NEC Smart Intersection Deployment

Video Analytics Testing, V2X Comms and Data Privacy

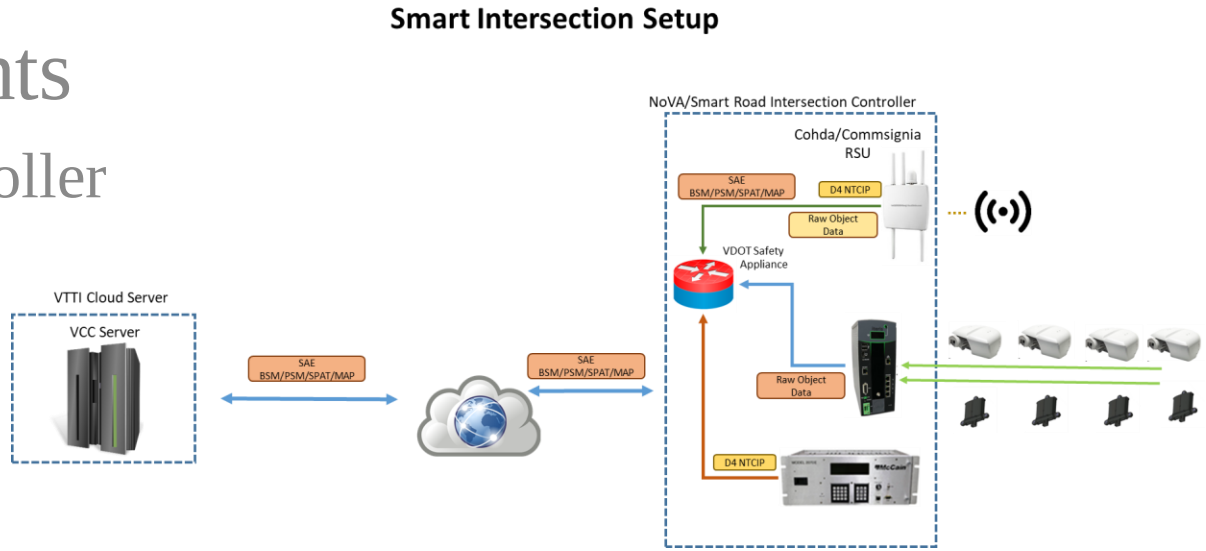
VIRGINIA TECH TRANSPORTATION INSTITUTE

Video Analytics Testing

- Tested different scenarios including
  - Crosswalk, Jaywalking
  - Vehicle pass, stop, turn
  - Motorcycle, bicycle.
- Findings
  - System provides detection within a time gap
  - Statistics portal values are not aligned with Video Source

V2X Integration

- Main Components
  - Intersection Controller
  - C-V2X RSU
  - Safety Appliance
  - Edge/Computing Platform



SAE J2735

- This SAE standard specifies a message set, and its data frames and data elements, for use by applications that use vehicle-to-everything (V2X) communications systems. While the data dictionary was originally designed for use over DSRC, this document is intended to be independent of the underlying communications protocols used to exchange data between participants in V2X applications.

SAE J2735 Messages

- **Basic Safety Message (BSM)**
- Common Safety Request (CSR)
- Emergency Vehicle Alert (EVA)
- Intersection Collision Avoidance (ICA)
- **Map Data (MAP)**
- NMEA Corrections (NMEA)
- Personal Safety Message (PSM)
- Probe Data Management (PDM)
- Probe Vehicle Data (PVD)
- Roadside Alert (RSA)
- RTCM Corrections (RTCM)
- **Signal Phase and Timing (SPaT)**
- Signal Request Message (SRM)
- Signal Status Message (SSM)
- **Traveler Information Message (TIM)**
- Test Messages 01 - 15

SAE J7235 Messages

SAE J2735
ASN message definition

```
MessageTypes MESSAGE-ID-AND-TYPE ::= {
   { BasicSafetyMessage     IDENTIFIED BY basicSafetyMessage    } |
   { MapData                IDENTIFIED BY mapData               } |
   { SPAT                   IDENTIFIED BY signalPhaseAndTimingMessage } |
   { CommonSafetyRequest    IDENTIFIED BY commonSafetyRequest   } |
   { EmergencyVehicleAlert  IDENTIFIED BY emergencyVehicleAlert } |
   { IntersectionCollision  IDENTIFIED BY intersectionCollision } |
   { NMEAcorrections        IDENTIFIED BY nmeaCorrections       } |
   { ProbeDataManagement    IDENTIFIED BY probeDataManagement   } |
   { ProbeVehicleData       IDENTIFIED BY probeVehicleData      } |
   { RoadSideAlert          IDENTIFIED BY roadSideAlert         } |
   { RTCMcorrections        IDENTIFIED BY rtcmCorrections       } |
   { SignalRequestMessage   IDENTIFIED BY signalRequestMessage  } |
   { SignalStatusMessage    IDENTIFIED BY signalStatusMessage   } |
   { TravelerInformation    IDENTIFIED BY travelerInformation   } |
   { PersonalSafetyMessage  IDENTIFIED BY personalSafetyMessage } |
   { TestMessage00          IDENTIFIED BY testMessage00 } |
   { TestMessage01          IDENTIFIED BY testMessage01 } |
   { TestMessage02          IDENTIFIED BY testMessage02 } |
   { TestMessage03          IDENTIFIED BY testMessage03 } |
   { TestMessage04          IDENTIFIED BY testMessage04 } |
   { TestMessage05          IDENTIFIED BY testMessage05 } |
   { TestMessage06          IDENTIFIED BY testMessage06 } |
   { TestMessage07          IDENTIFIED BY testMessage07 } |
   { TestMessage08          IDENTIFIED BY testMessage08 } |
   { TestMessage09          IDENTIFIED BY testMessage09 } |
   { TestMessage10          IDENTIFIED BY testMessage10 } |
   { TestMessage11          IDENTIFIED BY testMessage11 } |
   { TestMessage12          IDENTIFIED BY testMessage12 } |
   { TestMessage13          IDENTIFIED BY testMessage13 } |
   { TestMessage14          IDENTIFIED BY testMessage14 } |
   { TestMessage15          IDENTIFIED BY testMessage15 } ,
   ... -- Expansion to be used only by the SAE V2X Core TC
   }
```

Basic Safety Message (BSM)

- BSM Part 1 (coreData):
  - Contains the core data elements (vehicle size, position, speed, heading acceleration, brake system status)
  - Transmitted approximately 10x per second
- BSM Part 2:
  - Added to part 1 depending upon events (e.g., ABS activated)
  - Contains a variable set of data elements drawn from many optional data elements (availability by vehicle model varies)
  - Transmitted less frequently
- Regional Option

ASN.1 Representation:

```
BasicSafetyMessage ::= SEQUENCE {
   -- Part I, Sent at all times with each message
   coreData       BSMcoreData,

   -- Part II Content
   partII         SEQUENCE (SIZE(1..8)) OF
                  PartIIcontent {{ BSMpartIIExtension }} OPTIONAL,

   regional       SEQUENCE (SIZE(1..4)) OF
                  RegionalExtension {{REGION.Reg-BasicSafetyMessage}} OPTIONAL,
   ...
   }
```

BSM Core Data

- Connected vehicle safety application are greatly dependent BSM to exchange the core data that describe vehicle status, position, and motion among vehicles, as well as between vehicle and Infrastructure.

ASN.1 Representation:

```
BSMcoreData ::= SEQUENCE {
    msgCnt          MsgCount,
    id              TemporaryID,
    secMark         DSecond,
    lat             Latitude,
    long            Longitude,
    elev            Elevation,
    accuracy        PositionalAccuracy,
    transmission    TransmissionState,
    speed           Speed,
    heading         Heading,
    angle           SteeringWheelAngle,
    accelSet        AccelerationSet4Way,
    brakes          BrakeSystemStatus,
    size            VehicleSize
    }
```

BSM Part II

- BSM Part II includes:
  - Vehicle Safety Extensions
  - Special Vehicle Extensions
  - Supplemental Vehicle Extension

```
-- BSM Part II content support
PARTII-EXT-ID-AND-TYPE ::= CLASS {
   &id     PartII-Id UNIQUE,
   &Type
   } WITH SYNTAX {&Type IDENTIFIED BY &id}

PartIIcontent  { PARTII-EXT-ID-AND-TYPE: Set} ::= SEQUENCE {
   partII-Id     PARTII-EXT-ID-AND-TYPE.&id( {Set} ),
   partII-Value  PARTII-EXT-ID-AND-TYPE.&Type( {Set}{@partII-Id} )
   }

PartII-Id ::= INTEGER (0..63)
   vehicleSafetyExt       PartII-Id::= 0  -- VehicleSafetyExtensions
   specialVehicleExt      PartII-Id::= 1  -- SpecialVehicleExtensions
   supplementalVehicleExt PartII-Id::= 2  -- SupplementalVehicleExtensions
   -- NOTE: new registered Part II content IDs will be denoted here

-- In a given message there may be multiple extensions present
-- but at most one instance of each extension type.
BSMpartIIExtension  PARTII-EXT-ID-AND-TYPE ::= {
   { VehicleSafetyExtensions       IDENTIFIED BY vehicleSafetyExt} |
   { SpecialVehicleExtensions      IDENTIFIED BY specialVehicleExt} |
   { SupplementalVehicleExtensions IDENTIFIED BY supplementalVehicleExt} ,
   ...
   }
```

BSM Regional Data

- Several possible places in the BSM message structure could be used to add custom data, because regional extension points are found both at the message level and in data frames within the message. There are regional extension points present within several of the Part II content areas. The last three elements in the message specification might include (among others):

```
special        SpecialVehicleExtensions       OPTIONAL,
supplemental   SupplementalVehicleExtensions OPTIONAL,
regional       RegionalExtension {{REGION.Reg-BasicSafetyMessage}} OPTIONAL,
```

For Port Automated Project, we could simply use the Reg-BasicSafetyMessage to add "custom payload" to be transmitted inside the BSM packet.

TIM Traveler Data Frame

- The Traveler Data Frame is used to send a single “message” in a TIM message. The data frame allows sending various advisory and road sign types of information to equipped devices.
- It uses the ITIS encoding system to send well-known phrases, but allows limited text for local place names.
- The supported message types specify several sub-dialects of ITIS phrase patterns to further reduce the number of octets to be sent.
- The expressed messages are active at a precise start and duration period, which can be specified to a resolution of a minute.
- The affected local area (or set of areas) can be expressed using either a radius system or one of the two systems of short defined regions.
- This expression is similar to the way roadway geometry is defined in the map fragment messages.

ASN.1 Representation:

```
TravelerDataFrame ::= SEQUENCE {
    -- Part I, Frame header
    notUsed     SSPindex,
    -- always set to 0 and carries no meaning;
    -- legacy field maintained for backward compatibility
    frameType   TravelerInfoType,  -- (enum, advisory or road sign)
    msgId CHOICE {
        furtherInfoID   FurtherInfoID, -- links to ATIS msg
        roadSignID      RoadSignID     -- an ID to other data
        },
    startYear   DYear OPTIONAL,  -- only if needed
    startTime   MinuteOfTheYear,
    durationTime MinutesDuration,
    priority    SignPrority,

    -- Part II, Applicable Regions of Use
    notUsed1  SSPindex,
    regions SEQUENCE (SIZE(1..16)) OF GeographicalPath,

    -- Part III, Content
    notUsed2    SSPindex,  -- set to 0
    notUsed3    SSPindex,  -- set to 0
    content  CHOICE {
            advisory     ITIS.ITIScodesAndText,
                         -- typical ITIS warnings
            workZone     WorkZone,
                         -- work zone signs and directions
            genericSign  GenericSignage,
                         -- MUTCD signs and directions
            speedLimit   SpeedLimit,
                         -- speed limits and cautions
            exitService  ExitService
                         -- roadside avaiable services
            -- other types may be added in future revisions
            },
    url     URL-Short OPTIONAL,  -- May link to image or other content
    ...
    }
```

TIM Traveler Data Frame

- The Geographical Path data frame is used to support the cross-cutting need in many V2X messages to describe arbitrary spatial areas (polygons, boundary lines, and other basic shapes) required by various message types in a small message size. This data frame can describe a complex path or region of arbitrary size using either one of the two supported node offset methods (XY offsets or LL offsets), or using simple geometric projections. Both open and closed paths are supported, as well as a simple index and naming methodology.
- The Geometric Projection data frame is used to describe various geometric spatial areas (circles and other basic shapes) required by various message types in a small message size.

ASN.1 Representation:

```
GeographicalPath ::= SEQUENCE {
    name            DescriptiveName          OPTIONAL,
    id              RoadSegmentReferenceID   OPTIONAL,
    anchor          Position3D               OPTIONAL,
    laneWidth       LaneWidth                OPTIONAL,
    directionality  DirectionOfUse           OPTIONAL,
    closedPath      BOOLEAN                  OPTIONAL,
                    -- when true, last point closes to first
    direction       HeadingSlice             OPTIONAL,
                    -- field of view over which this applies
    description CHOICE  {
       path         OffsetSystem,
                    -- The XYZ and LLH system of paths
       geometry     GeometricProjection,
                    -- A projected circle from a point
       oldRegion    ValidRegion,
                    -- Legacy method, no longer recommended for use
       ...
       } OPTIONAL,

    regional   SEQUENCE (SIZE(1..4)) OF
           RegionalExtension {{REGION.Reg-GeographicalPath}} OPTIONAL,
    ...
    }
```

ASN.1 Representation:

```
GeometricProjection ::= SEQUENCE {
    direction       HeadingSlice,
                    -- field of view over which this applies,
    extent          Extent OPTIONAL,
                    -- the spatial distance over which this
                    -- message applies and should be presented
    laneWidth       LaneWidth OPTIONAL, -- used when a width is needed
    circle          Circle, -- A point and radius

    regional        SEQUENCE (SIZE(1..4)) OF
                    RegionalExtension {{REGION.Reg-GeometricProjection}} OPTIONAL,
    ...
    }
```

TIM Traveler Data Frame

- Generic Signage is a data frame to allow sequences of ITIS codes, short text strings, and numerical values to be expressed in the normal ITIS vocabulary method and pattern. Note that the allowed text strings are more limited than the normal ITIS format in order to conserve bandwidth.
- All ITIS phrase data, when encoded in a DER or UPER form, shall be expressed as integer values rather than their full text equivalents.

ASN.1 Representation:

```
GenericSignage ::= SEQUENCE (SIZE(1..16)) OF SEQUENCE {
  item CHOICE    {
       itis    ITIS.ITIScodes,
       text    ITIStextPhrase
       }
  }
```

ITIS Codes

- J2540 provides ITIS code list.
- TIM message can use several ITIS Codes to form a message:
  - Parking (4120)
  - Truck (9227)
  - Truck Route (8469)
- TIM also accept Text String

ASN.1 Representation:

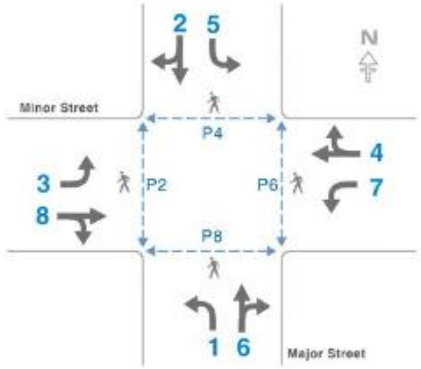
```
ParkingInformation ::= ENUMERATED {
   normal-parking-restrictions-lifted    (4097),
   parking-meter-restrictions-lifted     (4098),
   special-parking-restrictions-in-force (4099),
   full-parking-lot                      (4100),
   full-parking-garage                   (4101),
   all-parking-lots-full                 (4102),
   no-parking-spaces-available           (4103),
   only-a-few-spaces-available           (4104),
   spaces-available                      (4105),
   no-parking                            (4106),

   parking-on-one-side-of-street-only    (4107),
   parking-on-both-sides-of-street       (4108),
   parallel-parking-only                 (4109),
   parking-meters-not-available          (4110),
   use-of-parking-meters-restricted      (4111),
   event-parking                         (4112),
   handicapped-parking                   (4113),
   long-term-parking                     (4114),
   overnight-parking                     (4115),
   short-term-parking                    (4116),
   parking-by-permit-only                (4117),
   emergency-parking-only                (4118),  -- NEW:
   emergency-stopping-only               (4119),  -- NEW:
   parking                               (4120),  -- NEW:  Typically followed by
                                                  -- restriction data
   stopping                              (4121),  -- NEW:  Typically followed by
                                                  -- restriction data
   standing                              (4122),  -- NEW:  Typically followed by
                                                  -- restriction data
   tow-away-zone                         (4123),  -- NEW:
   school-zone                           (4124),  -- NEW:  Treat as Speed Limit, with
                                                  -- details to follow
   speed-zone                            (4125),  -- NEW:  Treat as Speed Limit, with
                                                  -- details to follow
   loading-zone                          (4126),  -- NEW:  Typically followed by
                                                  -- restriction data
   state-law                             (4127),  -- NEW:
   -- Cancel Types
   van-accessible                        (4128),  -- NEW:
   special-parking-restrictions-lifted   (4222),
   no-parking-information-available      (4223),
   ... -- # LOCAL_CONTENT_ITIS
   }

   -- Vehicle Groups Affected
   all-vehicles                          (9217),
   bicycles                              (9218),
   motorcycles                           (9219),  -- to include mopeds as well
   cars                                  (9220),  -- (remapped from ERM value of
                                                  -- zero)
   light-vehicles                        (9221),
   cars-and-light-vehicles               (9222),
   cars-with-trailers                    (9223),
   cars-with-recreational-trailers       (9224),
   vehicles-with-trailers                (9225),
   heavy-vehicles                        (9226),
   trucks                                (9227),  -- Use for RG-190
   buses                                 (9228),
   articulated-buses                     (9229),
   school-buses                          (9230),
   vehicles-with-semi-trailers           (9231),
   vehicles-with-double-trailers         (9232),  -- Alternative Rendering:
                                                  -- western doubles
   high-profile-vehicles                 (9233),
   wide-vehicles                         (9234),
   long-vehicles                         (9235),
   hazardous-loads                       (9236),
   exceptional-loads                     (9237),
   abnormal-loads                        (9238),
   convoys                               (9239),
```

SPaT Challenge

- What is SPaT?
  A Signal Phase and Timing (SPaT) message defines the current intersection signal light phases
  Current state of all lanes at intersection are provided, as well as any active pre-emption or priority



SPaT Challenge

- Why do this Challenge?

To provide Infrastructure Owner-Operators (IOOs) with an entry into DSRC-based V2I deployment and gain valuable procurement, licensing, installation, and operation experience, which in turn will:

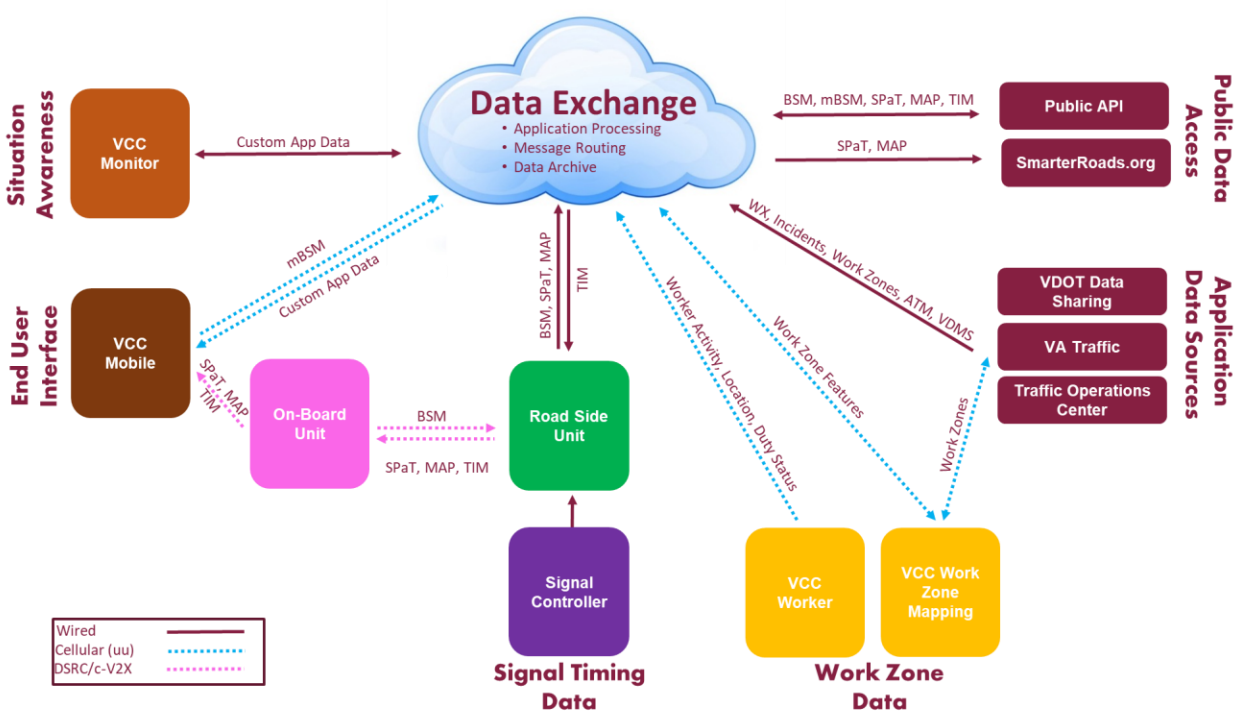
  - Lay ground work for more advanced V2I testing and/or deployments
  - Show a commitment to OEMs and applications developers

SPaT Challenge

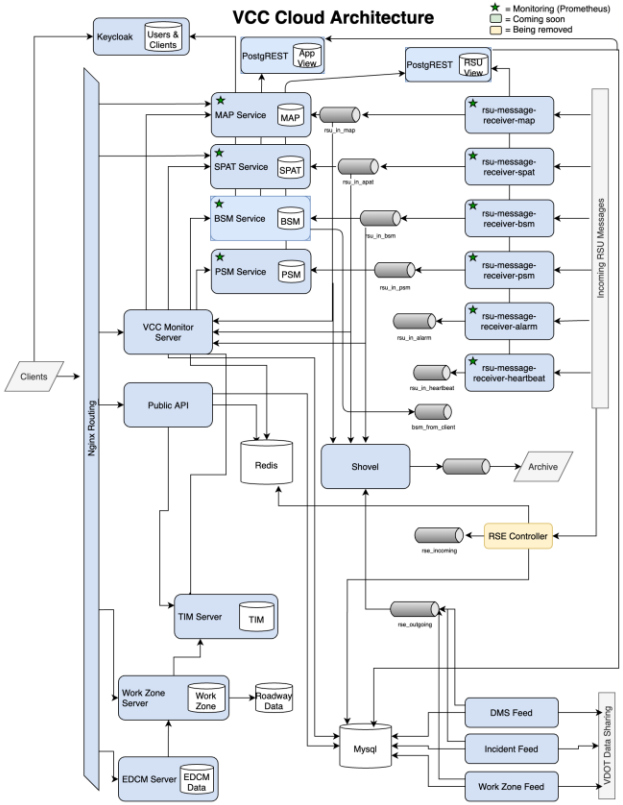
- SPaT broadcasts are typically accompanied by:
  - Broadcasts of MAP/GID data (a detailed data file that describes the physical intersection)
  - Ultimately, SPaT broadcasts will also need:
    - A security certificate (SCMS)
    - A GPS Real-time Correction Message (RTCM)

VCC Architecture

- Public API
- SAE J2735 Support
  - https://obj-sys.com/
- VDOT Data Sharing
- Apps
  - Vehicle Safety
  - Worker Safety
  - Work Zone Data



- Kubernetes Deployment
- Database support
- Authentication support
- Monitoring Services



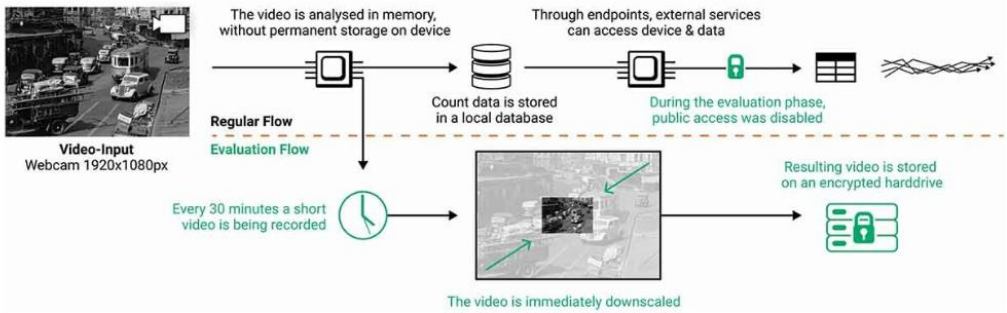
Data Privacy

Four key stakeholders required to establish effective data governance and management

- Join/Collaboration effort between Cities, Citizens and Industry partners.
- People are active creators and not objects.
- Protection of the privacy of individuals

Data Privacy

1. No image data can be accessed by third parties
2. Information is provided to the public through signs at the camera's location, linking to
3. A website that presents information about the associated research project
   - Based on the first requirement, we adjusted our operating scenario as follows
   - ODC is not connected to the Internet
   - Resolution of the videos is reduced so far that faces of persons or license plates are not recognizable
   - Only limited personnel directly involved in the project have access to the system
   - Videos for the evaluation setup are stored and processed on encrypted hard disks



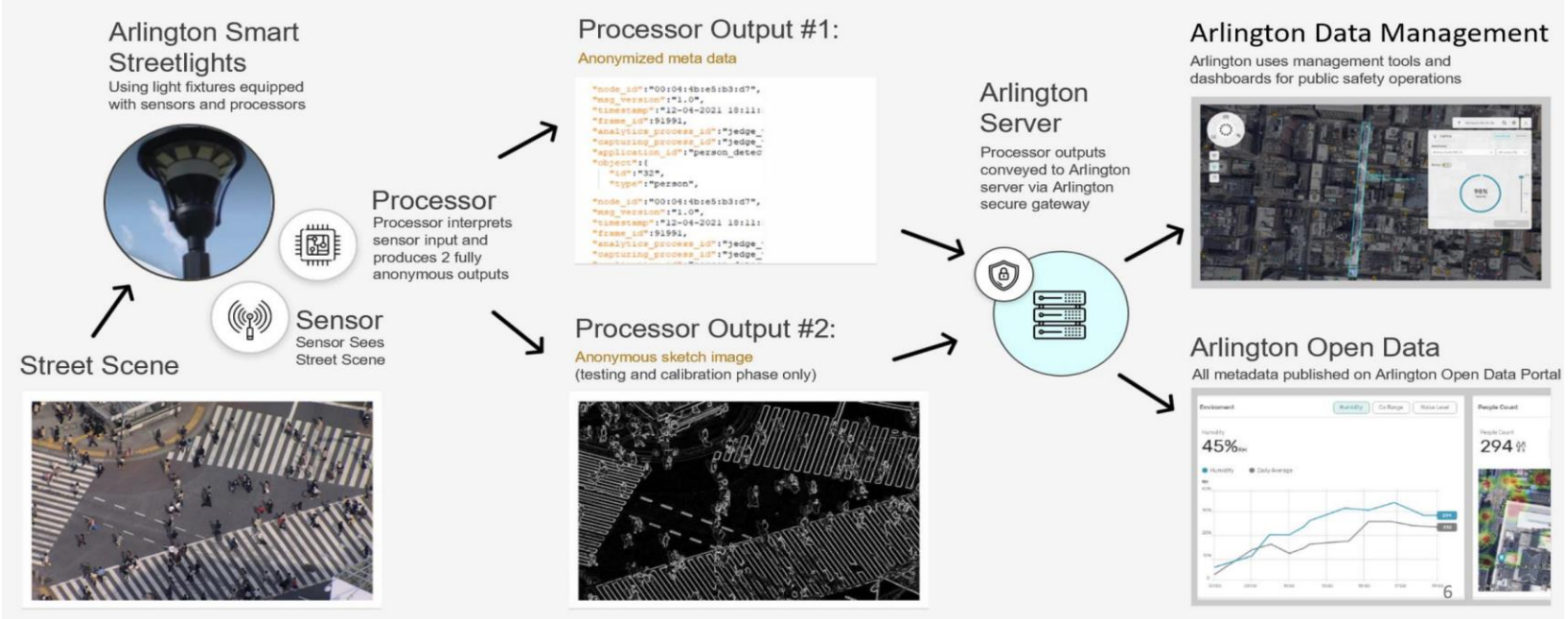
Source: https://www.tandfonline.com/doi/full/10.1080/21650020.2021.1950044

Data Privacy

- Smart Cities and Data Security concerns
  - Operational security and cyberattack
  - Security of Data
  - Review Policy, Regulatory and Legal solutions
    - Fair Information practice principles (FIPPs)
    - Education and Training
  - Smart City Advisory Boards

Domain	Privacy breach	Description
Information collection	Surveillance	Watching, listening to, or recording of an individual's activities
	Interrogation	Various forms of questioning or probing for information
Information processing	Aggregation	The combination of various pieces of data about a person
	Identification	Linking information to particular individuals
	Insecurity	Carelessness in protecting stored information from leaks and improper access
	Secondary use	Use of information collected for one purpose for a different purpose without the data subject's consent
	Exclusion	Failure to allow the data subject to know about the data that others have about her and participate in its handling and use, including being barred from being able to access and correct errors in that data

Arlington Architecture



Data Sharing

- Private access to data
  - Report mentions pedestrian traffic data is accessible by businesses (no mention of public access)
- The City owns the data generated by the sensors
- Raw video and image data are not accessible to general city staff or the public but are retained in the sensor for 5 days and accessible to the chief of police
  - City and public were unaware of this access from 2016-2019
- Waterfront Toronto's Digital Strategy Advisory Panel reviewed the draft and asserted it was "frustratingly abstract" and "did not appear to put the citizen at the center of the design process for digital innovations"
- Sidewalk labs claimed all data they collected will be de-identified at the source
- Concerns raised over 3rd party access to identifiable data (sidewalk owned by alphabet, owner of google) and citizen privacy so Digital Strategy Advisory Panel was created
- Privacy commissioner of Ontario resigned in 2018 stating "I imagined us creating a Smart City of Privacy, as opposed to a Smart City of Surveillance"
- AoT Data - the City (Dept of Information Technology, Seattle Public Utilities, Seattle City Light and Department of Neighborhoods) owns, locates, and maintains the sensors
  - University of Washington collects and maintains the data