



RealWorld Surveying and Geomatic Corp.

Digital Twin : High Definition Map Production Development in Taiwan

Speaker : Robert Tsai (蔡世霖) Vice president

Company : RealWorld Surveying and Geomatics Corp.

(詮華國土測繪有限公司)



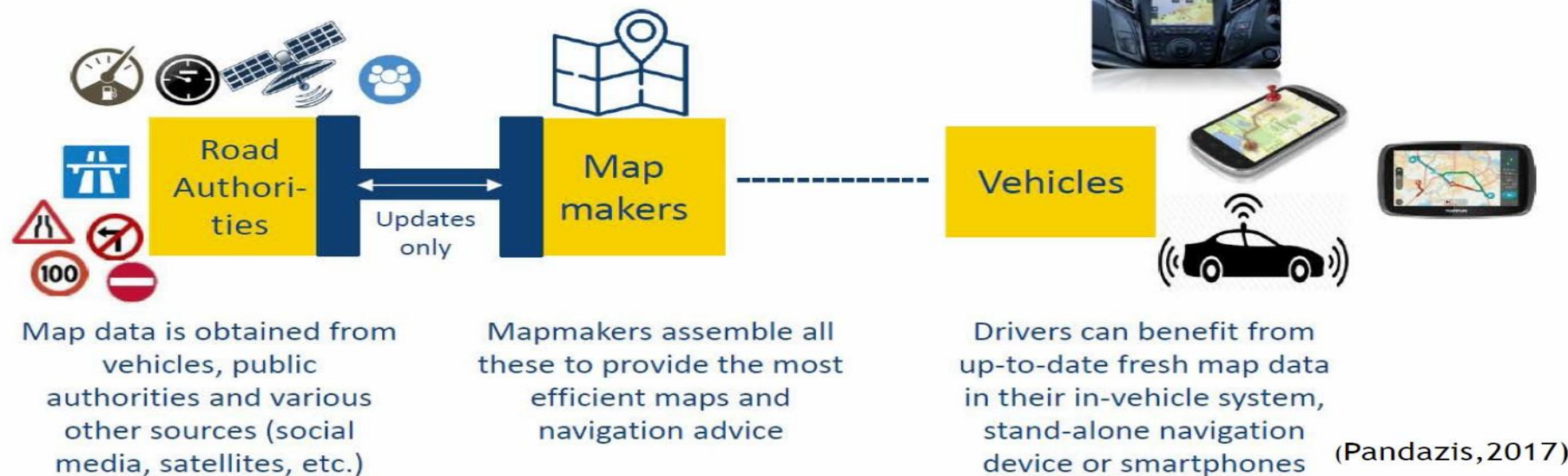
Outline

- Abstract
- Mobile Mapping System
- HD MAP Work Flow
- HD Map format in Taiwan
- Challenges in the Future
- Conclusion



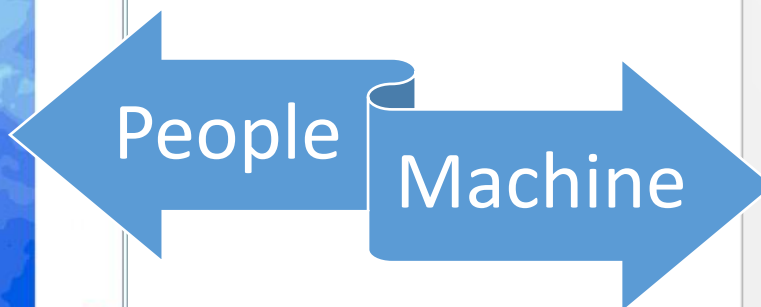
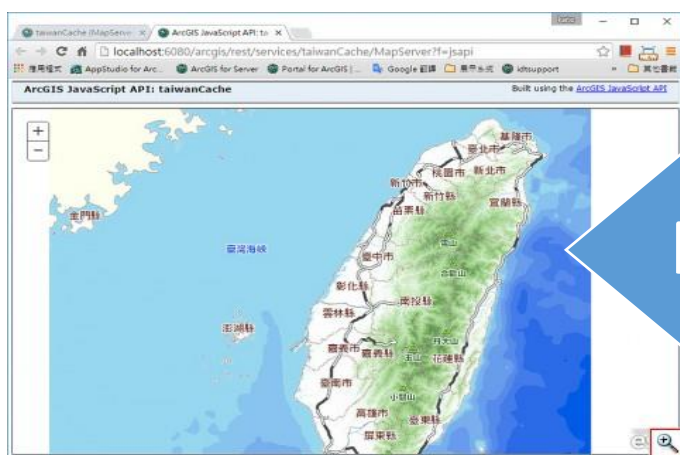
Abstract

- Self-driving cars can not respond immediately
- Big Data(ADAS/Image/LiDAR/GPS/other sensor)
- We still need HD MAP
- We don't want **Big** car





Abstract



```

<?xml version="1.0"?>
<quiz>
  <qanda seq="1">
    <question>
      Who was the forty-second
      president of the U.S.A.?
    </question>
    <answer>
      William Jefferson Clinton
    </answer>
  </qanda>
  <!-- Note: We need to add
  more questions later.-->
</quiz>

```

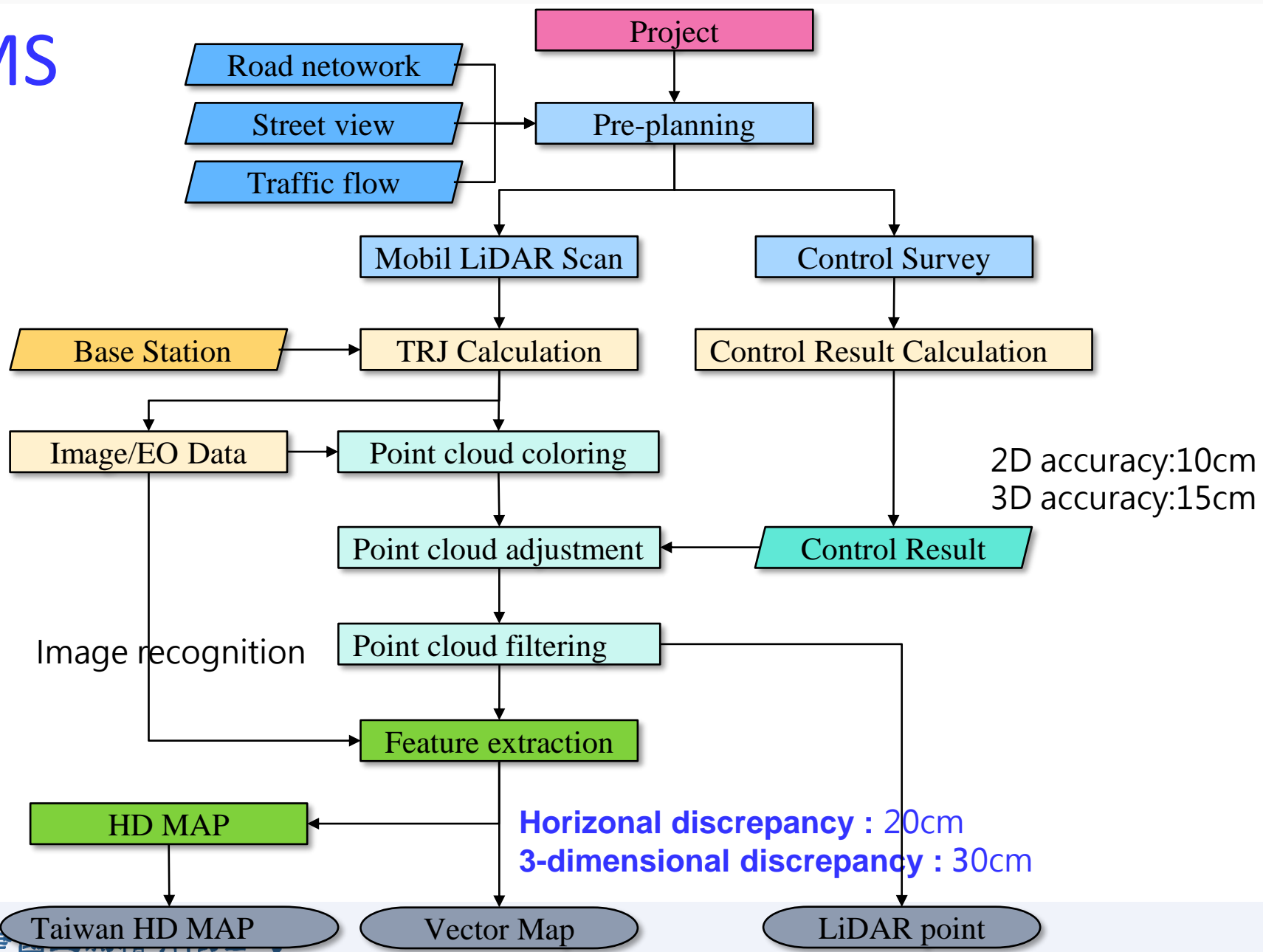
XML



	Traditional MAP	HD MAP
Accuracy	30cm~1m	Horizontal : 20cm Three-dimensional: 30cm
Point density	N/A	2,500~10,000 point/m ²
Data Format	DWG/SHP	SHP OPENDRIVE/Autoware/DMP/NDS/others
Attributes	Database All category attributes are not closely related to each other	All category attributes are related to each other
Error Rate	5~10%	0%
Work flow	Thinking through human logic	Thinking through machine logic



MMS





RIEGL VMX-250

移動雷射掃描





MMS



2,00,000 points/sec

The best accuracy : 5cm

High precision TRJ

4 industrial camera

720° panoramic image



- High integration
- Risk reduction



MMS

Coordinate system

- Plane coordinate system
TWD97
- Elevation coordinate system
Ellipsoid height
- Geodetic coordinate system
WGS84

Control Survey

- e-GNSS/total station
- Feature/Mark
- Horizontal accuracy : 10 cm
- 3D accuracy : 15cm

GNSS base station

- CWB
- NLSC
- RW



e-GNSS



Total station

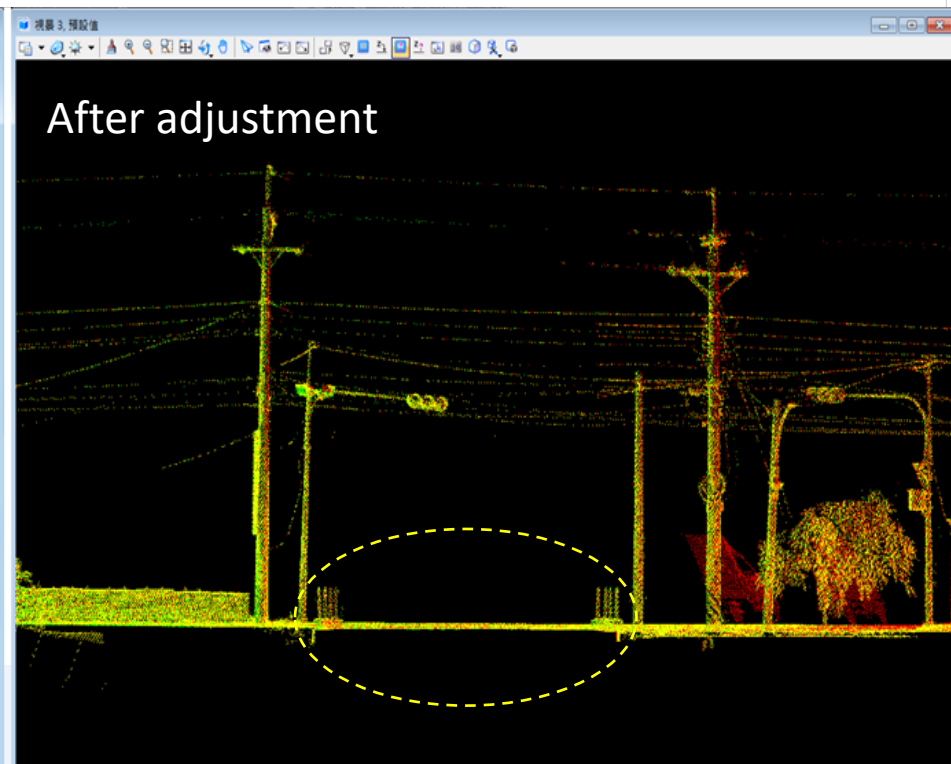
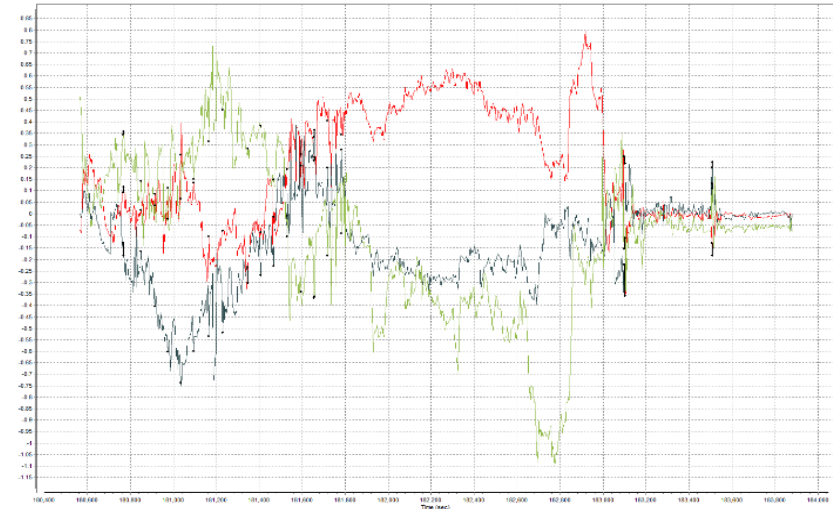


Base Station



MMS

- Trajectory accuracy
- GPS/Glonass/Galileo/Beidou
- PDOP/Combine separation

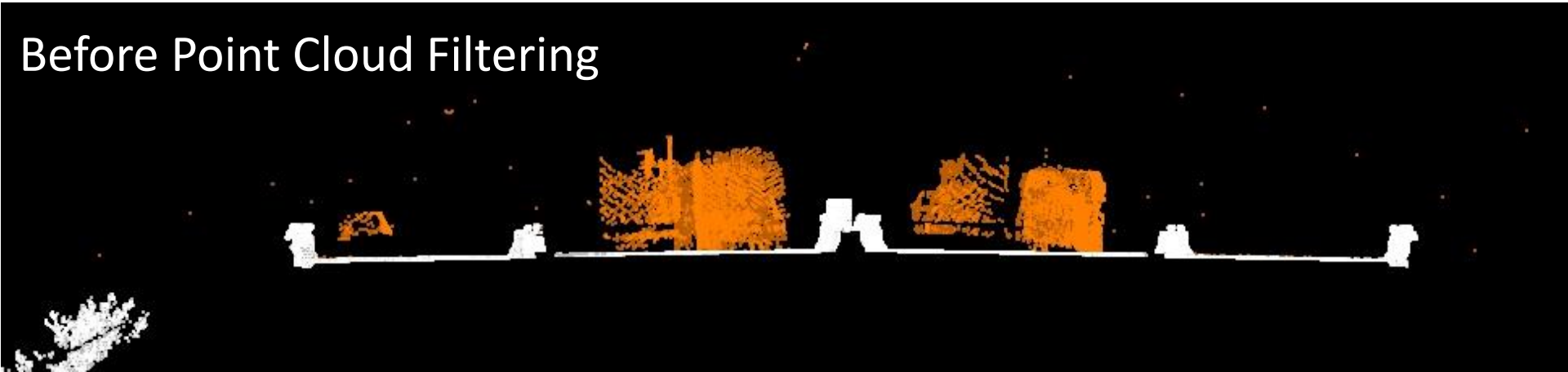




MMS

- Automatic filtering (about 50% success rate)
- Classified for ground point and non-ground point

Before Point Cloud Filtering



After Point Cloud Filtering

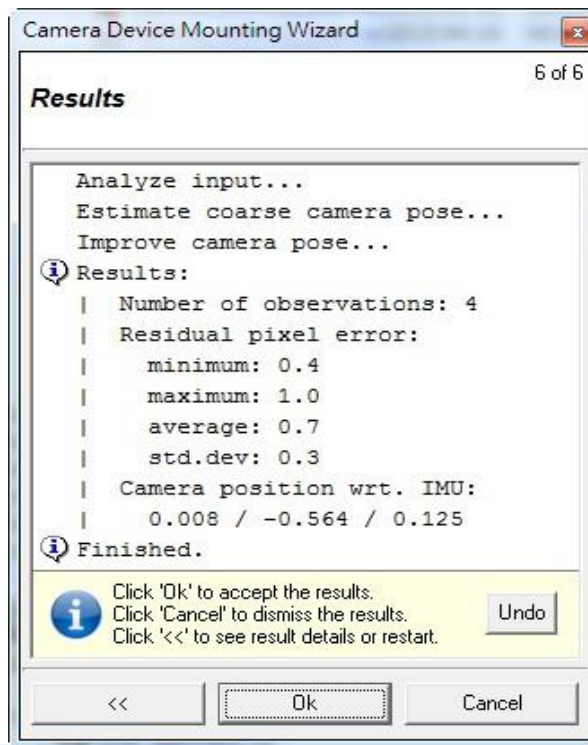
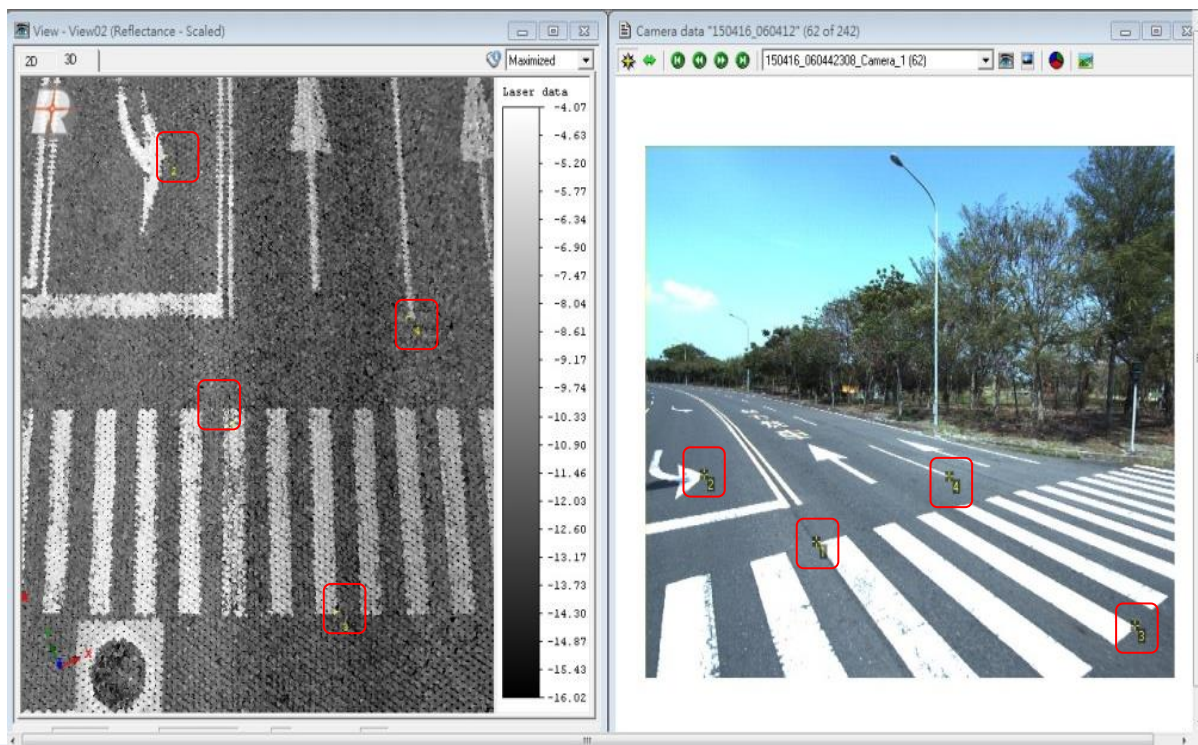
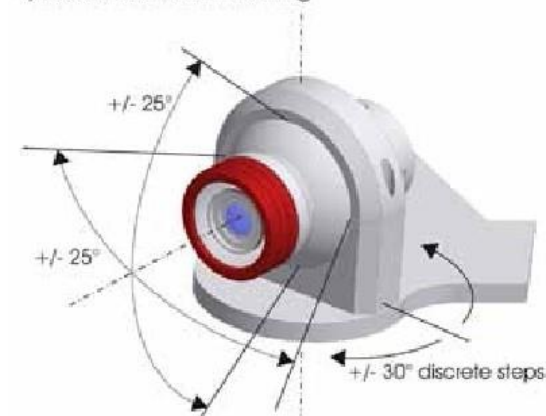




MMS

- Camera orientation
- Image recognition
- AI replace manpower

spherical camera mounting





MMS

- Data storage space is very large
 - ❑ Raw Data : 286G
 - ❑ LiDAR : 28G
 - ❑ Image : 5G
- Point density : 10,000 point /m²
- Image recognition
- AI replace manpower



HD MAP

ROAD

LANE

ROAD
MARKING

OBJECT

TUNNEL

BRIDGE

SIGN

TRAFFIC
SIGNAL

LIGHT

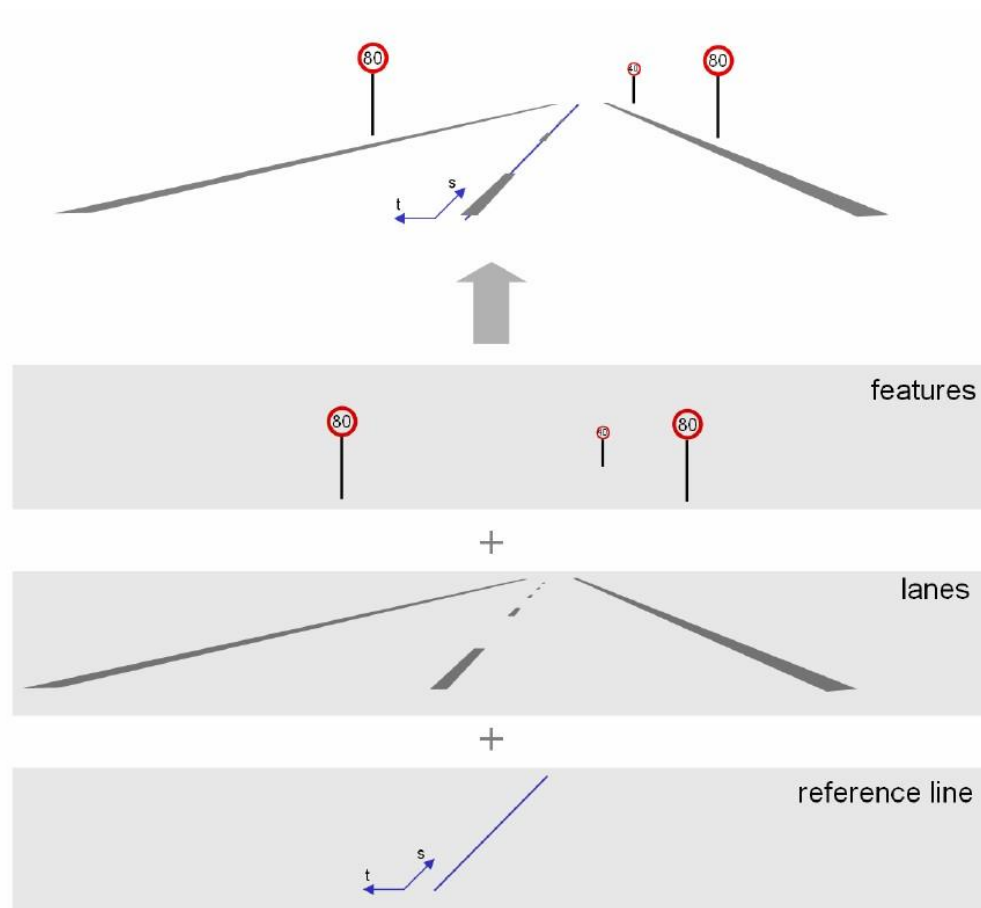
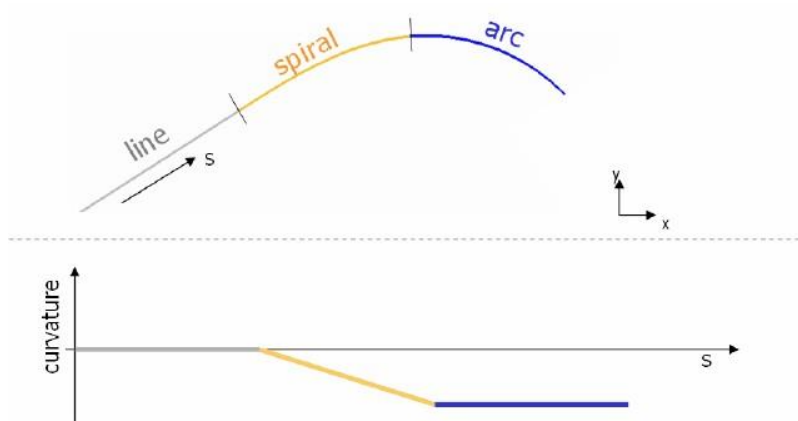
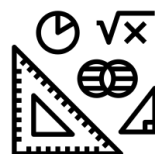
Pole





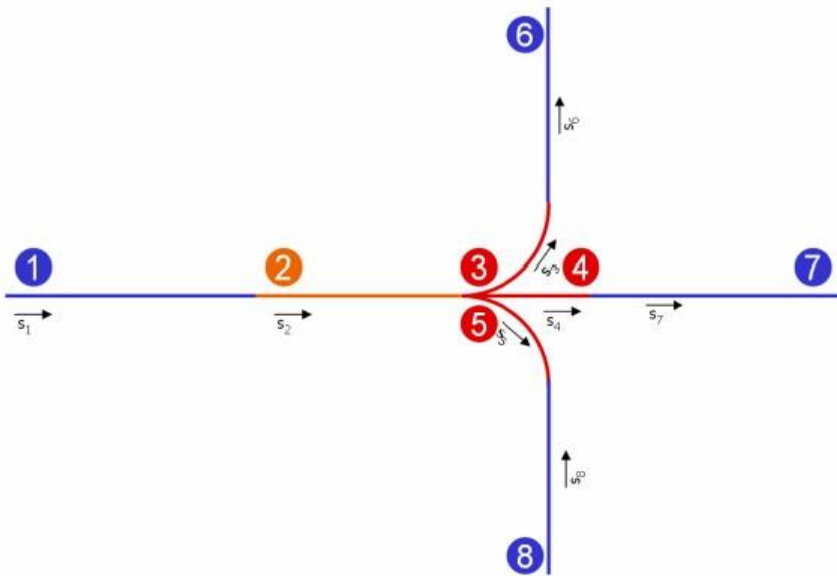
OpenDRIVE format

- Reference line
- Mathematical function
- Every field is unique

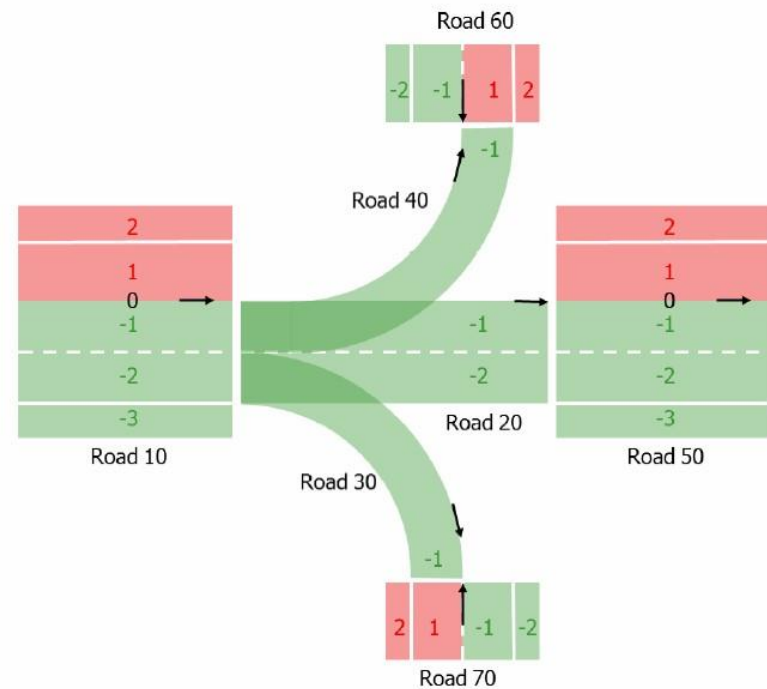




OpenDRIVE format



Road	Predecessor	Successor
1	-	2
2	1	ambiguous
3	2	6
4	2	7
5	2	8
6	3	-
7	4	-
8	-	5





HD MAP



ROAD
JUNCTION

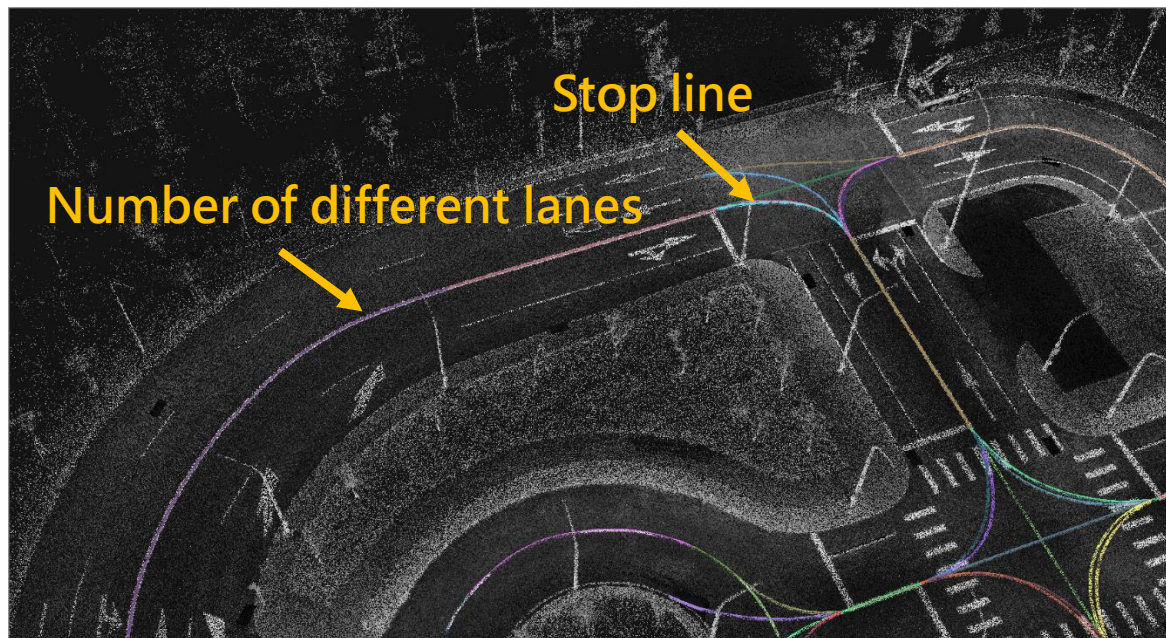




HD MAP

- The reference line builds the core for the OpenDRIVE format
- Directional three-dimensional virtual line
- Divided into sections
 - The nature of the lane changes
 - The number of lanes changes
 - Stop line

項次	類別	名稱	中文名稱	說明	資料型別	填寫說明
1.	ReferenceLine (道路參考線)	name	名稱	道路參考線的名稱	Char	
2.		length	長度	道路參考線的xy平面長度	Char	
3.		id	識別碼	道路參考線的識別碼	Char	
4.		junction	交叉路口	記錄道路屬於交叉路口或道路	Char	road junction
5.		rule	規則	記錄左駕或右駕	Char	
6.		predecessor	前參考線識別碼	前一參考線的識別碼	Char	
7.		successor	後參考線識別碼	下一參考線的識別碼	Char	
8.		type	道路等級類型	道路等級類型	Char	
9.		speed	速限	道路速度上限	Integer	單位 km/h
10.		startNode	起始節點	道路參考線的起始節點識別碼。	Char	
11.		endNode	結束節點	道路參考線的結束節點識別碼。	Char	
12.		geometry	幾何坐標	記錄道路參考線三維線狀坐標。	3D Shapes linestring	

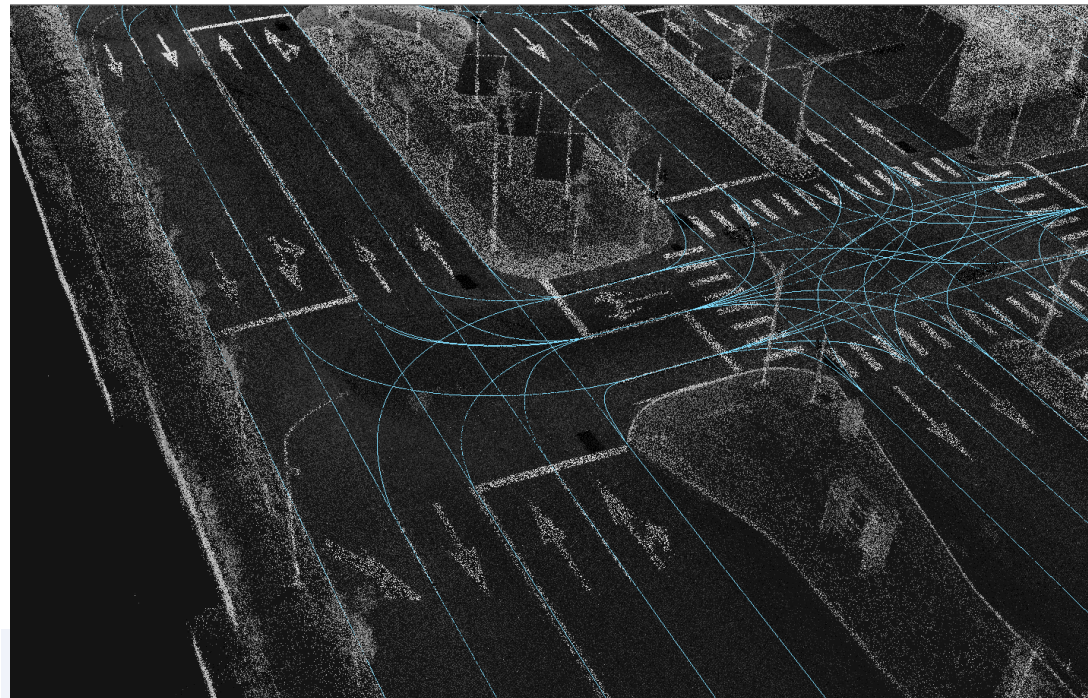




HD MAP

- The lane line is the three-dimensional feature line
- Take the centerline of the lane line when road mapping
- Different colors and styles can have different driving regulations

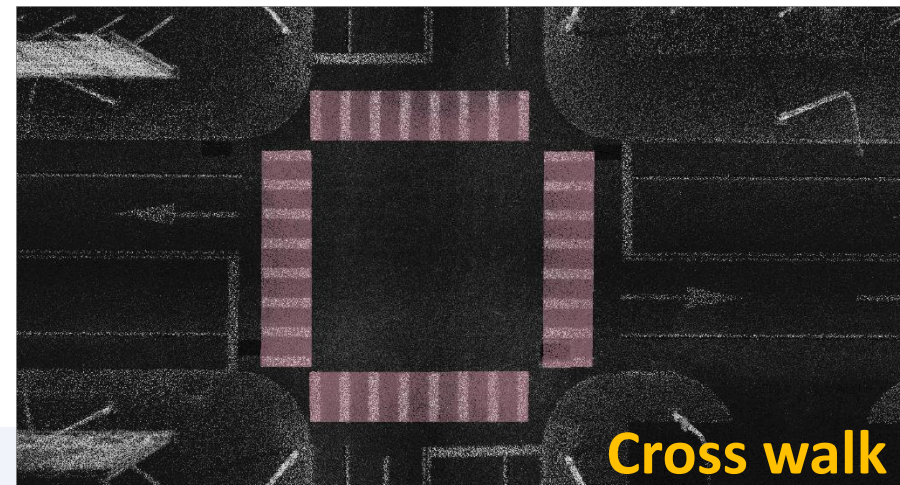
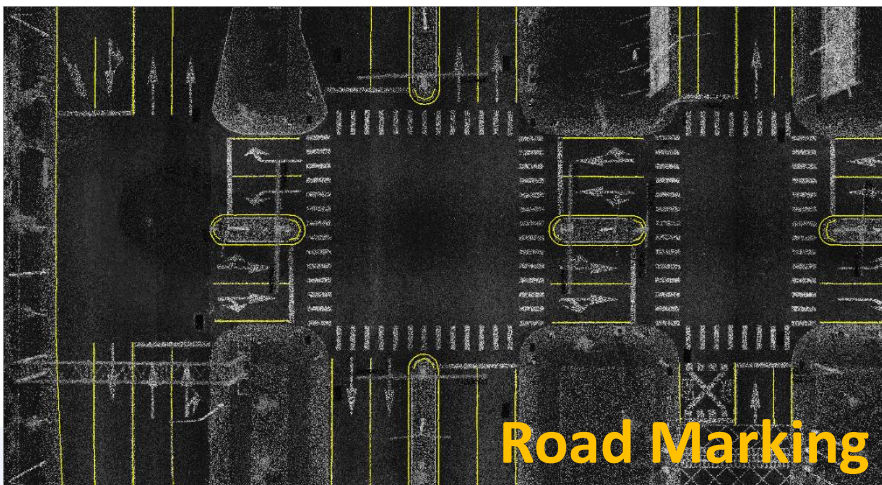
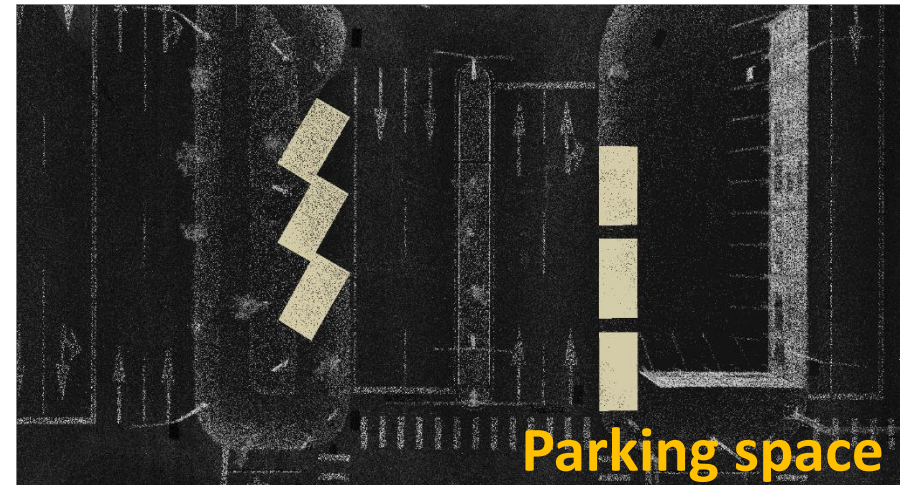
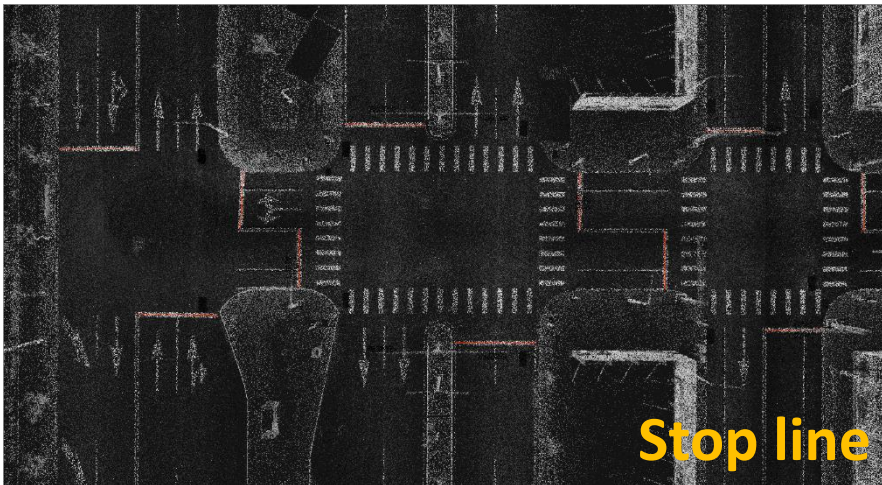
項次	類別	名稱	中文名稱	說明	資料型別	填寫說明
1.	LaneLine (車道線)	id	車道線識別碼	車道線的識別碼		
2.		type	車道線種類	車道線的種類。	標線代碼	表 11-3
3.		color	車道線顏色	車道線的標線顏色。	道路標記 顏色代碼	表 11-9
4.		style	車道線樣式	車道線的標線樣式	道路標記 類型代碼	表 11-7
5.		material	車道線材質	車道線的標線材質。	Char	統一填寫 standard
6.		width	車道線寬度	車道線的寬度。	Double	單位為公 尺
7.		startNode	起始節點	車道線的起始節點 識別碼	Char	對應到 Node 圖層 的識別碼
8.		endNode	結束節點	車道線的結束節點 識別碼	Char	對應到 Node 圖層 的識別碼
9.		geometry	幾何坐標	記錄車道線的中心 線三維線狀坐標。	3D Shapes linestring	





HD MAP

Regulations for Road Traffic Signs, Markings and Signals

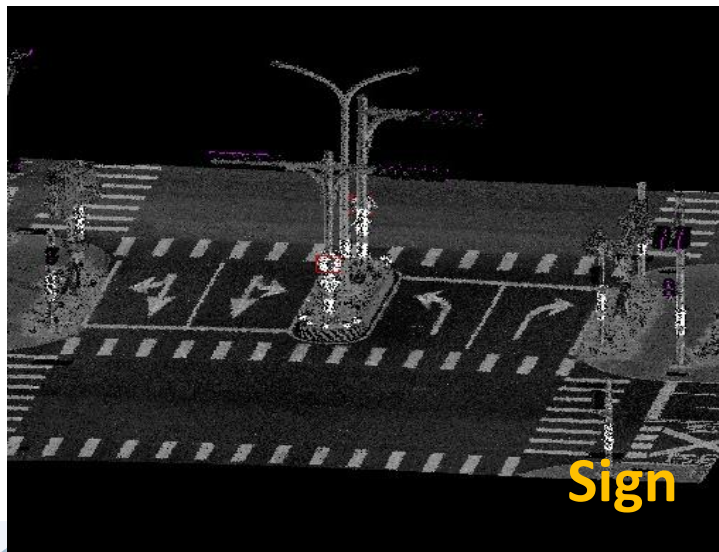




HD MAP

■ Traffic Signal :

- The center of the sign board
- The angle between the normal vector of the sign board and the true north
- Record the lower left and upper right coordinates of the enclosing rectangle that covers the mark

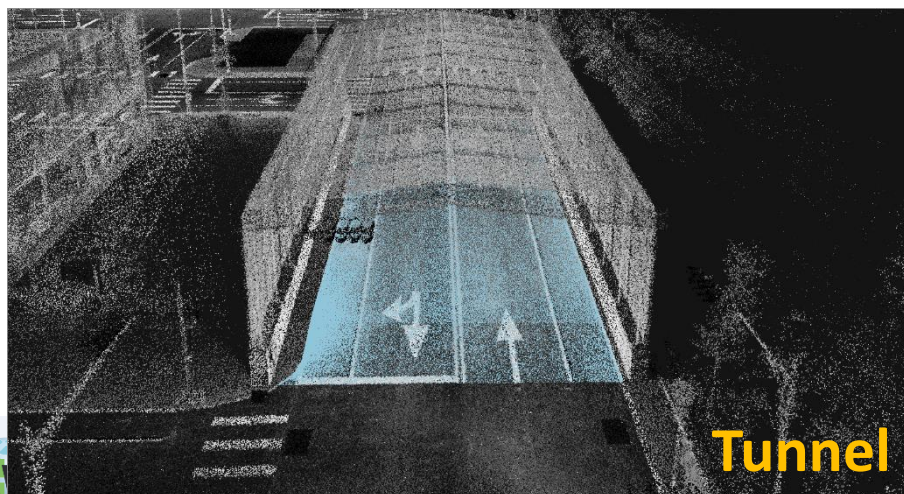
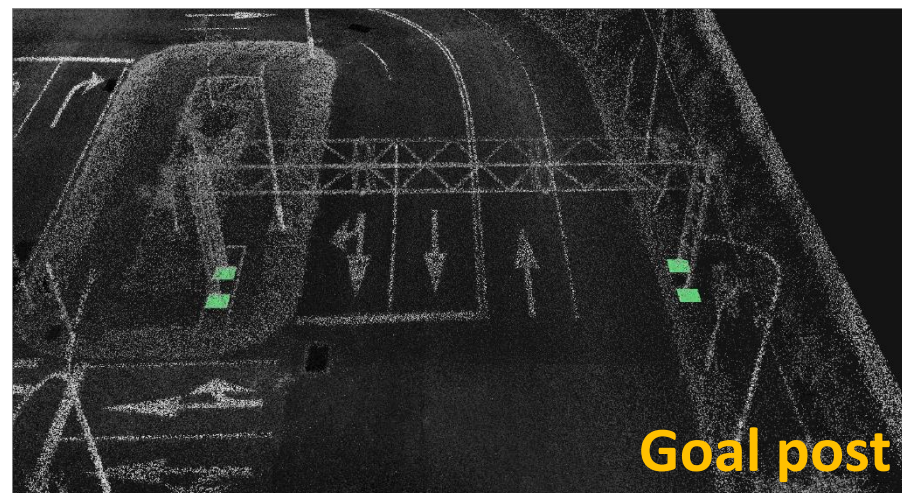
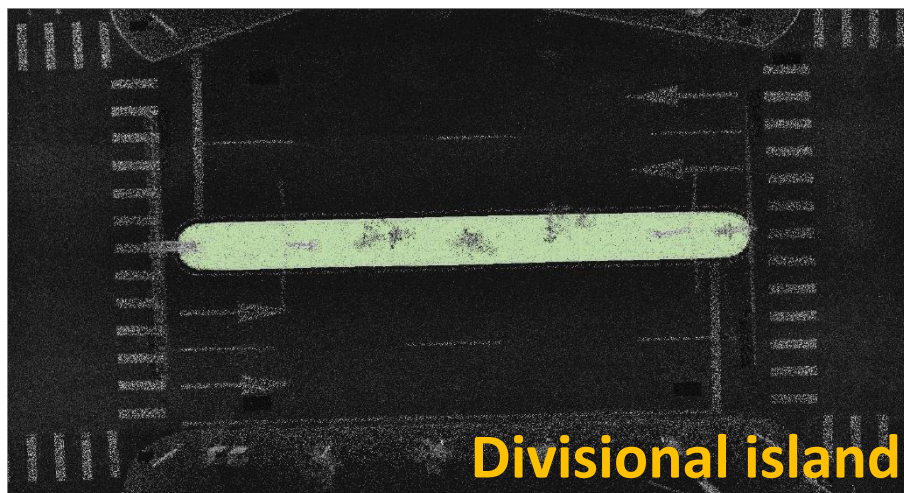




HD MAP

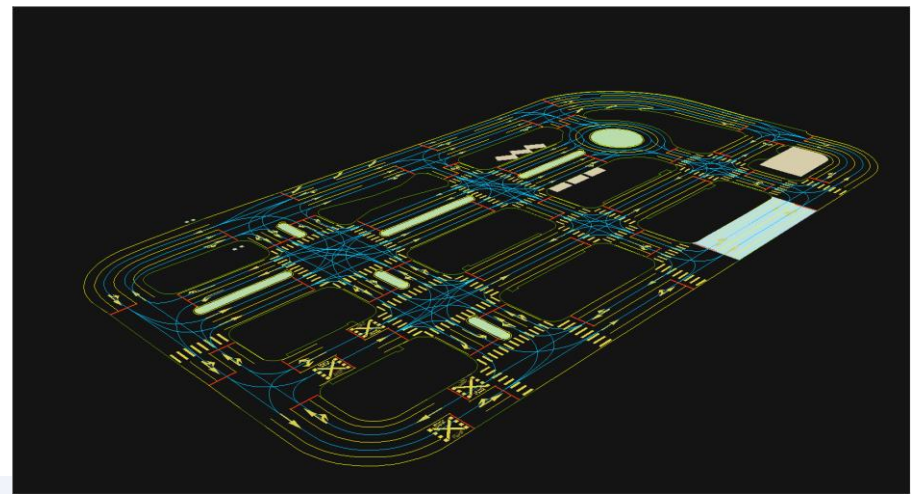
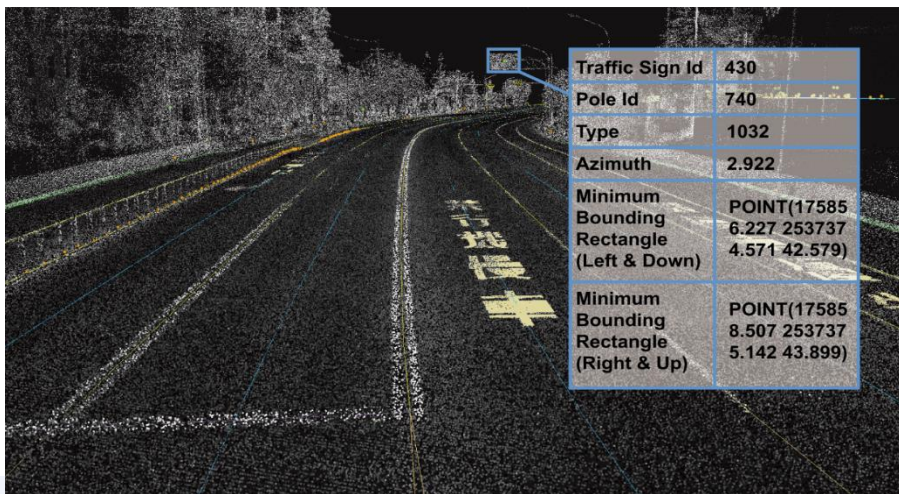
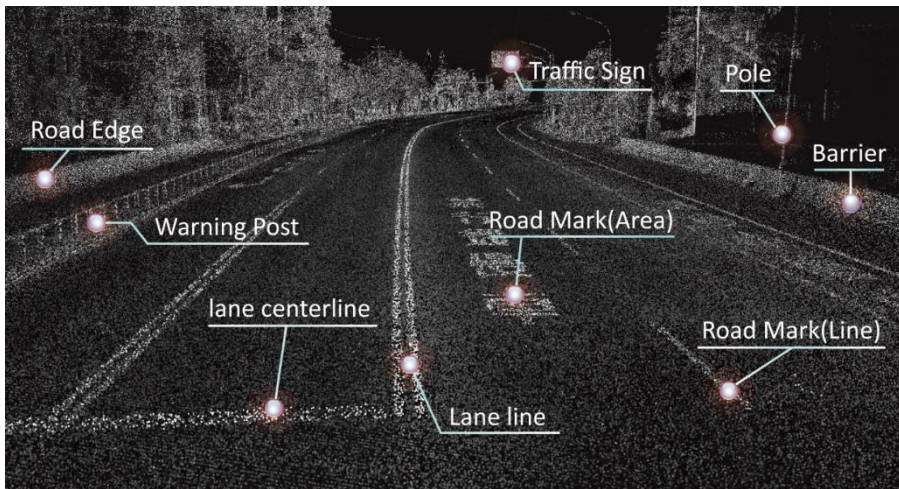
■ Object:

➤ Taiwan OpenDRIVE EXTENSIVE



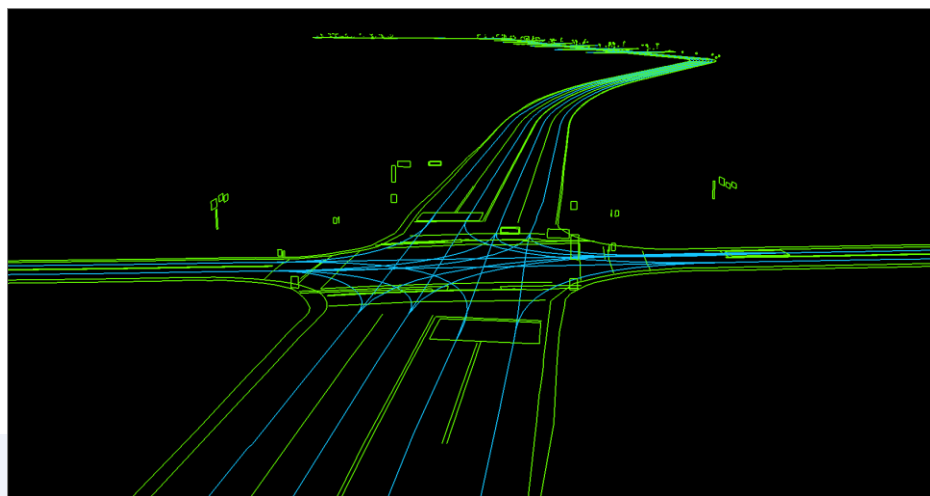
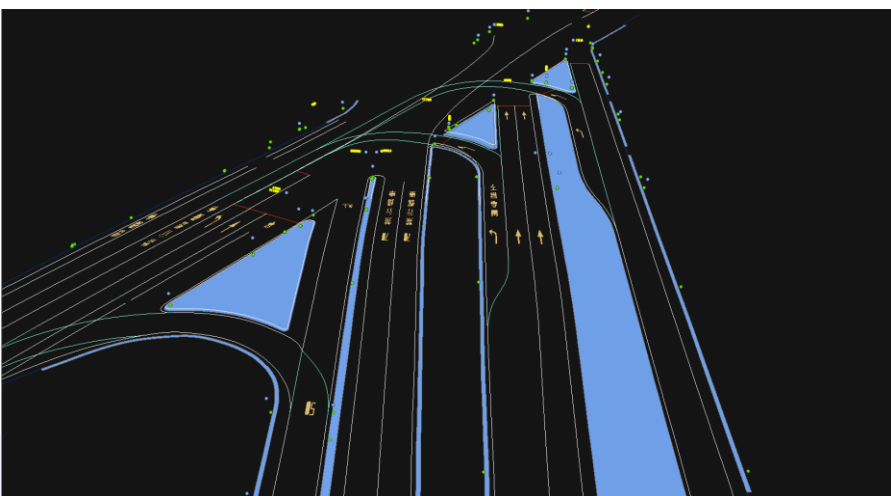
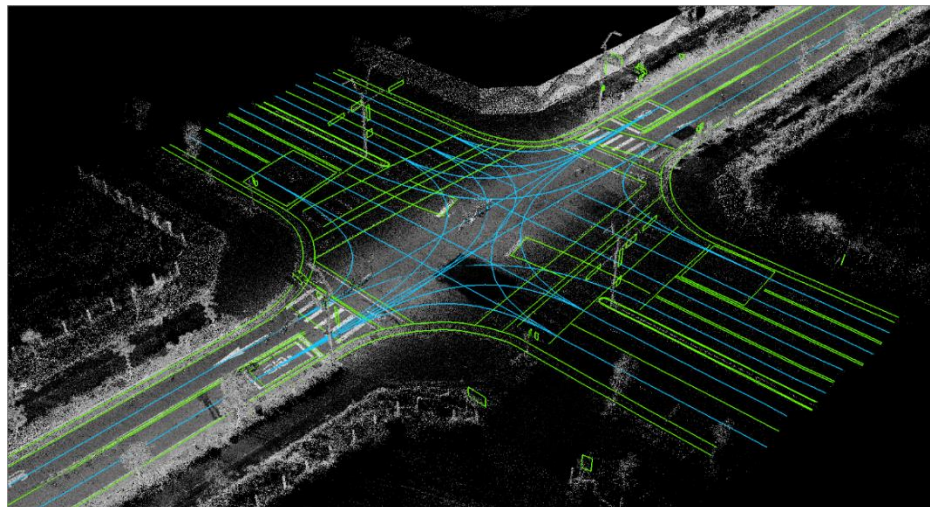
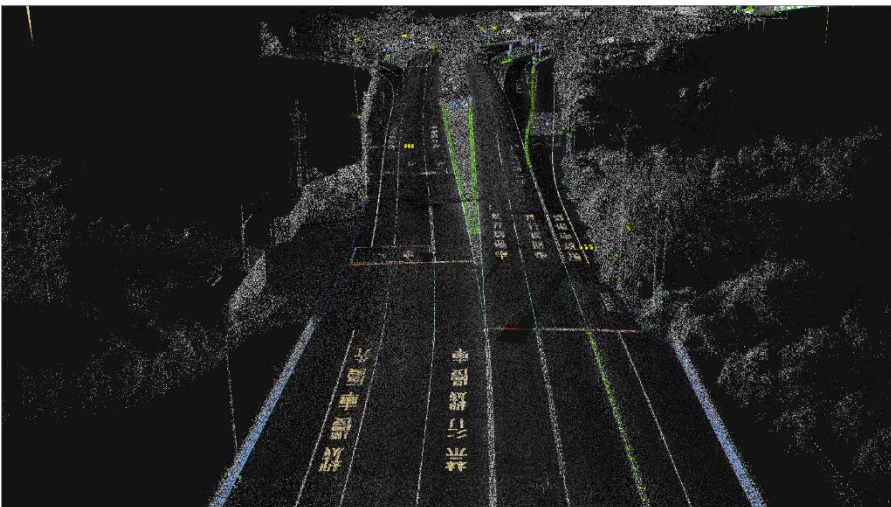


HD MAP





HD MAP





HD MAP

XODR File

```

\\192.168.1.231\專案區\航測專案\專案執行中\109-033-高精地圖測製(內政部)\005_沙崙場域\7_臺灣高精地圖\OpenDrive成果\1100222-人工修正4版\MOI_Shalun_1100222_offset.xodr
<?xml version="1.0" ?>
<OpenDRIVE xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <header>
    <offset x="0" y="0" z="0" hdg="0"/>
    <geoReference><![CDATA[+proj=tmerc +lat_0=0 +lon_0=121 +k=0.9999 +x_0=250000 +y_0=0 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs]]></geoRef
  </header>
  <road name="" length="0.20000000043347277" id="409" junction="-1">
    <link>
      <predecessor elementType="junction" elementId="0"/>
      <successor elementType="road" elementId="685" contactPoint="start"/>
    </link>
    <type s="0" type="town"/>
    <planView>
      <geometry s="0" x="31.8587" y="-476.695" hdg="1.9952291261205324" length="0.20000000018626474">
        <paramPoly3 aU="0" bU="0.13778577518959575" cU="0.2694629670749575" dU="-0.2072487420782887" aV="0" bV="0.0" cV="-5.587935447692871e-09" dV="3
      </geometry>
    </planView>
    <elevationProfile>
      <elevation s="0" a="44.215543717801395" b="-0.004839576507449239" c="0" d="0"/>
    </elevationProfile>
    <lanes>
      <laneSection s="0">
        <center>
          <lane type="driving" level="false" id="0"/>
        </center>
        <right>
          <lane type="driving" level="false" id="-1">
            <link>
              <successor id="-1"/>
            </link>
            <link>
            </link>
            <width sOffset="0" a="4.180175914181819" b="-5.420251277595066e-10" c="0" d="0"/>
          </lane>
        </right>
        <left/>
      </laneSection>
    </lanes>
  </road>
  <road name="" length="0.20000000043347285" id="410" junction="-1">

```



HD MAP

RW 詮華國土測繪有限公司 HMap 檢核輔助工具

詮華國土測繪有限公司 HMap 檢核輔助工具

HMap Shapefile 繳交成果屬性檢核程式

OpenDRIVE Shapefile 圖資屬性檢核程式

版本：2020-11 (V.01)

OpenDRIVE Shapefile 圖資屬性檢核程式

Shp檔案資料夾位置

*亦可直接將資料夾路徑複製到上方的文字欄位中

道路參考線(Referenceline) 進行檢核

車道線(LaneLine) 進行檢核

儲存檢核結果



HD MAP

Check(QA/QC)



Id



Predecessor



Successor



Junction



Laneno

shp檔路徑：D:\CODE\@RealWorld\HDMAP\試驗場\1204\ReferenceLine.shp
DBF - ReferenceLine 筆數：167

(1) 車道參考線 前一、後一 中心線識別碼 屬性關聯性錯誤檢核

```
----- begin
id      predecesso
158      60
----- end
```

(2) 車道參考線 後一、前一 中心線識別碼 屬性關聯性錯誤檢核

```
----- begin
id      successor
52      145
69      158
145     47
168     94
169     94
----- end
```

(3) road junction 屬性正確性檢核

```
----- begin
type    id
road    95
road    87
----- end
```

shp檔路徑：D:\CODE\@RealWorld\HDMAP\試驗場\1230\LaneLine.shp

DBF - LaneLine 筆數：444 (檢驗時間：2020/01/20 16:53:36)

(0) 車道線識別碼 屬性 重複錯誤檢核

```
----- begin
id      重複次數
----- end
```

(1) 檢核「車道線識別碼」、「前一車道線識別碼」屬性配對關聯性

```
----- begin
id      predecesso RefLid  錯誤描述
44      224          176    [44 ← 224 ID 配對完整性問題]
44      327          176    [44 ← 327 ID 配對完整性問題]
412     44           87     [412 ← 44 ID 配對完整性問題]
16      226          176    [16 ← 226 ID 配對完整性問題]
16      227          176    [16 ← 227 ID 配對完整性問題]
16      326          176    [16 ← 326 ID 配對完整性問題]
399     248          71     [399 ← 248 ID 配對完整性問題]
335     293          91     [335 ← 293 ID 配對完整性問題]
327     412          86     [327 ← 412 ID 配對完整性問題]
326     411          86     [326 ← 411 ID 配對完整性問題]
293     355          92     [293 ← 355 ID 配對完整性問題]
227     411          175    [227 ← 411 ID 配對完整性問題]
143     142          29     [143 ← 142 ID 配對完整性問題]
101     349          150    [101 ← 349 ID 配對完整性問題]
451     388          60     [451 ← 388 ID 配對完整性問題]
299     300          82     [299 ← 300 ID 配對完整性問題]
349     102          50     [349 ← 102 ID 配對完整性問題]
----- end
```

(2) 檢核「車道線識別碼」、「後一車道線識別碼」屬性配對關聯性

```
----- begin
id      successor  RefLid  錯誤描述
454     408          89     [454 ← 408 ID 配對完整性問題]
44      413          176    [44 ← 413 ID 配對完整性問題]
435     425          56     [435 ← 425 ID 配對完整性問題]
354     240          85     [354 ← 240 ID 配對完整性問題]
338     451          59     [338 ← 451 ID 配對完整性問題]
252     419          70     [252 ← 419 ID 配對完整性問題]
240     355          133    [240 ← 355 ID 配對完整性問題]
226     411          128    [226 ← 411 ID 配對完整性問題]
224     412          128    [224 ← 412 ID 配對完整性問題]
209     351          147    [209 ← 351 ID 配對完整性問題]
143     28           29     [143 ← 28 ID 配對完整性問題]
67      375          161    [67 ← 375 ID 配對完整性問題]
19      339          15     [19 ← 339 ID 配對完整性問題]
9       374          2      [9 ← 374 ID 配對完整性問題]
452     435          60     [452 ← 435 ID 配對完整性問題]
300     380          41     [300 ← 380 ID 配對完整性問題]
351     209          87     [351 ← 209 ID 配對完整性問題]
393     143          72     [393 ← 143 ID 配對完整性問題]
401     143          74     [401 ← 143 ID 配對完整性問題]
----- end
```

(3) 車道線 laneno 對應同一 RefLid 屬性關聯性錯誤檢核

```
----- begin
id      RefLid  lanenoGroup  錯誤描述
52      115     -111:1      [車道編號未含 0 編號] [車道編號序列編號未連續] [車道編號重複]
----- end
```





HD MAP

Virtual Test Drive GUI - Version 2020 - Setup:Standard - Project:SampleProject - Parameter:

File Edit Simulation View Tools Docs Info

TaskControl - 4.8.12 MM_moduleMgr - 5.1.3 Traffic - 2020.0.25858 IG_3645@pointaw1 - 2020.0.25972

Project Configuration Name Size Date Modified Scenario

mainRS

Virtual Test Drive

HEXAGON VIRES

LOG SCP

OpenDRIVE Scenario Editor 2020.0 /home/user/VIRES/VTD.2020/Data/Projects/Current/Scenarios/chuanwha_08

File Edit View Extra

New Open Save Reset Properties Traffic Lights Network Monitor

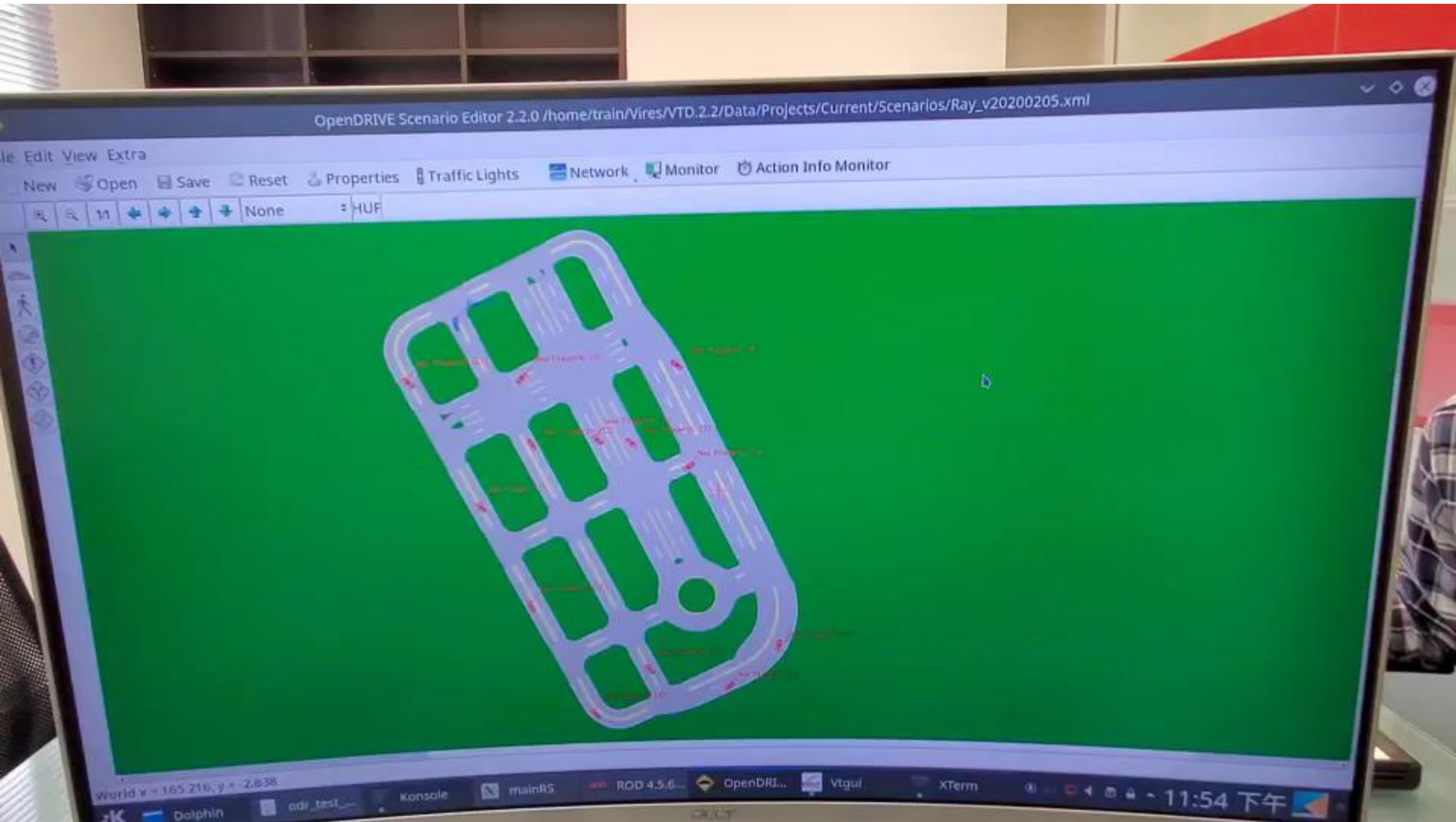
1:1 Ego HUP

World x = 63.038, y = -117.551



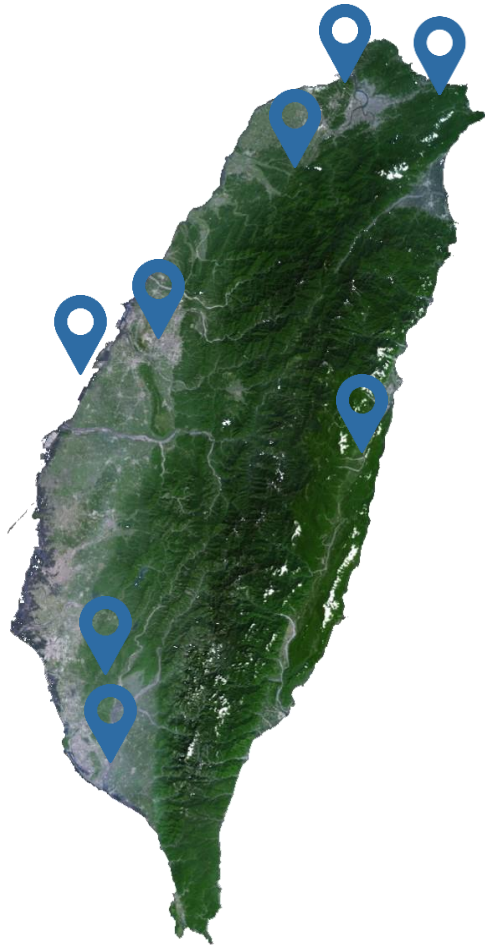


HD MAP





HD MAP



Nearly 10 Area for HD MAP Mapping
Customized Customer Needs
Over 100km for HD MAP





Challenge In The Future

- Too Expensive(TWD 250,000/km)
- Who should pay the money to build HD MAP
 - Government ???
 - Automotive Industry???
 - Map Industry ???
 - Service Industry???
 - Road Users ???
- **Signal Phase and Timing(SPaT) & Map Data**
- **V2X MAP**



Challenge In The Future

Various forms of roads in Taiwan





Challenge In The Future

How to provide **correct** map information





Conclusion Data Collection

LiDAR Data
Image Data
Other Sensor Data

System

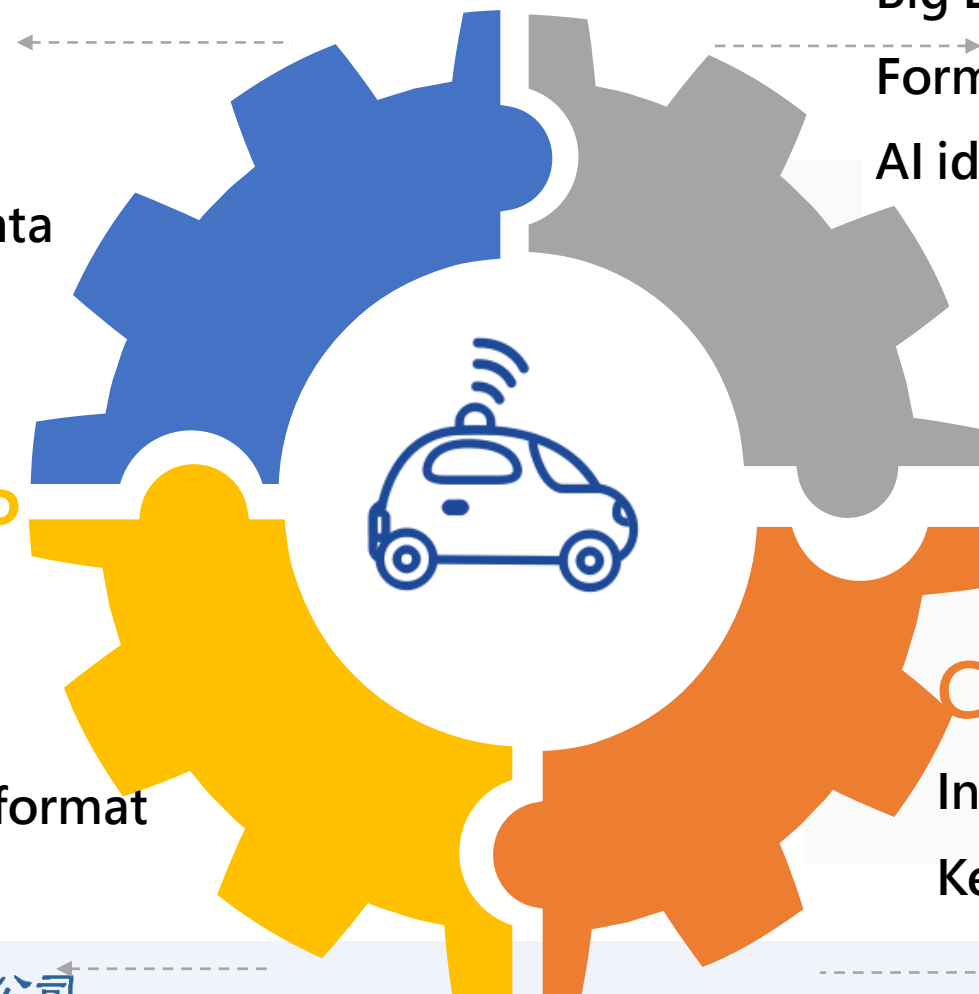
Big Data Management
Format Converter
AI identification

HD MAP

Geometric Data
Attribute Data
Different HD MAP format
Service

Consultant

Integrate Information
Key for what ?





Thanks for your attention

