Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Vehicle CamCom for Advanced Driver Assistance System

Date Submitted: March 2017

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Abstract: This documents introduce the Advanced Driver Assistance System (ADAS) using Vehicle CamCom Concept models for Vehicular Assistant Technology (VAT). This proposed VAT using Image Sensor Communication to operate on the application services like ITS, ADAS, IoT/IoL, LED IT, Digital Signage with Advertisement Information etc.

Purpose: To Provided Concept models of Vehicle OCC to Vehicular Assistant Technology (VAT) Interest Group

Vehicle CamCom for Advanced Driver Assistance System

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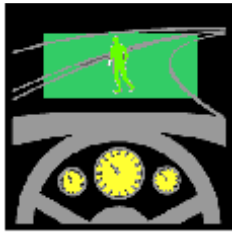
Intelligent Transportation System (ITS)

- Technologies of communications, control, electronics and computer hardware & software to the surface transportation system.
- To add information and communications technology to transport infrastructure and vehicles, in order to:
  - Improve safety
  - Reduce vehicle wear
  - Reduce transportation times
  - Reduce fuel consumption
- Functional Areas
  - Advanced Traffic Management Systems (ATMS)
  - Advanced Traveler Information Systems (ATIS)
  - Commercial Vehicle Operations (CVO)
  - Advanced Public Transportation Systems (APTS)
  - Advanced Vehicle Control Systems (AVCS)



Driver Assistance System

Collision Avoidance System

Freeway Management

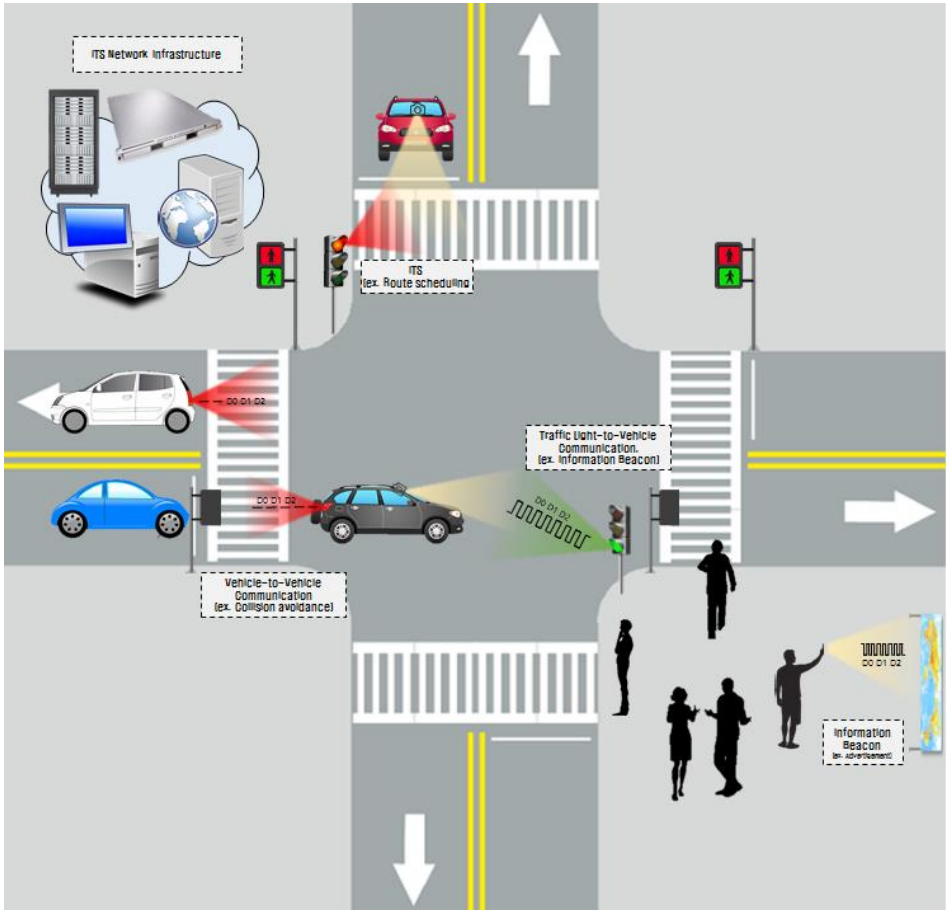
Transit Management

Vehicle CamCom Integration for Cooperative ITS

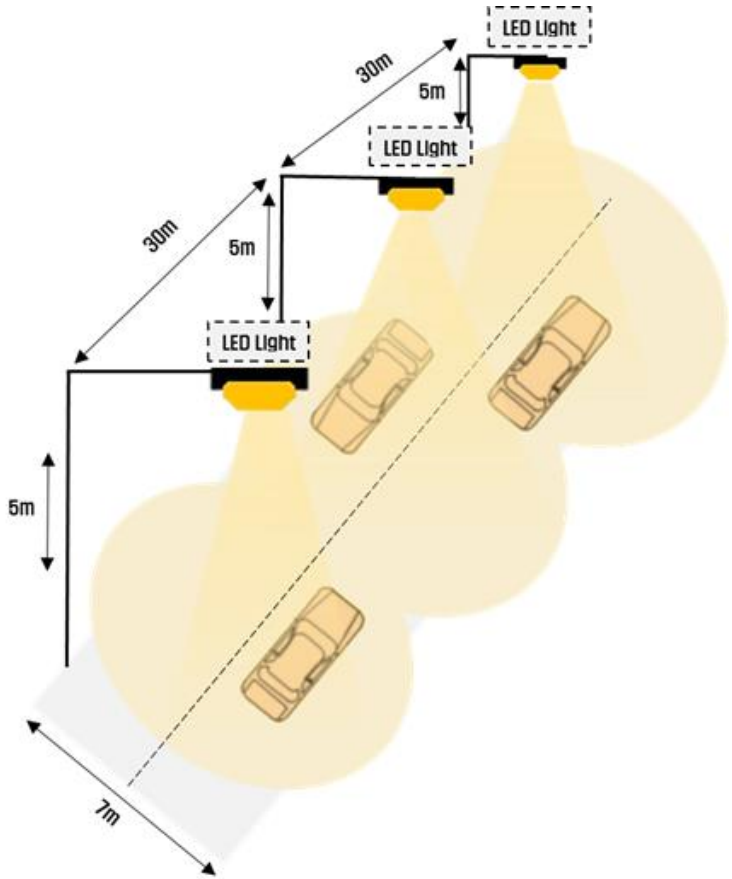
[Note : From Fig. 2.4 ITS scenario - Intelligent Transportation Systems, Studies in Systems, Decision and Control]

- Vehicle CamCom is adopted in ITS Applications
  - Surface transportation system, Airway transportation System, Water Transportation System
  - Used in Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I)

Vehicle CamCom for Advanced Driver Assistance Systems



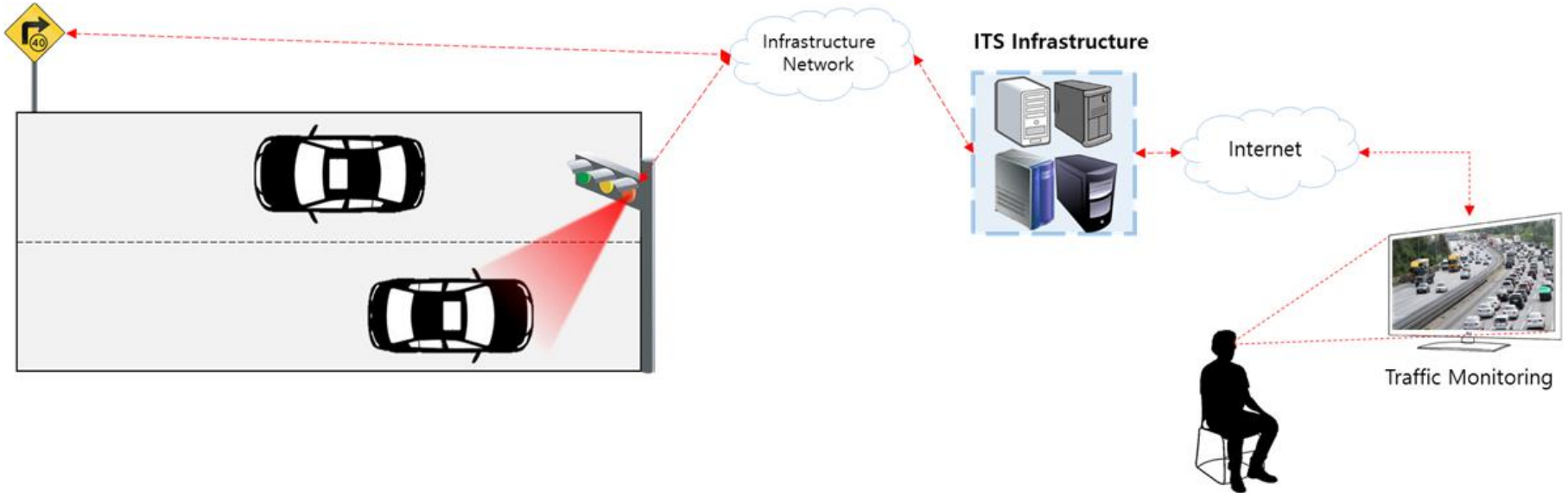
VLC ITC Application Scenario



Ubiquitous Communication with Road Illumination

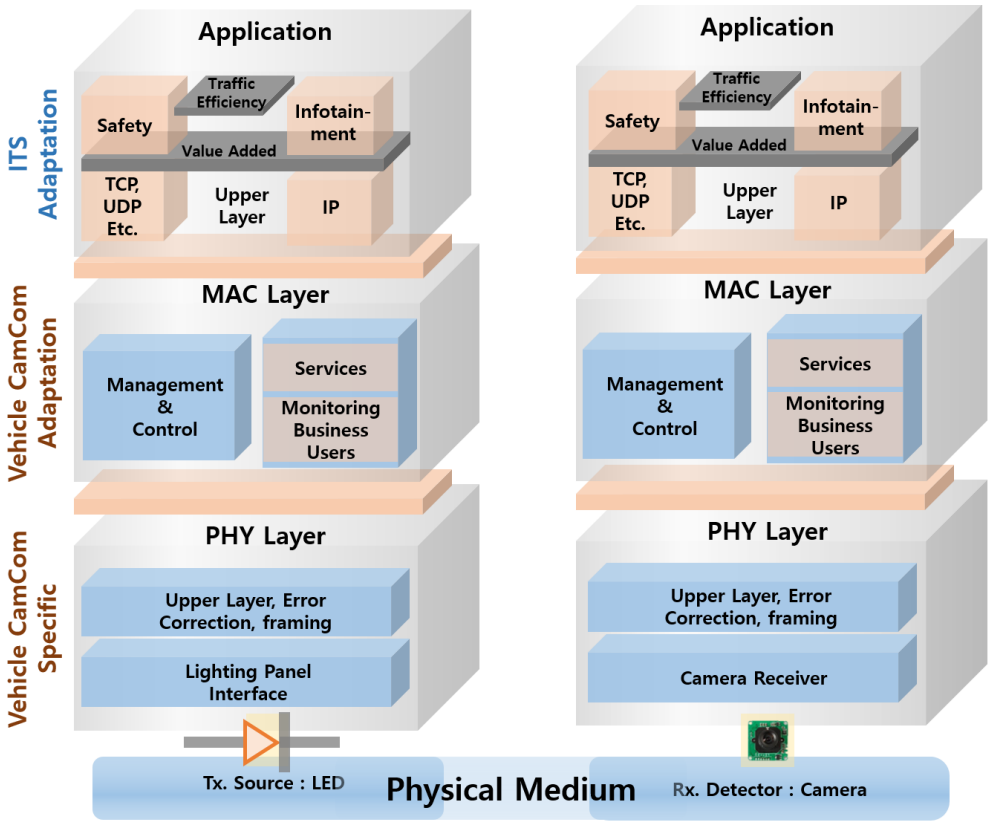
- Vehicle CamCom is adopted in ITS applications instead of IR, there is no need to put Ad-Hoc IR Emitters in the environment due to the existence of LED traffic lights and LED car headlamps

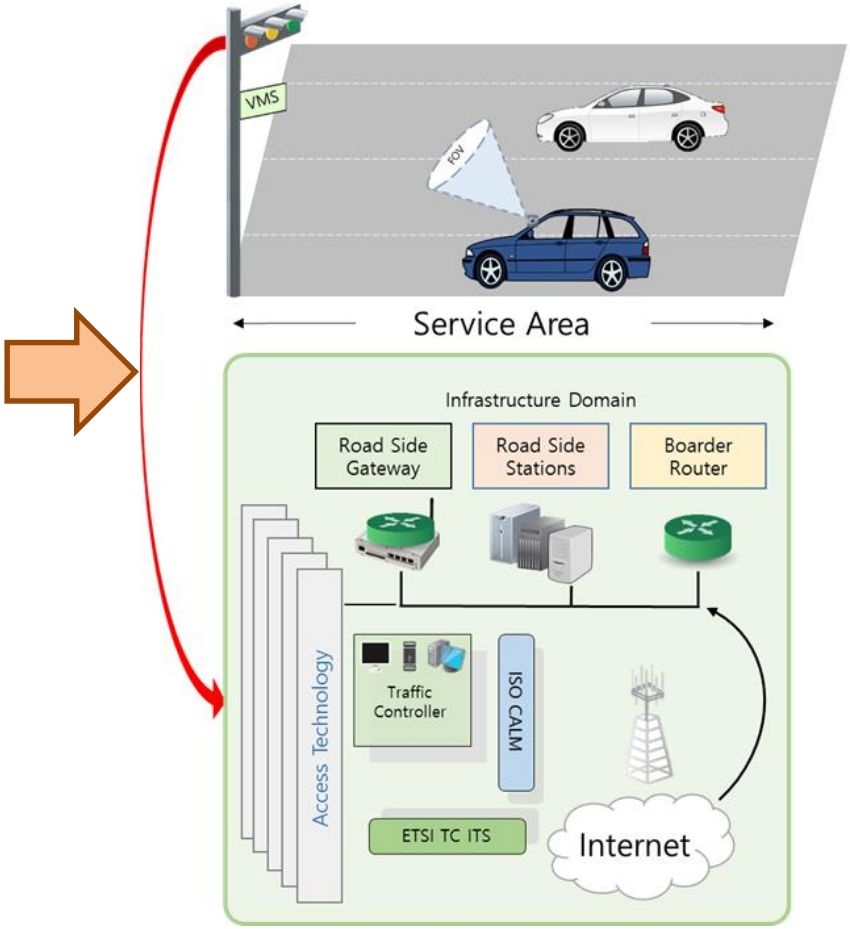
Vehicle CamCom Network Architecture



- Vehicle CamCom Network consists of vehicles as mobile nodes and infrastructure lighting sources as fixed gateways
- Both the mobile nodes and the infrastructure lightings, such as traffic lights, can be equipped with multiple transmitters and receivers which can operate simultaneously.

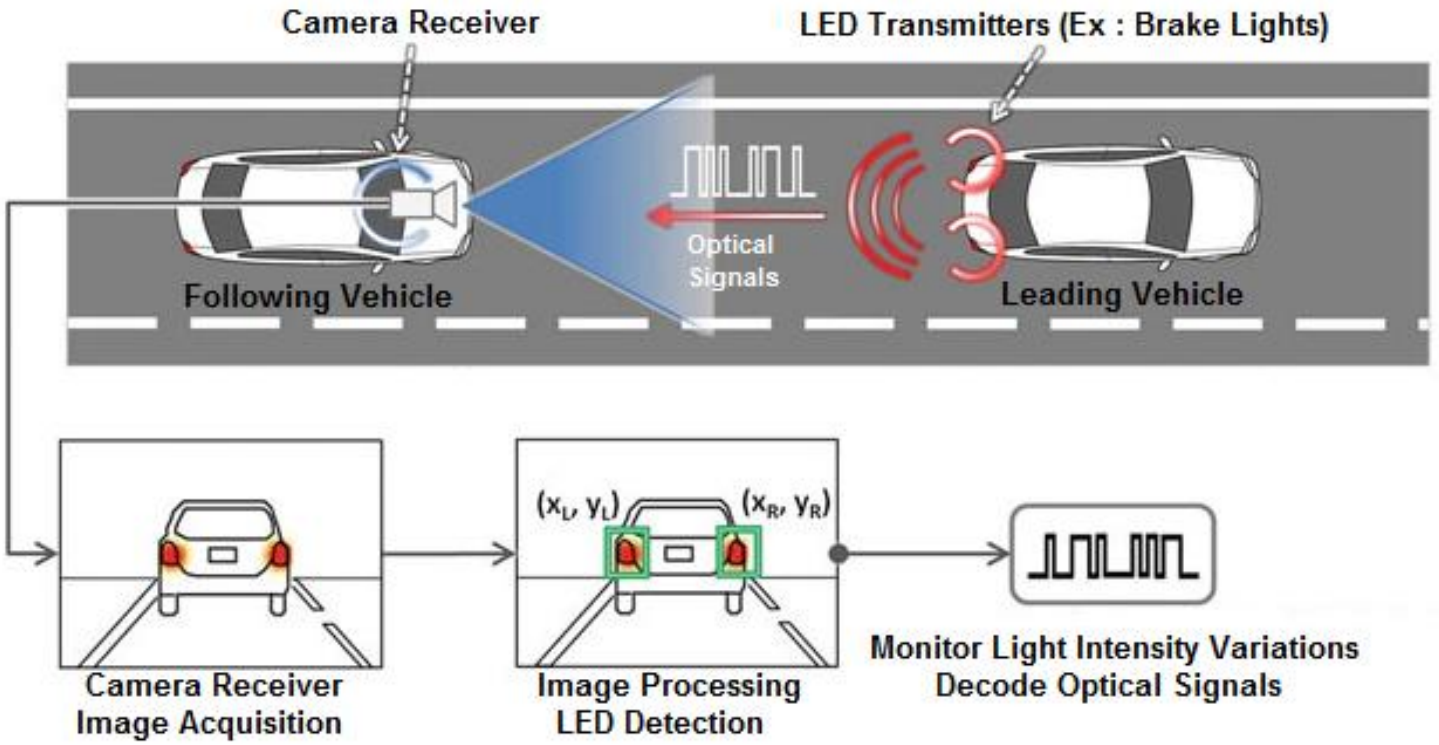
Vehicle CamCom Layer Architecture - ITS Integration





- Vehicles Nodes follow three Layer Model
  - PHY Layer
  - MAC Layer
  - ITS Adaptation Layer

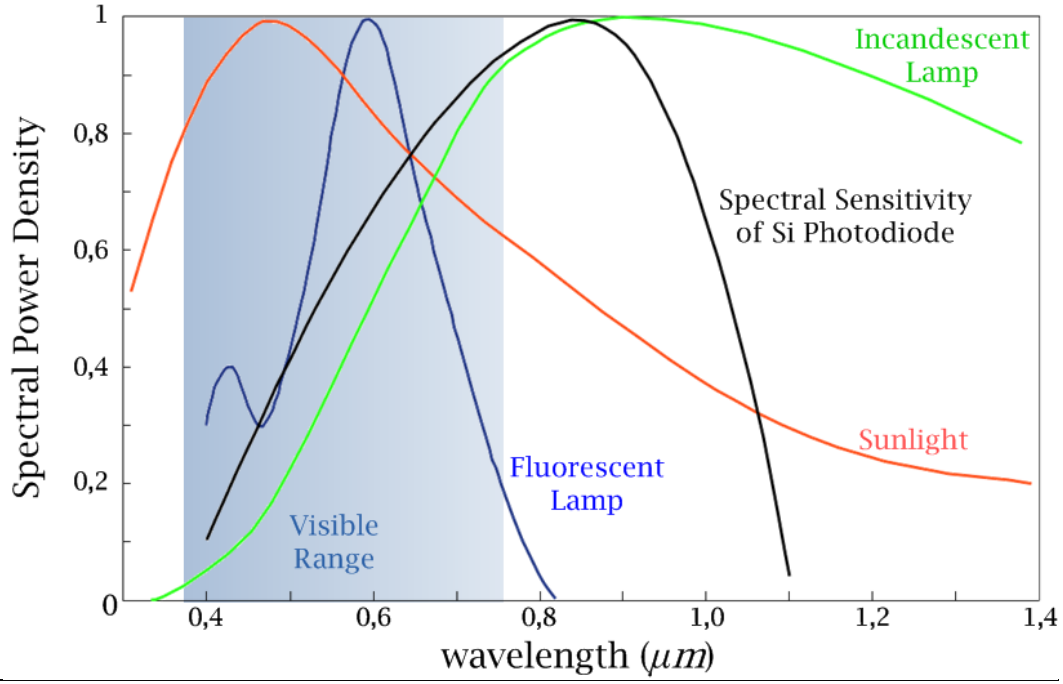
V2V Optical Image Sensor Communication



- Image Sensor based V2V Communication
  - Tx – LED ; Rx – CMOS Image Sensor
  - Data Rate : 10 Mb/s
  - Day-Night Communication Mode

Design Parameters Considerations

- Noise Sources
  - CamCom system in ITS is largely affected by natural and artificial lights (noise and interference) such as Sun light, ambient lights, road/street lights etc.
- Issues Needs to be address in design
  - Minimizing the effect of external noise
    - Artificial or Natural
  - Ambient lights effect
  - Interference minimization

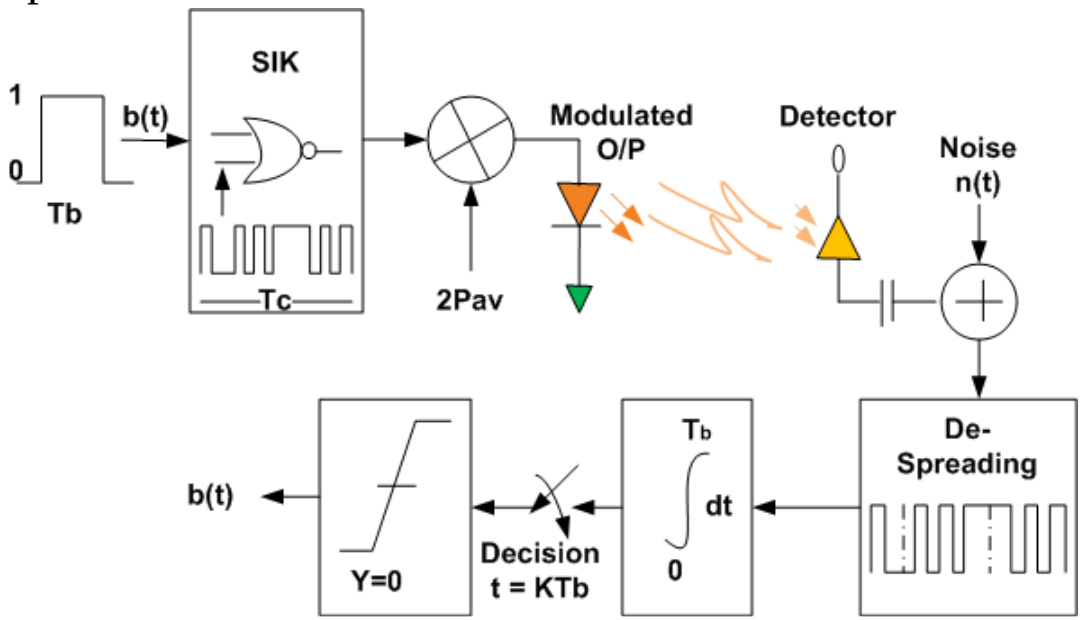


Design Parameters Considerations…

- Noise and Interference Minimization Techniques
  - Optical filter
  - Infrared filter
  - Robust modulation techniques
- Robust Modulation Techniques
  - Different Modulation used including Optical MIMO
  - Adaptive Modulation Techniques for different applications
  - Equalization Techniques have advantages in design
  - Suitable Modulation
    - OOK
    - Multilevel PPM
    - Inverted PPM
    - Sub Carrier PPM
    - DSSS SIK

Design Parameters Considerations…

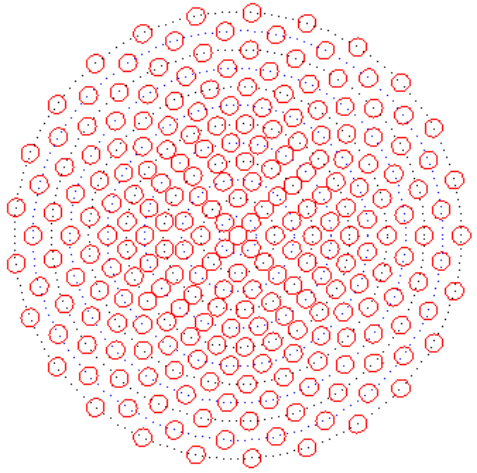
- DSSS SIK
  - Direct Sequence Spread Spectrum (DSSS) Sequence Inverse Keying (SIK) modulation technique which is found to be very effective against such interference
  - Use of DSSS limits the data transmission rate, but in traffic broadcast system high data rate is not an important issue
  - Advantages
    - Interference Cancellation
    - Avoid Jamming
    - Tolerance of Noise



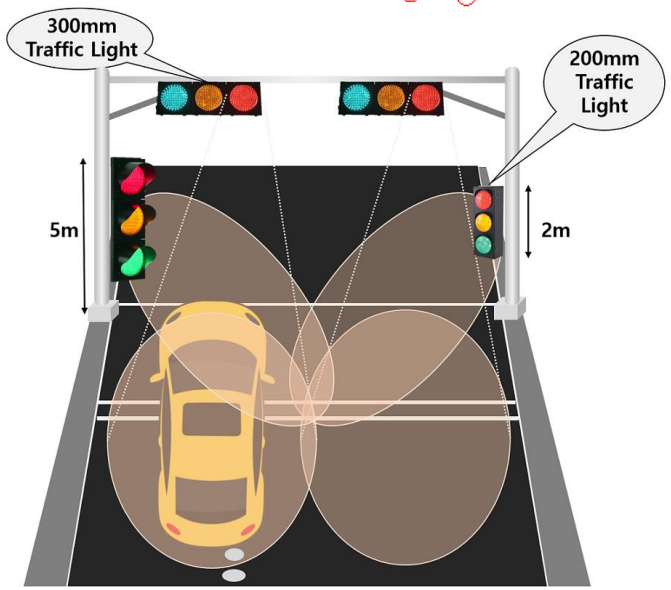
Design Parameters Considerations…

- Uplink Design Requires
  - Long Range Communication
  - Line-of-Sight (LoS)
  - Limiting Communication range and many more …
  - Integration with Infrastructure
    - RF / OWC Integration
- To Increase the Range
  - Optimize Illumination
  - Optimize Placement of Luminaries
    - Traffic Lights
  - Use Relaying Techniques
    - Vehicle-to-Vehicle
    - Break Lights

Placement Strategy



Traffic Light Arrangement



Conclusion

- Supported by existing infrastructures, a low cost CamCom can find wide range of applications, both outdoor and indoor offering ubiquitous and seamless connectivity
- CamCom guarantees data communication from infrastructure-to-vehicle, broadcasting many safety related information, hence suitable for road safety applications.
- Use of CamCom in ITS as road safety system is a novel idea and directly related to human and material safety