
# Deploying Visual AI on Edge Devices: Lessons From the Real World

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# Teledyne's Imaging World

**Teledyne Technologies Inc.: Conglomerate high-tech provider in four major segments:**

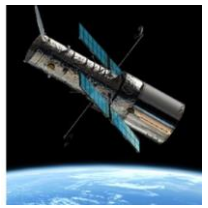
**Digital Imaging,** Instrumentation, Engineered Systems, Aerospace and Defense Electronics

**The Digital Imaging group consists of several different companies focused on various vision and imaging technologies:**

TELEDYNE DALSA
TELEDYNE CARIS
TELEDYNE e2v
TELEDYNE ANAFOCUS
TELEDYNE SCIENTIFIC & IMAGING
TELEDYNE OPTECH
TELEDYNE ICM
TELEDYNE JUDSON TECHNOLOGIES
TELEDYNE IMAGING SENSORS
TELEDYNE IDI
TELEDYNE LUMENERA
TELEDYNE PHOTOMETRICS
TELEDYNE PRINCETON INSTRUMENTS
TELEDYNE ACTON OPTICS
TELEDYNE FLIR

- **Leading imaging technologies manufacturer**
- **Teledyne operates in various markets and applications**

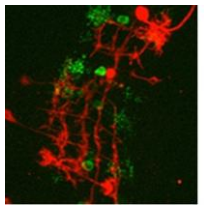
**Machine Vision**



**Aero-space**

**Geo-spatial**

**Life Science**



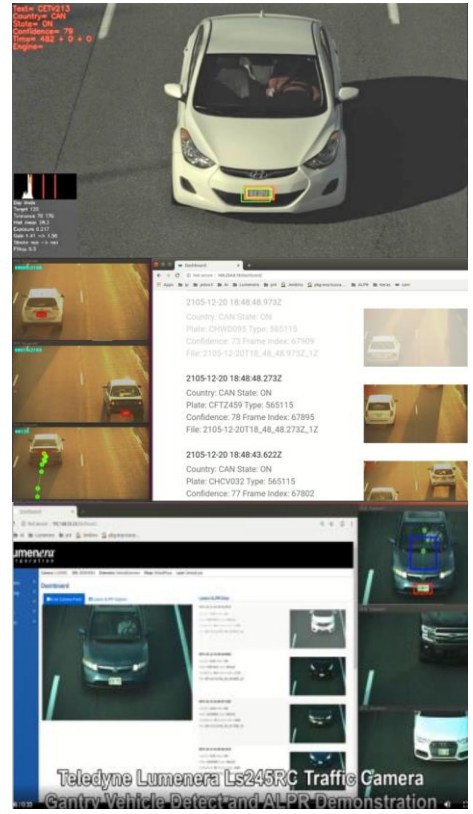
**Science**

**Semicon**

TELEDYNE IMAGING

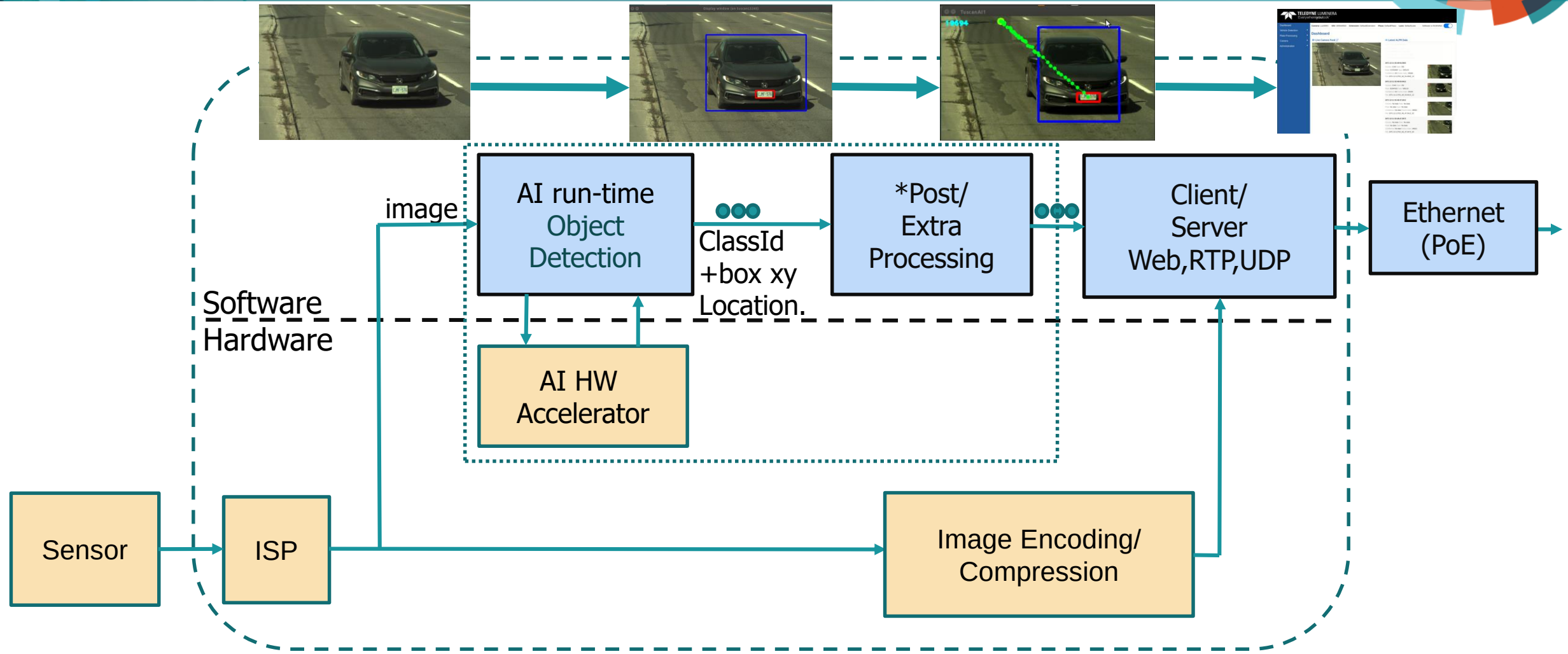
# Introduction: Deploying AI on Edge Devices

- This presentation aims to pinpoint tips from experience on designing and deploying AI systems on edge devices.
  - As opposed to workstations, deploying AI on edge devices has limitations and tradeoffs that need to be considered:
  - **Hardware**: cost, power, application processors feature sets, processing power, sensors, ISP, CPU complex, AI Hardware accelerator, IOs
  - **Software**: on dev. platform (SDKs), on camera, development can be done on both.
  - **Artificial Intelligence**: Supported neural network models, supported AI frameworks, other AI tools such as Astrocyte™

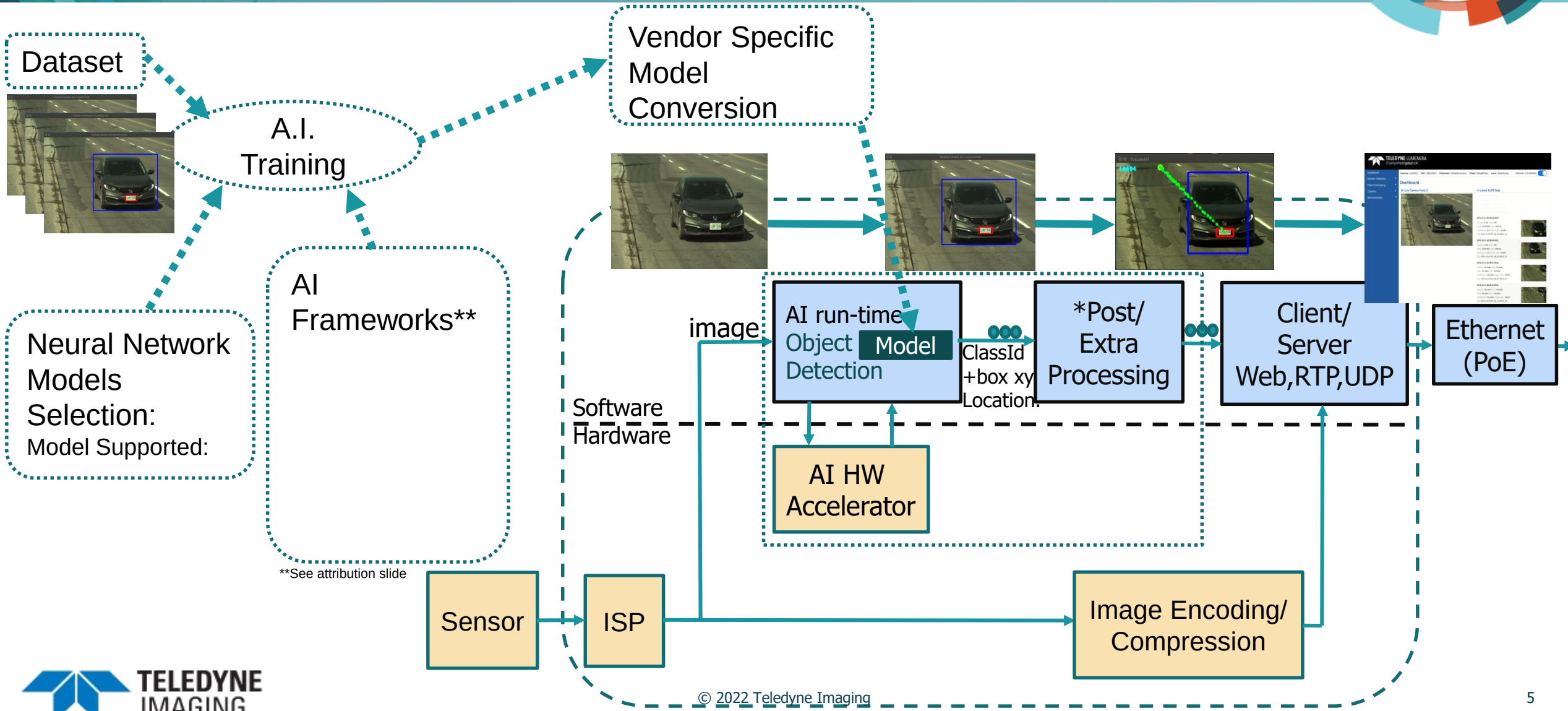





# A Simple Edge AI Camera System Pipeline

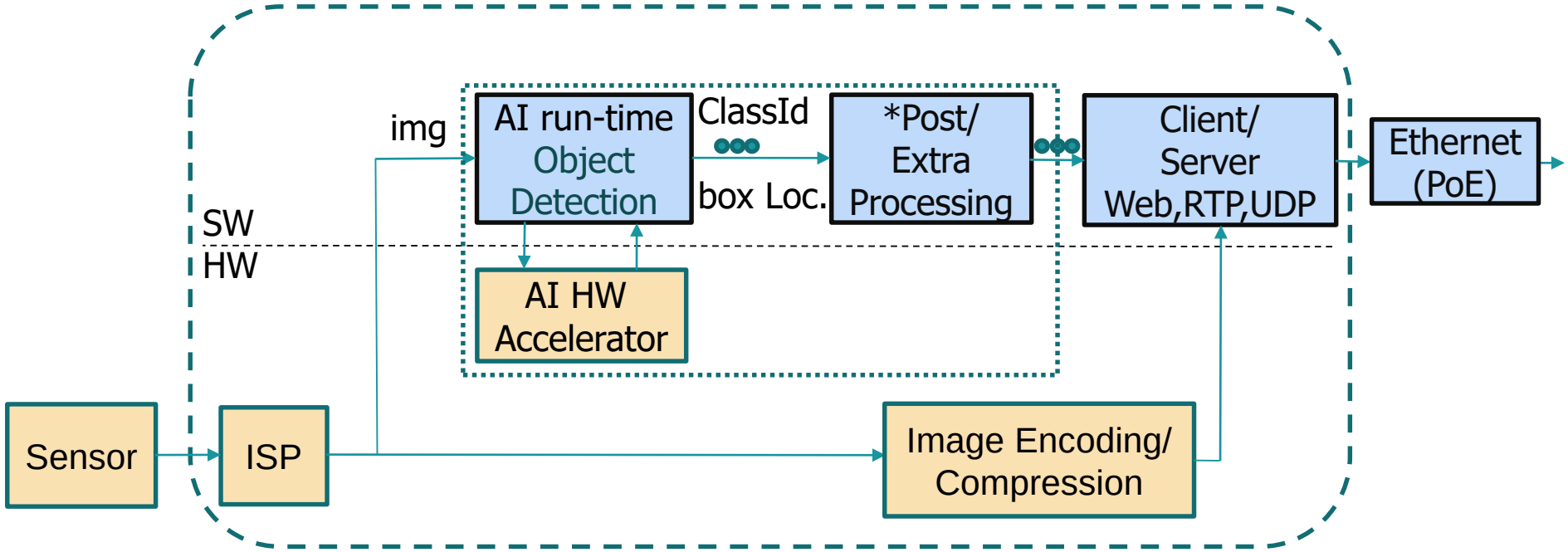


# Artificial Intelligence Flow



# A Simple AI Camera System Pipeline

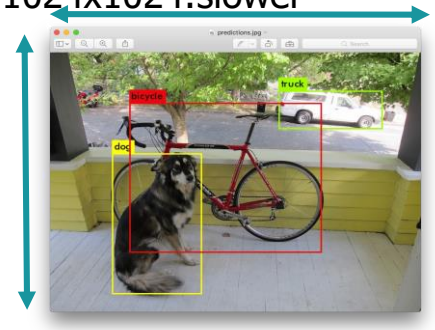
- How to optimize for real time in SW and HW
- Modularity is important
- Easy deployment



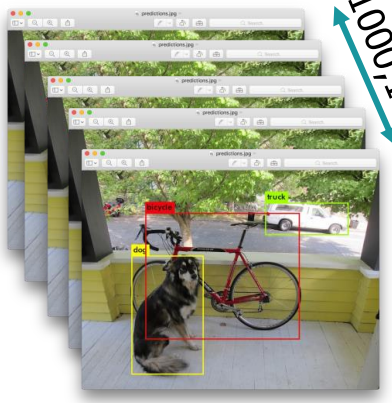
# The AI Components Challenges and Takeaways

- AI frameworks and tools
- Training and inference
- Detected object dimensions
- CNN Models, depth, accuracy
- Size of datasets
- Post/extra processing
- Ease of use

**Neural Network**
**Input Image resolution size:**
320x320 pixels: fast
1024x1024:slower



**Size of Dataset**
100,1000,1000 images



**Neural Network Size:** Shallow Model depth

```
CUDA-version: 11020 (11020), cuDNN: 7.5.0, CUDNN_HALF=1, GPU count: 1
CUDNN_HALF=1
OpenCV version: 3.2.0
0 : compute capability = 750, cudnn_half = 1, GPU: GeForce RTX 2080 Ti
   layer   filters  size/strd(dil)      input                output
   0 conv     16       3 x 3/ 1    192 x  96 x   3 ->  192 x  96 x  16 0.016 BF
   1 max                2x 2/ 2    192 x  96 x  16 ->   96 x  48 x  16 0.000 BF
   2 conv     32       3 x 3/ 1     96 x  48 x  16 ->   96 x  48 x  32 0.042 BF
   3 max                2x 2/ 2     96 x  48 x  32 ->   48 x  24 x  32 0.000 BF
   4 conv     64       3 x 3/ 1     48 x  24 x  32 ->   48 x  24 x  64 0.042 BF
   5 max                2x 2/ 2     48 x  24 x  64 ->   24 x  12 x  64 0.000 BF
   6 conv    128       3 x 3/ 1     24 x  12 x  64 ->   24 x  12 x 128 0.042 BF
   7 max                2x 2/ 2     24 x  12 x 128 ->   12 x   6 x 128 0.000 BF
   8 conv    256       3 x 3/ 1     12 x   6 x 128 ->   12 x   6 x 256 0.042 BF
   9 max                2x 2/ 2     12 x   6 x 256 ->    6 x   3 x 256 0.000 BF
  10 conv    512       3 x 3/ 1      6 x   3 x 256 ->    6 x   3 x 512 0.042 BF
  11 conv   1024       3 x 3/ 1      6 x   3 x 512 ->    6 x   3 x1024 0.170 BF
  12 conv    256       1 x 1/ 1      6 x   3 x1024 ->    6 x   3 x 256 0.009 BF
  13 conv    512       3 x 3/ 1      6 x   3 x 256 ->    6 x   3 x 512 0.042 BF
  14 conv    132       1 x 1/ 1      6 x   3 x 512 ->    6 x   3 x 132 0.002 BF
  15 yolo
  16 route  12                                     ->    6 x   3 x 256
  17 conv    128       1 x 1/ 1      6 x   3 x 256 ->    6 x   3 x 128 0.001 BF
  18 upsample                 2x     6 x   3 x 128 ->   12 x   6 x 128
  19 route  18 8                                   ->   12 x   6 x 384
  20 conv    256       3 x 3/ 1     12 x   6 x 384 ->   12 x   6 x 256 0.127 BF
  21 conv    132       1 x 1/ 1     12 x   6 x 256 ->   12 x   6 x 132 0.005 BF
  22 yolo
Total BFLOPS 0.586
avg outputs = 36594
```

**Object sizes:**
10x10 pixels:too small
30x30 pixels:ok

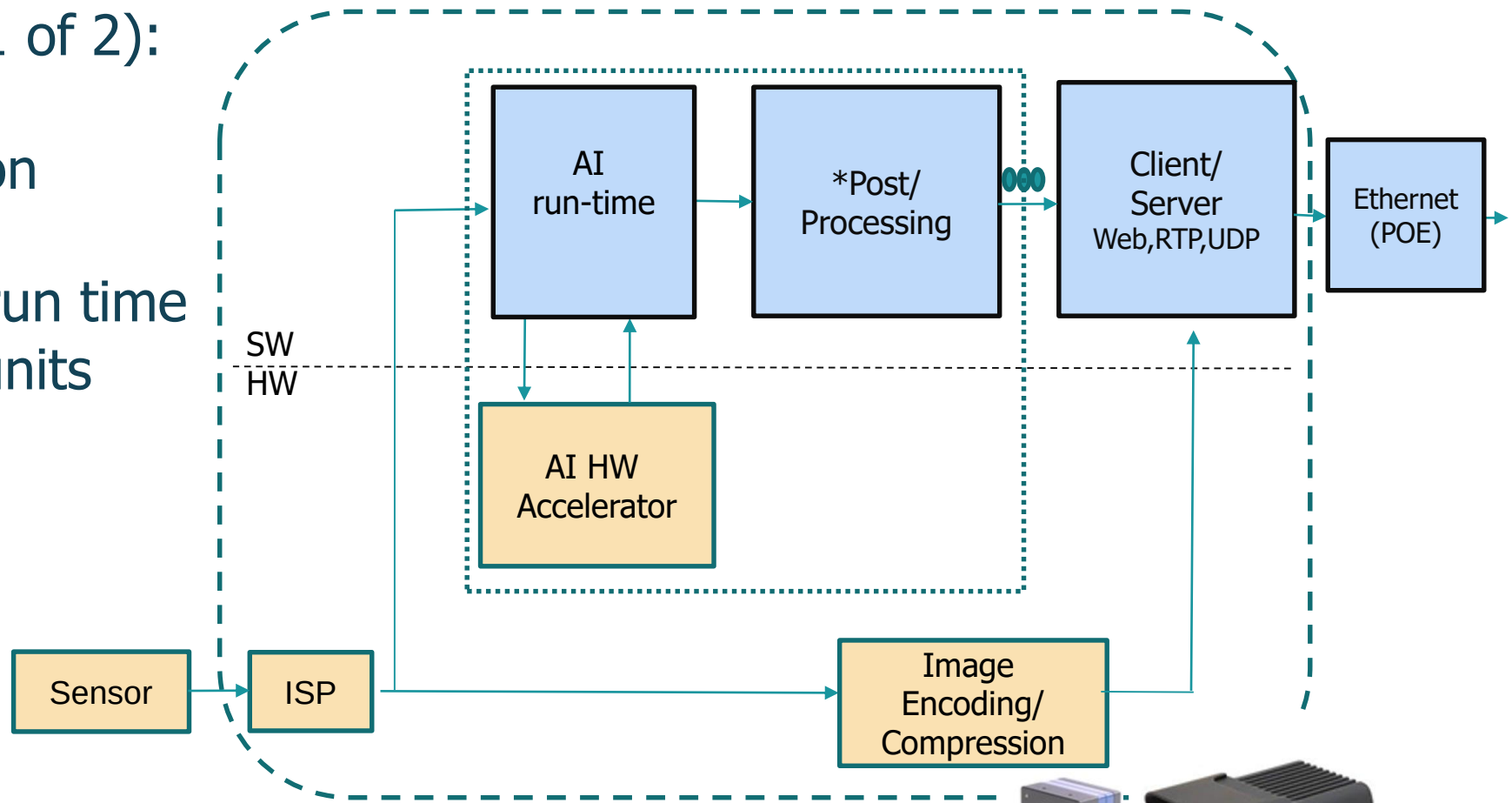
*Image source:https://pjreddie.com/darknet/yolo/*



# A Camera Platform Built with Modularity and Customizability in Mind (slide 1 of 2)

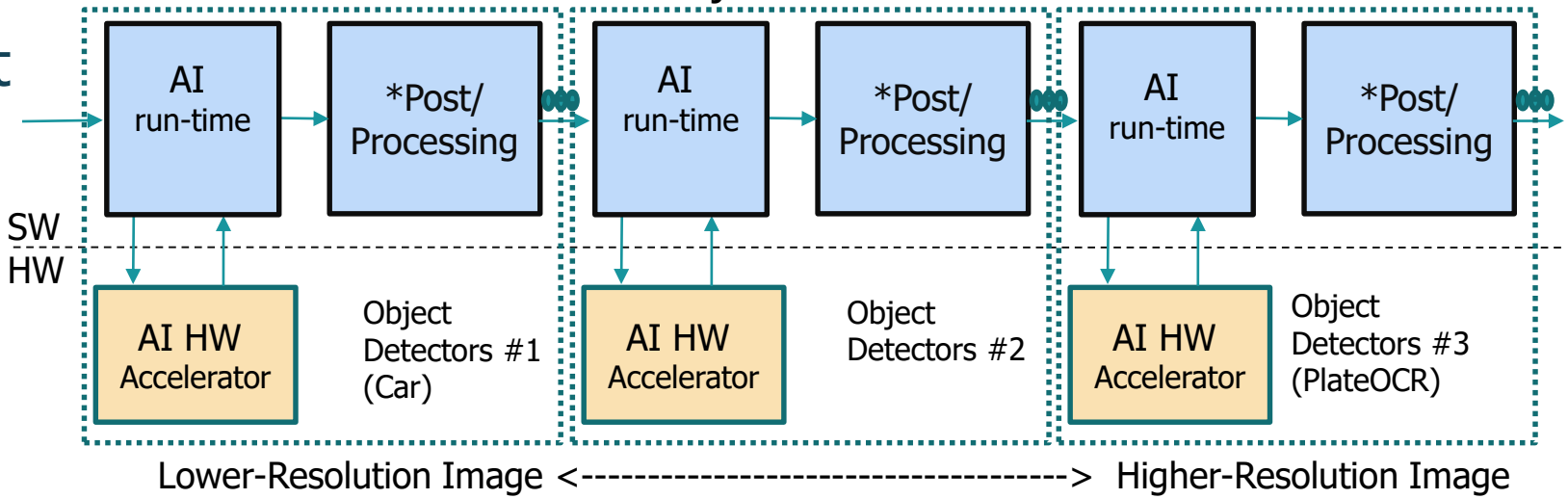
- Modularity kept in mind (1 of 2):
  - Sensor interfaces
  - Neural model selection
  - AI frameworks
  - AI models and their run time
  - The HW processing units

Single Object Detector
AI Camera system pipeline



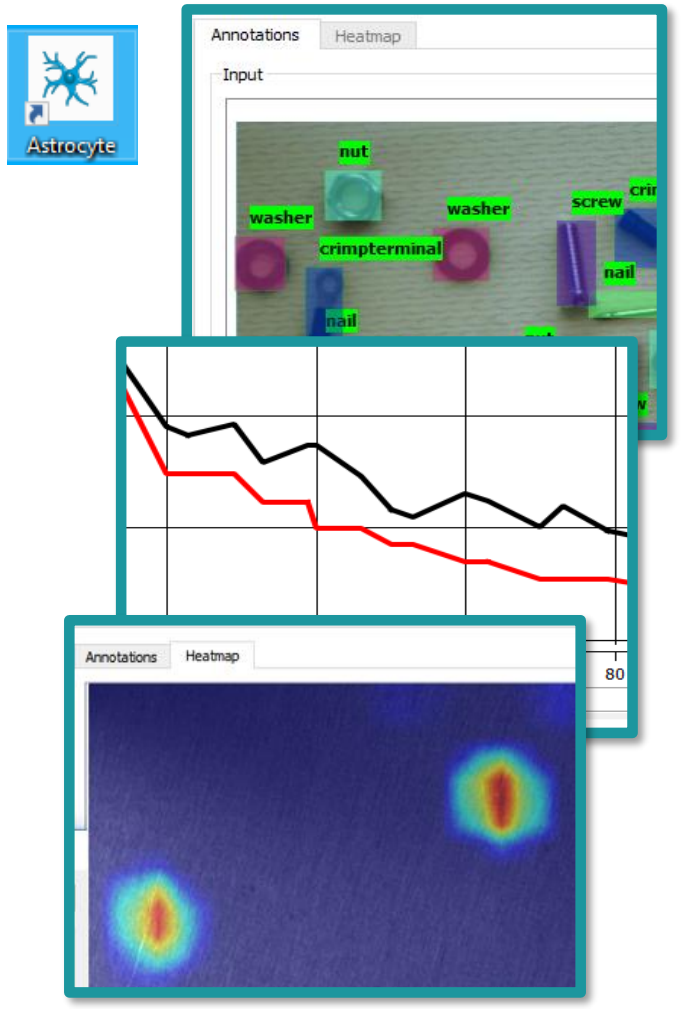
# A Camera Platform Built with Modularity and Customizability in Mind (slide 2 of 2)

- Modularity kept in mind (2 of 2):
  - The SW and interfaces:
  - Object detection
  - Trackers
  - "C" code Templates, examples, libraries API
  - Easily adapted for different AI applications
  - Easy deployment with PoE

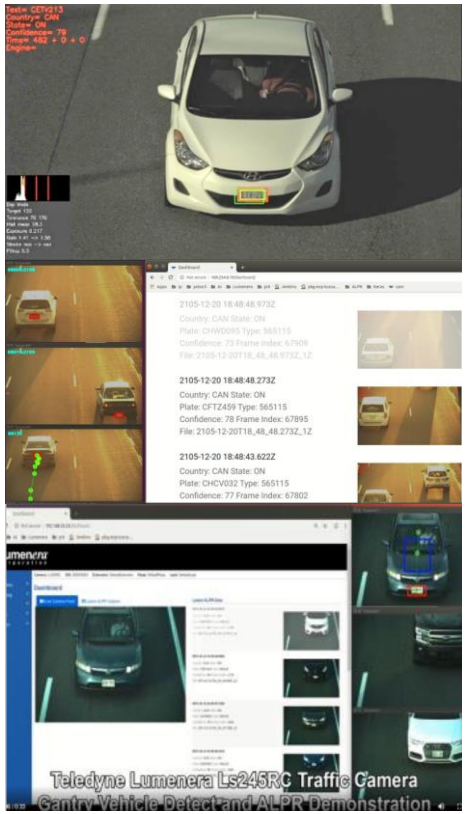
# Teledyne Astrocyte Trainer Tool

- AI model creation
- Features
  - GUI-based tool to simplifies Training
  - Training on user PC
  - Various neural networks
  - Hyper-parameter access
  - Visual training progress
  - Exported model files

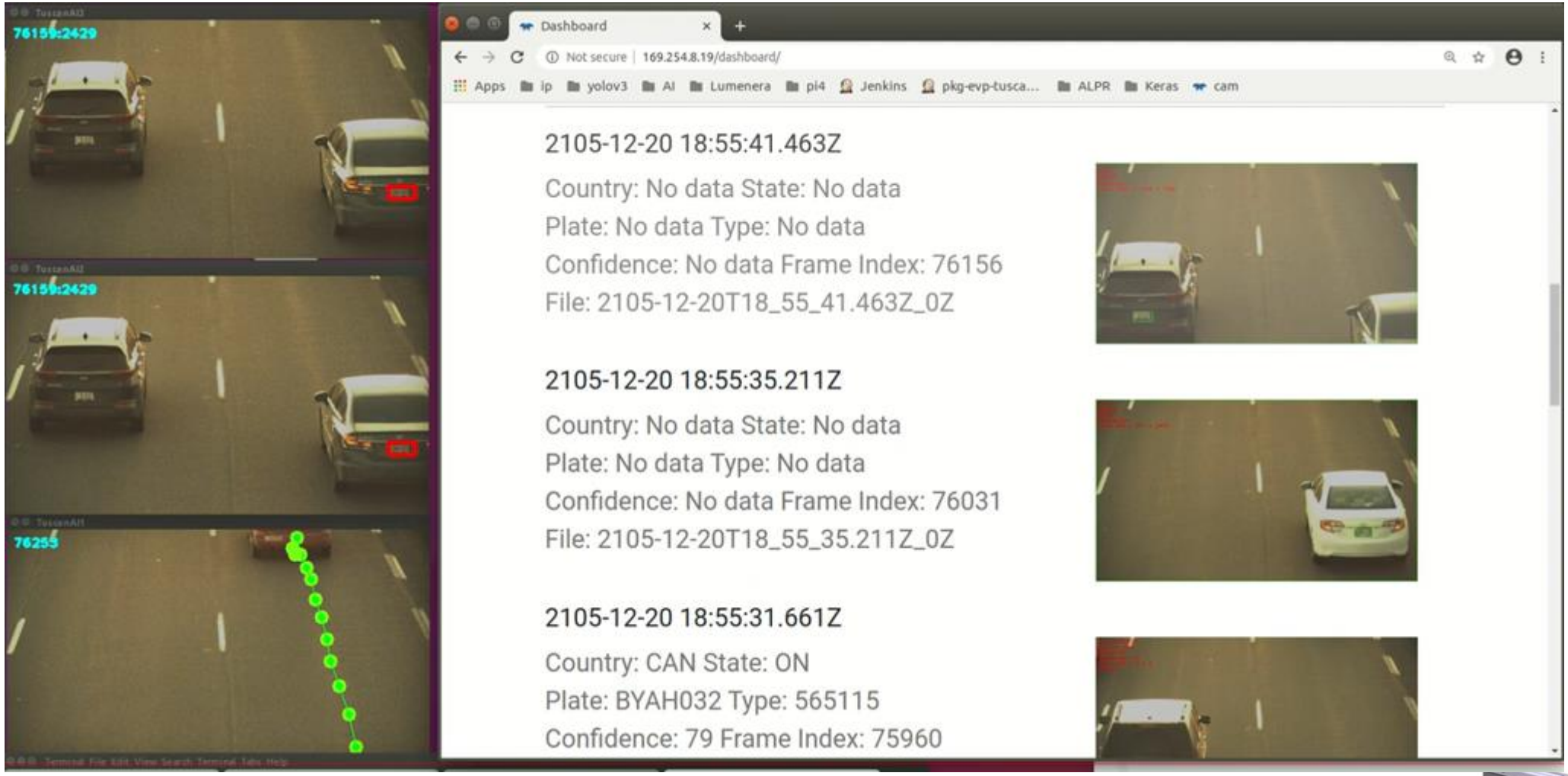


# Demo: Traffic Tolling Demo: Tuscan LS245

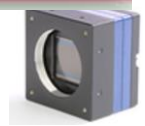
1. Object detection
   - Vehicles
   - License plates
   - from Low Resolution decimated image
2. Tracking of cars and plates
3. Optical character recognition from full-resolution image
   - Recognizes state and license plate number
4. Web interface
5. Simplified deployment with PoE




# Demo: Traffic Tolling Demo: Tuscan LS245




[Demo: Video 15s]



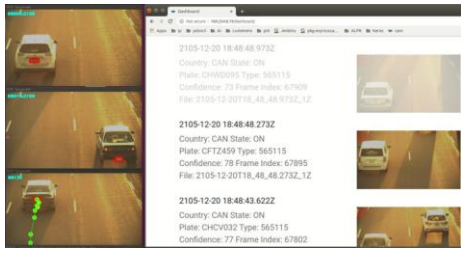
# In Conclusion

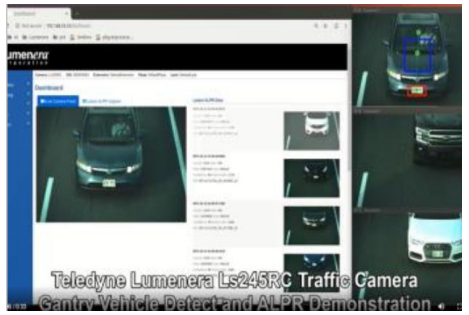
1. Teledyne has edge AI cameras

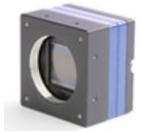
2. Astrocyte is Teledyne's GUI based tool to ease AI training

3. The same AI camera platform can be used for a wide range of AI applications

4. Edge AI camera platforms can be customized by customers, partners and integrators



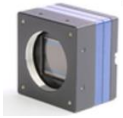


# Resources

## Teledyne Smart Cameras

TuscanLS245 

TuscanXL 

More cameras to come soon

## Teledyne DALSA Software

Astrocyte | Teledyne DALSA

Sapera Processing | Teledyne DALSA

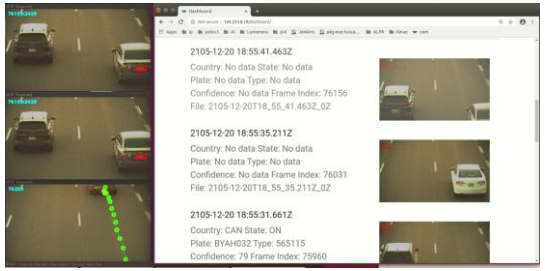
Sherlock | Teledyne DALSA

## Teledyne Imaging

Teledyne Imaging: Home

## Videos:

Video:AI Demo



Video: Camera TuscanLS245