INTRODUCTION
The number of vehicles on roads is on the increase yearly with traffic congestion becoming a widespread problem and road accidents have been identified as the leading cause of death among young people as issued by the World Health Organisation [1]. Therefore, the ability of vehicles to wirelessly exchange information with the neighbouring vehicles and the road side infrastructure, known as Intelligent Transport Systems and Services (ITS), can greatly improve road safety and transportation. Consequently, the increasing use of light emitting diodes in vehicle taillights, headlights and traffic lights offer excellent opportunities for implementation of visible light communications (VLC) based the wireless technology as part of ITS in smart environments.

The established wireless technology for vehicular communications is based on the dedicated short-range communications (DSRC), which is a 5.9 G Hz radio frequency (RF) technology [2]. 

Drawbacks of RF technology for ITS purposes
- Limited packet reception rate on dense roads
- Difficulty in visually recognizing the transmitters’ position due to the unidirectional feature of RF.

Consequently, VLC can serve as a complementary technology for vehicular communications.

VEHICULAR VLC - CHALLENGES

The current challenges in vehicular VLC systems are [3]:

Increasing Robustness to Noise
- The IEEE 802.15.7 standard - Moves the communication to an upper band
- Capacitive filters - To remove the DC component introduced by the unmodulated parasitic light.

Increasing the Communication Range
- Increasing the transmit power - Limited by the eye safety standards
- Use of optical lenses - Narrower angle emission pattern - Multi-hop transmission.

Enhancing Mobility
- Use more photodiodes (PDs) - Oriented for different reception angles, tracking mechanism that adjusts the PD’s position and relay VLC

Higher Data Rates
- Desirable provided it does not affect any of the other challenges.

VEHICULAR VLC - EFFECTS OF FOG

Few works have been reported on the investigation of fog on VLC systems. Moreover, previous works reported have only considered the use of a PD as the receiver (Rx) and non has considered the use of a camera as the Rx.

Therefore, the use of camera-based Rx in vehicular communications given the availability of a dashboard camera is considered [4].

SYSTEM MODEL AND EXPERIMENTAL SETUP

The channel DC gain for the line of sight link can be expressed as [5]:

\[
H(f)_{LOS} = \frac{A_{IMAG}(\theta, f) \cos(\phi)}{\lambda} \cos(\phi) T_{s}(\phi) T_{r}(\phi) \cos(\delta) \leq \phi \leq \Psi_{CAM} \phi > \Psi_{CAM}
\]

where \( A_{IMAG} \), \( \phi \), \( T_{s}(\phi) \) and \( T_{r}(\phi) \) are the projected image of the transmitter (Tx) on the IS of the camera, distance between Tx and receiver (Rx), gains of the optical concentrator and optical filter respectively. \( \phi \), \( \Psi_{CAM} \) and \( m \) are the irradiance, incidence angle, the field of view (FOV) semi-angle of the camera and Lambertian order of emission of Tx respectively.

EXPERIMENTAL RESULTS

From the results obtained, the proposed OCC based VLC link shows high reliability even under the fog condition up to a meteorological visibility of 20 m for all the 3 Mis employed.

CONCLUSIONS

We have developed a new technique to increase the link-span of a RS-based OCC using the defocusing effect of the camera. No works to the best of our knowledge have reported long distance based RS-OCC link beyond 120 m.

A 400 M LONG DISTANCE ROLLING SHUTTER (RS) BASED OCC LINK