VIMOC Technologies

Town of Los Gatos
Pilot Project Report

Los Gatos Parking Occupancy Management

November 5, 2015

Landscape Computing Solution for:

- **Parking Occupancy Management**
- **Image Sensors**

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November 5, 2015

Town of Los Gatos
Attn: Matt Morley
41 Miles Avenue
Los Gatos, CA 95030

Subject: Pilot Project Findings - Downtown Los Gatos
VIMOC Technologies Landscape Computing

Dear Matt,

VIMOC Technologies is pleased to submit this Preliminary Findings report for the Pilot Landscape Computing Project deployed in Downtown Los Gatos over the past six months.

Landscape Computing is VIMOC's flagship product, offering a sensor-agnostic and application-agnostic platform for sensory data management. The Downtown Los Gatos project focuses on Parking Occupancy Management and includes the Landscape Computing Network made up of VIMOC nBoxes and Routers that allow for the data collection, processing, and storage of sensory data. 112 parking occupancy sensors are deployed, 70 surface mount sensors and 42 flush-mount sensors. Verizon Wireless is the 4G cellular data carrier for the project.

VIMOC deployed the project in April 2015 following issuance of an Encroachment Permit for installation. The Landscape Computing network started with a total of 4 nBoxes and 11 routers. The nBoxes operate on 12V DC batteries that recharge at night using AC-power from streetlights. The routers are all solar-powered operating day and night on 12V DC batteries. The Landscape Computing network was upgraded over the summer to the current 2nd generation hardware to improve maintenance accessibility, ensure better network redundancy, and to introduce image sensor capabilities.

Immediately following initial deployment VIMOC experienced challenges in managing the computing network due to inconsistent 4G cellular data covered by Verizon Wireless. VIMOC deployed two different types of Verizon 4G cellular devices, settling finally on a Sierra Wireless Verizon Mobile-2-Mobile Router unit used in the 2nd generation hardware.

Landscape Computing Network Summary

Over the summer, VIMOC replaced the initial Landscape Computing hardware with its current Second Generation hardware. The new field equipment includes NEMA-rated outdoor enclosures, image sensors at nBox locations, remote power cycle devices, and 5db strength antennas.

The Second Generation equipment greatly improved the performance of the Downtown Los Gatos project. The 5dB antennas for example improved communications strength to parking sensors and between network devices improving the self-healing mesh network of the system. The new Image Sensors at each of the four nBox locations provide a remote monitoring feature through the system's User Interface (UI). The Image Sensors take a still snap shot every minute and stores the image in the system for up to 8 hours. When the UI is used, the system pull up the most current still image to help compare parking status on the UI against actual field conditions. During the trial period, the Los Gatos Police Department accessed the UI images twice to assist in active criminal investigations.

VIMOC Technologies nBox Solution with Image Sensor

The current 2nd generation Landscape Computing network operate the same as the initial deployment with AC-power connections at nBoxes and solar-powered facilities at router locations.

Final upgrades to the network were completed in mid-October with additional routes added to the network to further improve system performance and to provide additional redundancy should the town choose to expand the system following the trial period. *Attachment A – Los Gatos VIMOC Technologies Record Drawing*, provides a final inventory of all field equipment including:

VIMOC Technologies Router

- 4 nBoxes
- 14 Routers
- 112 Parking Sensors

Attachment A also highlights the location of AC power modifications implemented in the field, along with network Mac Address details for future maintenance.

User Interface (UI) Summary

The VIMOC Technologies – UI was made available to Town staff over the summer. The UI includes a cloud-based interface that allows Town staff to monitor the parking occupancy sensory data collected by the Landscape Computing network. Data is stored within the Landscape Computing network hardware in the field and is polled near real-time by the UI, approximately every 10 seconds. The UI also allows the user to run reports on individual sensors and sensor zones. The sensor zones were defined by VIMOC Technologies but can be reconfigured at the request of the user.

The UI includes two primary elements, color-coded parking space icons and image sensor icons. The parking space icons are shown as Red when a vehicle is occupying the parking space and green when the parking space is vacant. The image sensor images, when selected by the user, pull up the most recent image collected by the system. The image sensor icon is not a command icon to take a "snap shot" of field conditions at the moment that the icon is selected.

UI Web Link: http://ui.landscape-computing.com/login-lg.jsp
User Name: admin
Password: admin

UI Image Sample

Latency and Accuracy Testing

At the start of the Pilot Project, Town staff and VIMOC discussed a set of basic testing parameters to use to determine the performance of the system:

- > 90% Detection Accuracy
- < 30 second Latency

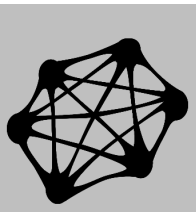
VIMOC Technologies conducted a Latency and Accuracy Test of the Los Gatos Landscape Computing network on Saturday, October 18, 2015 following the latest equipment upgrades that installed additional routers in the field.

Accuracy is defined as whether the Landscape Computing network is detecting the presence of a vehicle over the parking sensor. ***Except for a specific batch of parking sensors that were defective, the parking sensors and Landscape Computing network showed 100% accuracy in detection of a vehicle.*** During the the project implementation approximately 8 sensors were identified as not functioning properly (6 surface mount parking sensors and 2 flush-mount parking sensors) and were immediately replaced. ***At the writing of this report, all 112 sensors were functioning, equivalent to 100% detection accuracy.***

Latency is measured by VIMOC in two different ways: 1) latency of the network, and
2) latency of the UI

Latency in the Network is a measure of how long the monitoring nBox takes to identify a status change in a parking space. Latency of the UI is a measure of how long after a parking event takes place to the status change on the UI (i.e., color change on parking icon). To further test Latency of the UI VIMOC conducted a comparison of viewing the UI status change on both a mobile device (iPhone 6 on an AT&T Network) and an office computer with a standard broadband connection.

Network Latency measured at an average 21 seconds. UI Latency measured adds another 9 seconds of latency, for a total average latency of 30 seconds. The 9 seconds difference between Network and UI Latencies is consistent with the current 10 seconds polling rate of the administration UI. The 10 seconds polling rate allows for a near-real-time view of occupancy while reducing network usage and providing good UI responsiveness. VIMOC found no difference in UI Latency over a mobile device versus an office computer.



The average and network latency results are within the projects targets and show a strong and redundant Landscape Computing network within the town that VIMOC credits to the increase in recently router increase and robust Zigbee communications protocol used by the system.

In further evaluating, the Landscape Computing network VIMOC has identified the following opportunities to improve Network and User Latency:

1. *Replace Verizon Wireless 4G Network with AT&T 4G or Satellite Network*

   VIMOC has experienced inconsistent speeds and loss in data packets between the Landscape Computing hardware and cloud-based servers on the Verizon Wireless 4G Network in Downtown Los Gatos since the start of the project. Slowest speeds and inconsistent data verification occurred near the south end of the S Santa Cruz Avenue along the post office frontage and in near the Toll House Hotel.

   VIMOC recommends that if the Town pursue expansion of the system, conversion to an alternative carrier take place, such as AT&T should be considered to further improve system performance and reduce UI Latency. Another alternative can be to explore the use of a Satellite cloud-based service which would provide an improved level of system redundancy in the event of natural disasters where traditional cellular carrier service may be impacted. VIMOC is currently exploring the use of Satellite cloud-based service for future iterations of its field hardware as an alternative option for community partners. A third, and more desirable alternative, can be to utilize existing city connections to the cloud such as existing fiber optic cables, secured public wi-fi, or existing broadband community contracts with carriers such as Comcast.

2. *Mobile Device Polling*

   The polling rate of the mobile device to the cloud was found to impact UI latency. Due to cellular latency and interruptions on the cellular network, the update frequency needs to adapt to cellular conditions. Where Channel Partners consume the VIMOC Application Program Interface (API) to integrate data into real-time mobile applications, VIMOC would suggest a push-based API be used between the data proxy and the client application to reduce latency to match that of the Network, average of 21 seconds.

3. *VIMOC Heartbeat Monitoring*

   At the start of the project, VIMOC polled sensors once per minute to ensure that sensors are functioning properly. This is known as the Heartbeat of the network. VIMOC has reduced its Heartbeat to once times per three minutes to reduce demand on the

Landscape Computing network so that computer processing can instead by dedicated to monitoring for status change of sensors.

4. *S Santa Cruz Avenue nBox Dedication*

   Given the low cellular feed along S Santa Cruz Avenue along the post office and Toll House Hotel frontages, VIMOC recommends adding a fifth nBox in this immediate vicinity and whitelisting connection of sensors and routes to the new nBox. The Landscape Computing network is currently designed as a self-healing mesh network that allows sensors to jump between routers and nBoxes depending on signal strength allowing for system redundancy. Interference on the 2.4GHz spectrum in this area are causing sensors to repeatedly jump between different network devices resulting in a loss of data packets which can, at times, increase network and UI latency. The addition of an additional nBox should improve latency in this area and further reduce the average Network and UI latencies.

VIMOC wishes to extend its gratitude to the Town of Los Gatos for allowing the installation of its Landscape Computing Network for Parking Occupancy Management. We also would also appreciate the opportunity to meet with Town staff to discuss the roll out of the solution.

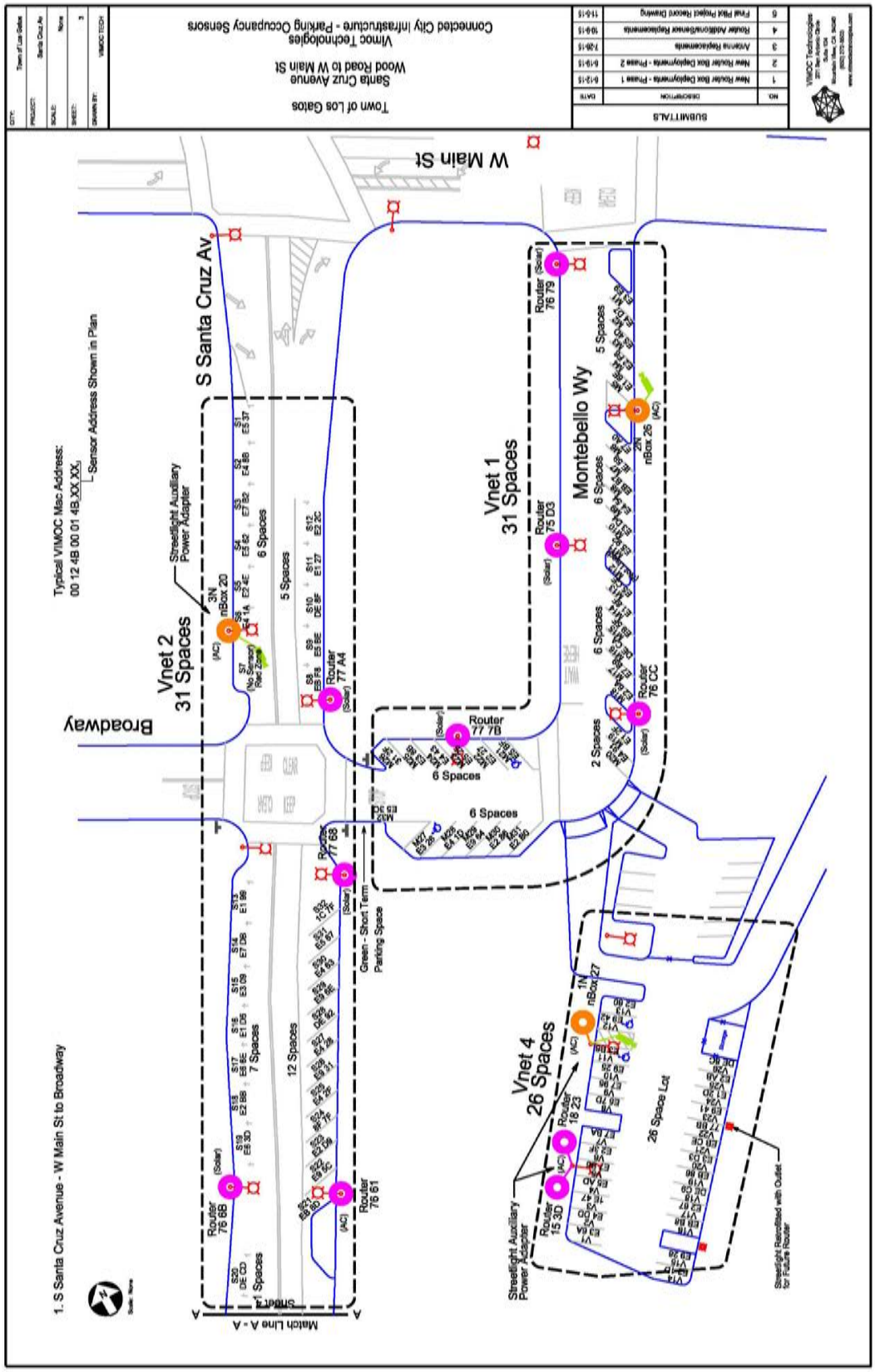
Based on the testing we conducted we believe the VIMOC solution is superior in performance than any product in the market place, the project also allowed us to build new tools for network IoT administration, management and maintenance. Another important feature of Landscape Computing is the ability to add more applications like people and bicycle, vehicle counting, and public safety applications.

VIMOC has conducted a preliminary assessment of the Downtown Core Area and recommends expansion of parking occupancy sensors within areas identified in Attachment B.

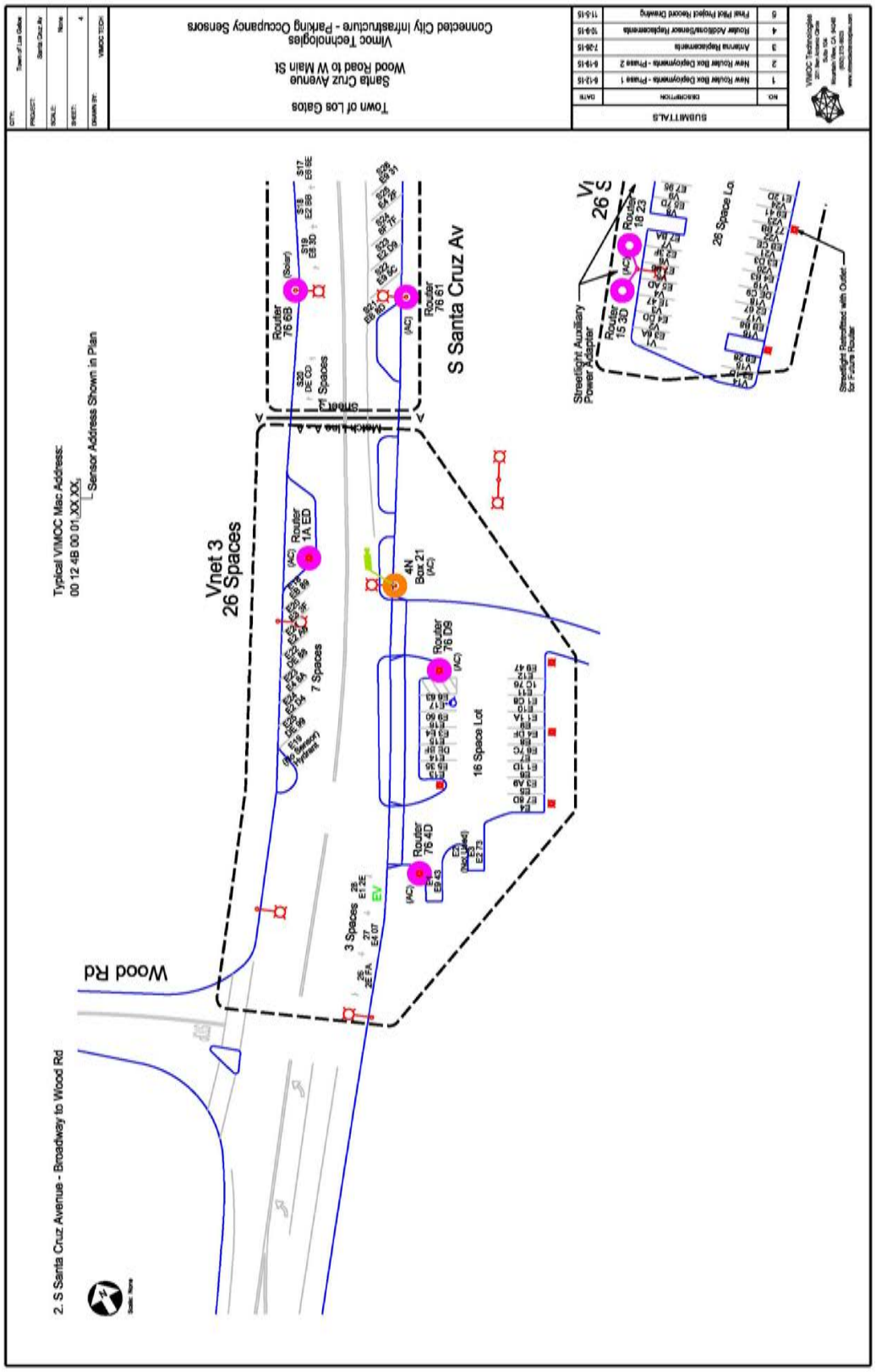
If you have any questions, please do not hesitate to contact either Alex Panelli, Director of Corporate & Business Development at (650) 678-3257 or Jaime Rodriguez, Traffic Patterns, at (408) 916-8141.

Sincerely,
Tarik Hammadou
CEO

Attachment A
Los Gatos Landscape Computing Network Diagram



Attachment A
Los Gatos Landscape Computing Network Diagram



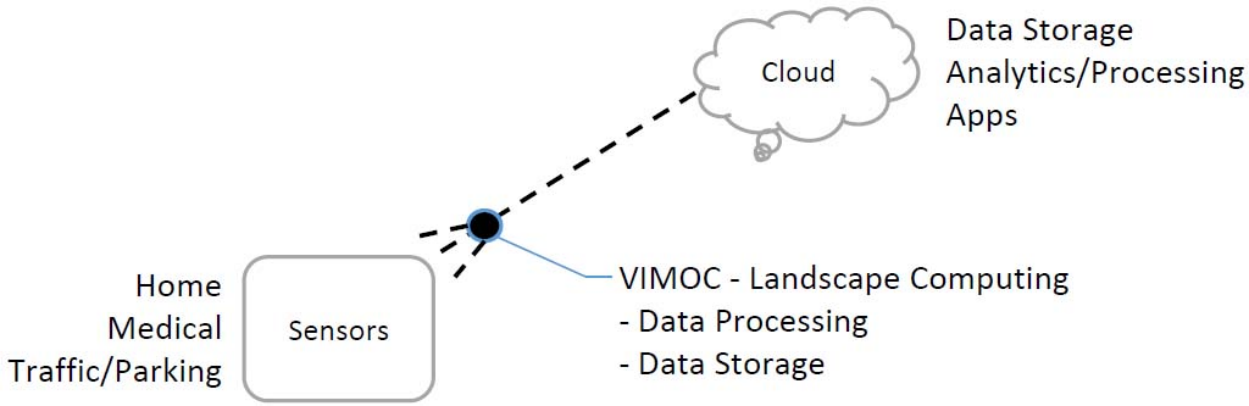
Attachment B
Proposed Los Gatos Landscape Computing Expansion Areas

Corridor	Block Segment	No. of Standard Parking Spaces by Side of Street			
		North	South	East	West
Downtown Surface Streets					
N Santa Cruz	W Main to Bean Av	-	-	22	22
	Bean Av to Grays Ln	-	-	10	9
	Grays Ln to Nicholson Av	-	-	9	9
	Nicholson Av to Bachman Av	-	-	13	13
	Bachman Av to Hwy 9	-	-	12	7
	Hwy 9 to Andrews St	-	-	7	4
	Andrews St to Roberts Rd	-	-	10	12
	Roberts Rd to Blossom Hill	-	-	9	14
W Main St	Bayview to Tait	8	3	-	-
	Tait to Lyndon Av	5	5	-	-
	Lyndon to Santa Cruz	12	9	-	-
	Santa Cruz to University Av	7	4	-	-
	University Av to Hwy 101	15	15	-	-
E Main St	Hwy 101 to College	0	3	-	-
	College to Church	15	13	-	-
	Church to Villa	14	23	-	-
	Villa to Jackson St	35	20	-	-
University Av	W Main to Elm	-	-	0	16
	Elm to Grays Ln	-	-	8	13
	Grays Ln to Royce	-	-	6	8
	Royce to Bachman Av	-	-	15	14
	Bachman Av to Hwy 9	-	-	4	9
Elm St	Santa Cruz to University Av	4	0	-	-
Greys Ln	Santa Cruz to University Av	7	1	-	-
Royce St	Santa Cruz to University Av	12	0	-	-
Bachman Av	Santa Cruz to University Av	9	13	-	-
	Santa Cruz to Wilder Av	9	8	-	-
Nicholson Av	Santa Cruz to Wilder Av	10	10	-	-
Bean Av	Santa Cruz to Wilder Av	8	10	-	-
Parking Lots		Estimate			
Station Wy	Main St to Elm St	110			
Boon Ln	Elm St to Grays Ln (Surface)	156			
	Elm St to Grays Ln (Garage)	100			
Civic Center/Library	Parking Lot	52			
Victor Lane	Parking Lot	117			
	Sum:	705	137	125	150

Est. Sensor Count
1117

Landscape Computing

VIMOC Technologies developed **Landscape Computing** as a **New Layer of the Internet** to help support the collection, processing, and data storage of sensory data. Landscape Computing is sensor-agnostic and application-agnostic making it an effective solution to support either Smart City Infrastructure or Private Networks within the growing market of the **Internet of Things** (IoT).



Landscape Computing provides a new computer-processing network that is located Near the Edge of the Internet. This allows data processing to take place before the Internet helping to save in Data Transmission costs.

The Landscape Computing network includes **Landscape Boxes** with VIMOC Technologies **NeuroBox** (nBox) technology where raw sensory data is processed and turned it into **Intelligence.** This intelligent data is only transmitted to the Cloud when requested by users through an advanced **User Interface** (UI) to query and view data.

Advanced technology **Routers** complete the Landscape Computing network and provide a self-healing network for which any low-cost sensor may be connected.

Landscape Box and Routers are available in either solar-powered or power grid solutions allowing for easy deployment and reliability under varying environmental applications.

When used as a solar-powered solution for Smart City Infrastructure, Landscape Computing can support Emergency Operations Center facilities and introduce Public-Private Partnerships solutions that can introduce revenue streams with Data Aggregators and the IoT Market Place connecting Public Sector agencies with the Technology industry.

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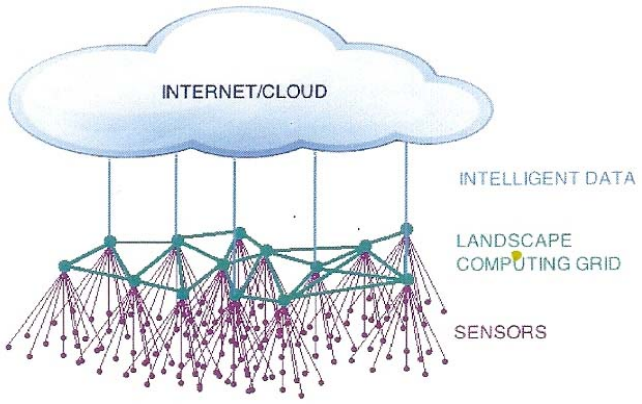
Parking Management

Landscape Computing Application

Parking Management is VIMOC Technologies first application for Landscape Computing as a common area of interest between Public and Private Sector partners. VIMOC Technologies has developed and open-sourced low-cost Parking Sensors available in either Surface-mount of Flush-Mount applications.

VIMOC's Parking Management solution takes advantage of Landscape Computing Networks to collect near real-time Parking Occupancy Data. The raw sensory data is processed into Intelligence and retained near the Edge of the Internet until requested through either the VIMOC Technologies User Interface (UI) or Application Program Interface (API).



Any preferred parking sensor can be used as part of VIMOC Technologies Parking Management solution and integration with any Parking Revenue System can be made through VIMOC's API. VIMOC's Parking Management solution can also be integrated with Advanced Traffic Management Systems (ATMS) solutions to provide an integrated real-time traffic and parking solution.

Current and active VIMOC Technologies Parking Management solution deployments include:

- City of New Castle (Australia)
- City of Palo Alto, CA
- City of Los Gatos, CA
- City of Redwood City, CA

Surface-Mount Sensors:

- Low-Cost
- Quick Installation
- Easy Removal and Maintenance
- Replaceable Battery Packs

Flush-Mount Sensors:

- Cored into Roadway for Discrete Installations
- Protective Cup allows for easy removal and replacement of sensor

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Image Sensor Count Stations

Landscape Computing Application

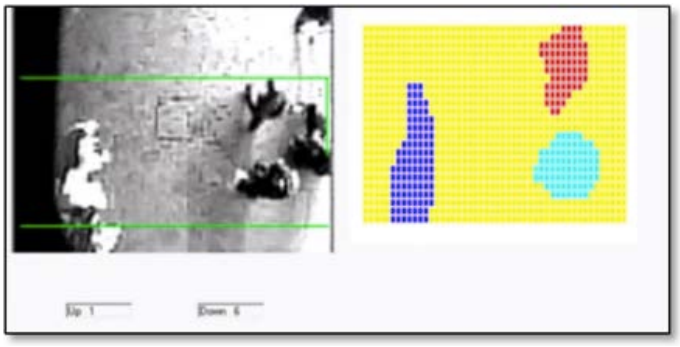
VIMOC Technologies introduced the Transportation industries first Image Sensor-based Bicycle and Pedestrian Count Station in 2014 to help transportation officials in Palo Alto, CA track use trends in the city's Bicycle Boulevard Network.

VIMOC takes advantage of off-the-shelf low-cost Image Sensors to deploy count stations. Raw data from the image sensors is processed in the field using VIMOC Technologies Landscape Computing Network. Raw Data is received in the form of "Blobs" that are then classified into Auto, Bicycle or Pedestrian count data. This Intelligent Data includes Wrong Way Bicycle Riding data, data sets previously not available within the Transportation industry.

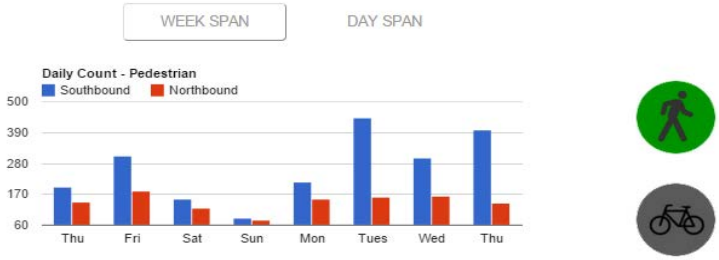
The next generation of Image Sensor Count Stations will include Vehicle Count and Classification data from the same Bicycle & Pedestrian Count Stations providing robust data sets previously not available within the Transportation Industry. Image Sensor Count Stations include optional "Near Miss" Bicycle/Pedestrian and Automobile processing capabilities.

For Retail applications, Image Sensor Count Stations help to tie Cash Register Sales to adjacent traffic. For Public Sector applications the data available from Image Sensor Count Stations can be used to make better informed decisions regarding Active Travel Modes and to help pursue Grant Funding for Active Transportation projects.

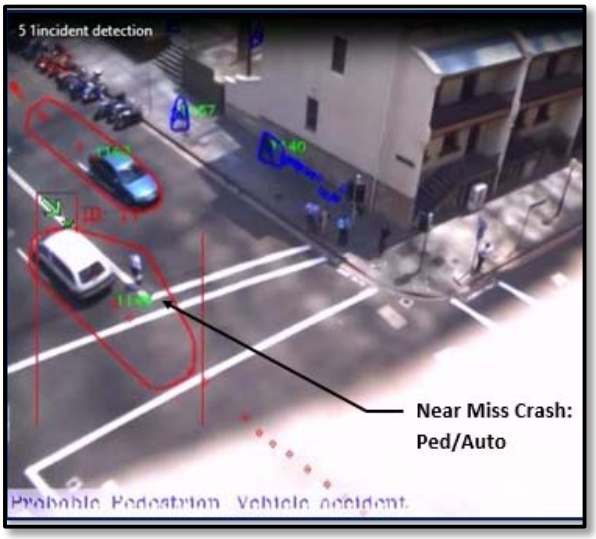
Raw "Blob" Data from Image Sensors



Bicycle/Pedestrian Count Station Data



Wrong Way Bicycle Monitoring



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