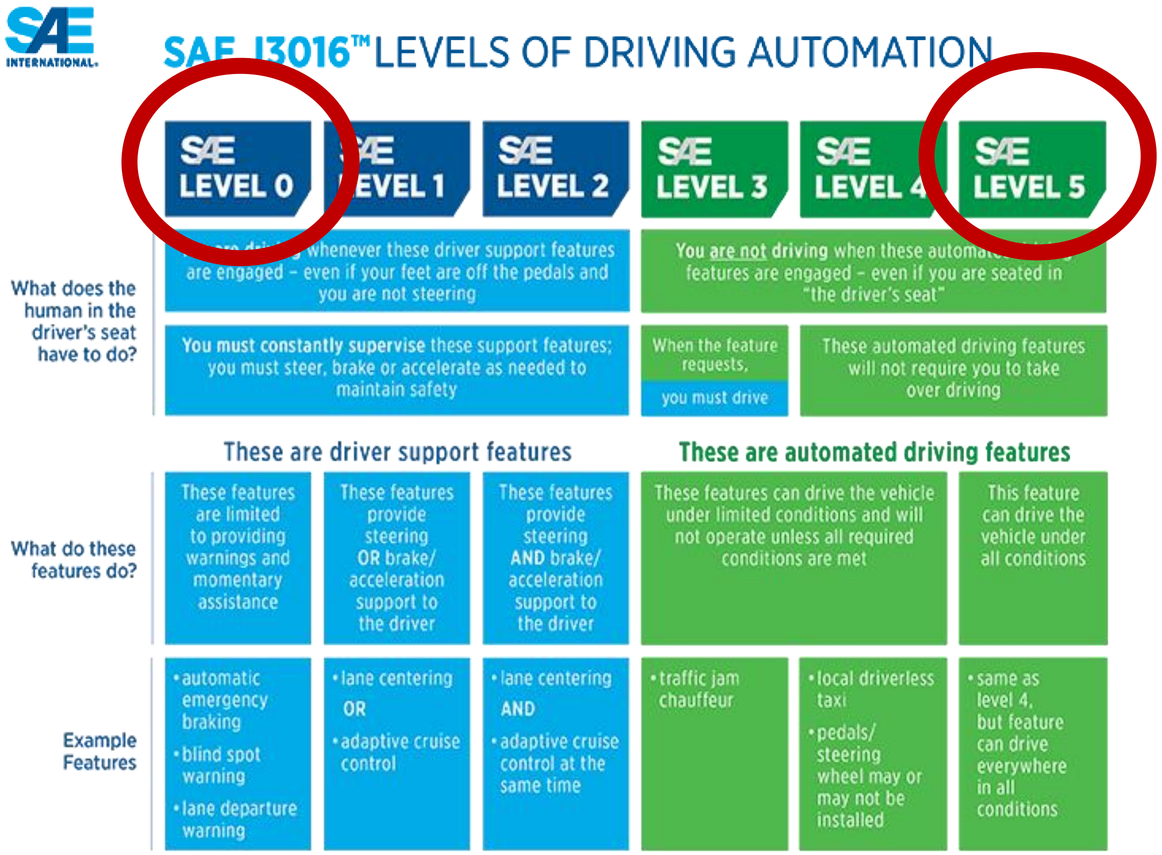


1.3 billion currently to 2 billion in 2030

Background: *Motivation*



Background: *AV Requirements*



Automated Driving System:

"hardware and software that are collectively [...] used specifically to describe a level 3, 4, or 5 driving automotive system" - SAE International, 2018a

Background: *AV Requirements*

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"Provide high resolution and accurate 3D maps around the vehicle that allow obstacle detection and support safe navigation" - Filgueira, 2017

Background: *AV Requirements*

"reduced contrast of the lanes (e.g. reflections, low light) or other disruptive factors such as snow or old lane markings" (Adali, 2018).

Background: *AV Requirements*

Background: *AV Requirements*

Methodology: *Area of Concentration*

Washington, D.C.

Access to data – opendata.dc.gov

Infrastructure – future integration potential

Interest within the City –

- Need to improve
- Member of an initiative group

Methodology: *Data Inputs*

Viewshed Tool in ArcMap

- Surface elevation raster – digital surface model (DSM)

- Poir ... (OFFSET ... ions

Longitude, Latitude and Altitude

e Group

Methodology: *Data Inputs*

Point data, including height (OFFSETA) – satellite locations

Almanac – easy to use .txt files, but less accuracy and additional calculations

******** Week 36 almanac for PRN-02 ********
*************YUCA FORMAT**************

ID:	02
Health:	000
Eccentricity:	0.1958465576E-001
Time of Applicability(s):	319488.0000
Orbital Inclination(rad):	0.9575060141
Rate of Right Ascen(r/s):	-0.8137481816E-008
SQRT(A) (m 1/2):	5153.544434
Right Ascen at Week(rad):	-0.4016685250E+000
Argument of Perigee(rad):	-1.688363071
Mean Anom(rad):	0.8161043692E+000
Af0(s):	-0.3690719604E-003
Af1(s/s):	-0.7275957614E-011
week:	36

iemerides – more accurate but harder to use

nerides – most accurate

El-naggar's paper: *New method of GPS orbit determination from GCPS network for the purpose of DOP calculations*

Methodology: *Data Inputs*

Point data, including height (OFFSETA) – satellite locations

Broadcast Ephemerides – more accurate but harder to use

IGS INTERNATIONAL GNSS SERVICE

.sp3.z format –
UNIX compressed ASCII

El-naggar's paper:
New method of GPS orbit determination from GCPS network for the purpose of DOP calculations

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Precise Ephemerides – most accurate

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Almanac – easy to use .txt files, but less accuracy and additional calculations

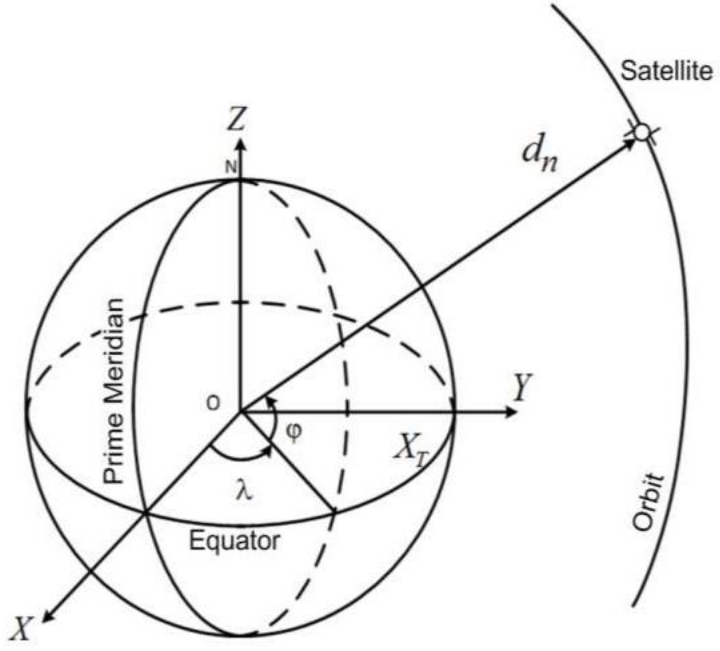
Broadcast Ephemerides – more accurate but harder to use

Precise Ephemerides – most accurate

Methodology: *Workflow*

Precise Ephemerides –

XYZ geocentric coordinates of satellites



Methodology: *Workflow*

Precise Ephemerides –

XYZ geocentric coordinates of satellites

Conversion into geodetic –

Latitude and Longitude: NGS's NCAT

Altitude:

$h = s\cos\mu+(pz+e2N\sin\mu)\sin\mu-N$

where the radius of curvature in the vertical prime ($\overline{N}$) is given by $N=RG1-e2(\sin\mu)2$

Methodology: *Workflow*

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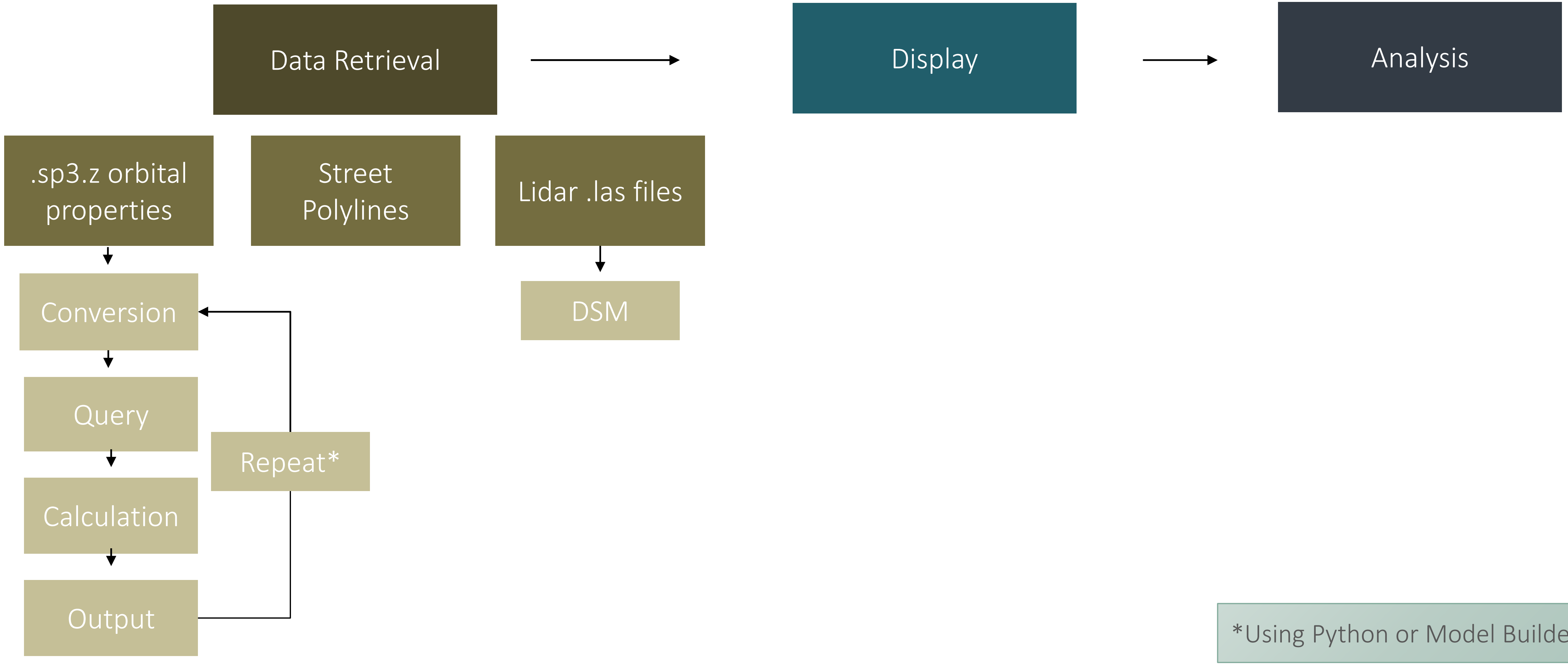
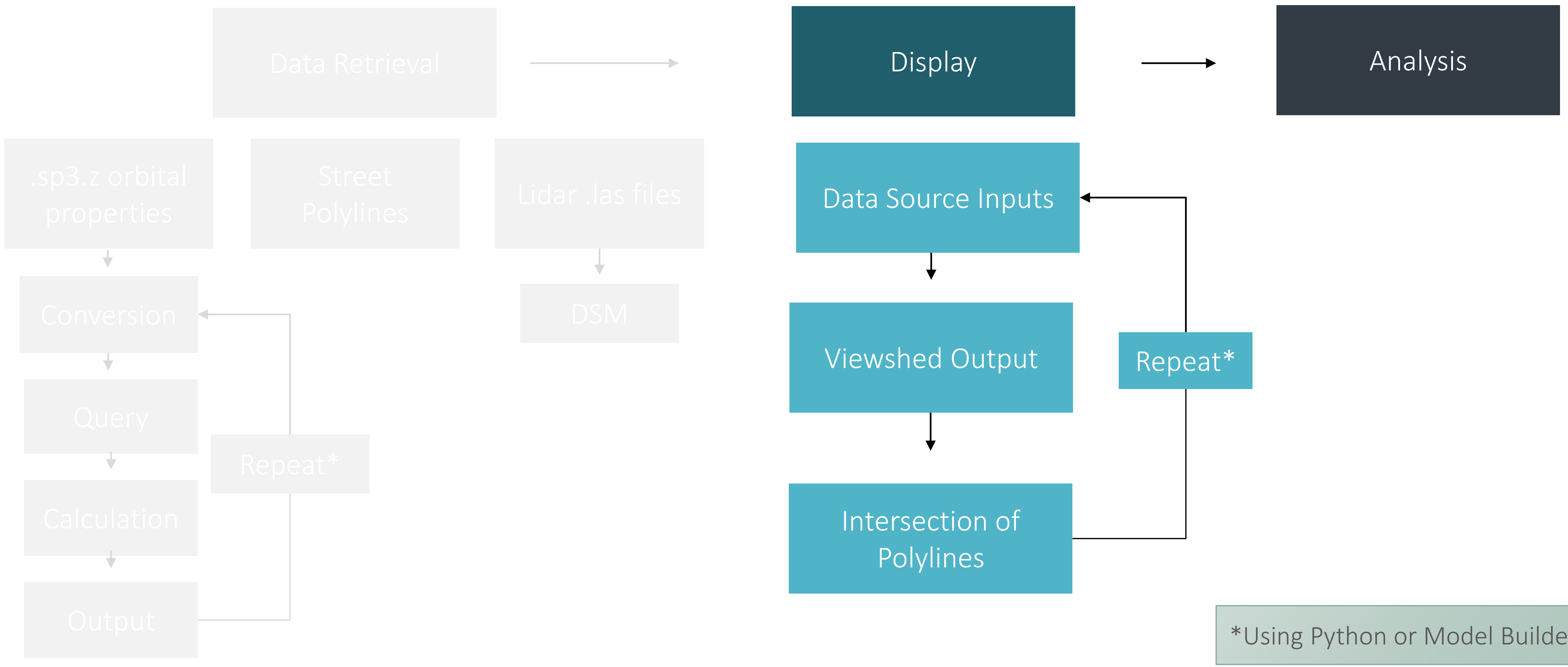


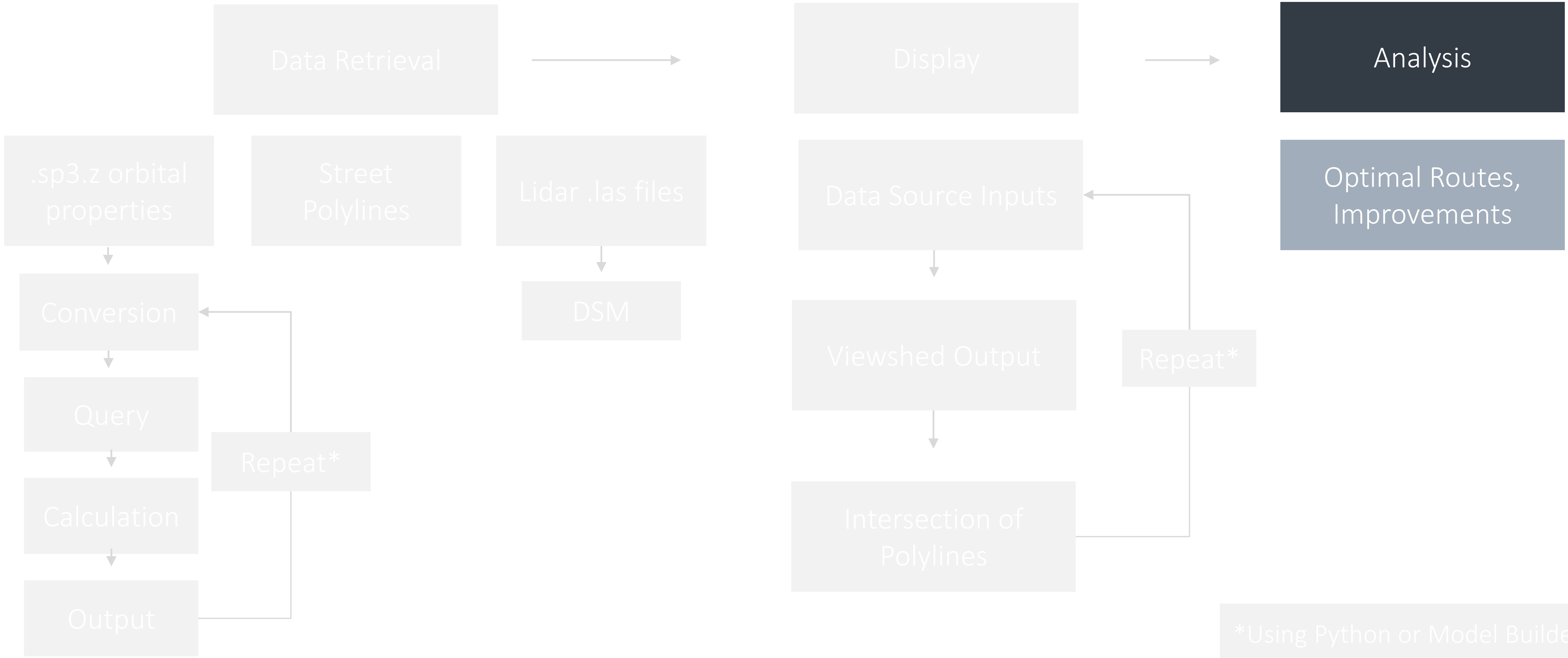
*Using Python or Model Builder

Methodology: *Workflow*



*Using Python or Model Builder

Methodology: *Workflow*



*Using Python or Model Builder

Tentative Results

Obstacle when obtaining .sp3.z files

Hypothesis:

Conversion still possible

Line of sight will be present for the majority of the city

Building height and street width increase visibility

Forest canopies in northwest may be only areas of limitation

ID	DESCRIPTION	ESTIMATED COMPLETION
1	Download lidar point cloud files from opendata.gov	Dec-19
2	Import to LP360	Jan-20
3	Create a DSM from point cloud	Jan-20
4	Import raster DSM to ArcMap	Jan-20
5	Determine calculation necessary for satellite locations	Jan-20
6	Submit Abstract	Feb-20
7	Assess ephemerides and Almanac data source parameters	Mar-20
8	Calculate satellite locations coordinates	Apr-20
9	Convert XYZ coordinates to geodetic latitude, longitude and altitude	May-20
10	Use Viewshed to determine visible areas across DC area	May-20
11	Replicate using for multiple satellites, dates and times – potential to use model builder or Python	Jun-20
12	Use polyline road features from open data DC or lidar classified road points as intersection against viewshed	Jun-20
13	Display areas of visibility from least to the greatest obstruction	Jun-20
14	Analyze areas including city street routes of optimal visibility	Jul-20
15	Draft Report	Sep-20
16	Draft Presentation	Sep-20
17	Present Findings	Oct-20
18	Finalize Report	Dec-20

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