Digital Infrastructure for the Next Generation

INTEGRATED ROADWAYS, LLC
# 5G Standalone Network Deployment Challenges

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<th>Political &amp; Economic</th>
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<td>Cities hate antennas &amp; they’re expensive</td>
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<td>Edge ubiquity – every antenna needs ULL Edge</td>
<td>Cities don’t benefit from giving up ROW for Edge</td>
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<td>Multicell coverage for handoff prediction</td>
<td>Small cell deployment costs are massive per Sq M</td>
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<td>Multiple tenants on each antenna</td>
<td>If one antenna is hard to get, how about thousands?</td>
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<td>Multiple protocols on each antenna</td>
<td>$10k+ per antenna permits, $25k to $250k leases</td>
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**Cost, difficulty, speed, scalability – 5G architecture & deployment mismatch vs 1G to 4G macrocell**
Smart Pavement Small Cell Deployment

5 APs per intersection:
• One providing 100m radial coverage
• Four directional 200m coverage

• Coverage can overlap significantly
• Matches City grid
• Matches radio horizon for key frequencies
• Geometry is essentially the same for antennas at 8’−16’ overhead
• Similar LOS issues for vehicle interference
• Devices can connect to multiple antennas & choose path based on strength
• Device vector is discoverable
What is a Smart Pavement System?

Durable precast concrete sections embedded with digital technology and fiber optic connectivity for:

- Traffic data collection through in-road sensors.
- Wi-Fi, 5G, and more through antennas in the Expansion Ports.
- Edge services and cloud access.
- Wireless EV charging and assisted autonomy.
• 40% of roads in the U.S. need immediate improvement.
• Road construction practices and procurement have barely improved since the Federal Aid Highway Act of 1956.
• Cities are demanding new technologies for connected, electric, and autonomous vehicles.
• COVID and online retail have disrupted local economies and led to capital outflows from local communities to major tech hubs.
Smart Pavement Managed Services Platform

**Traffic Data**: Sensors collect anonymous vehicle, traffic, pavement condition, weather, and other data.

**In-Road “Outlets”**: Leased to partners for wireless access points (Wifi, 5g, and 4G), new sensors, Smart Cities.

**Edge Services**: High-demand on-prem service for cell carriers, content distribution networks, and more.

**Networking**: Fiber capacity available for lease to carriers & network operators.

**Autonomy**: Sensors + Edge + Digital Twin + 5G + Wi-Fi etc. provides APNT for autonomy.
Political & Economic Benefits

- Aligned value prop for municipal & DOT permitting
- Open access networks enable more competition
- Open access enables new service ideation, origination, implementation
- Deployment costs spread over numerous integrated service deliveries
- CapEx is dramatically reduced
- Telecom expenses shift to OpEx
- Updates, modification, densification, and replacement are cheap
Logistic & Technical Benefits

- Removes backhaul for local CEAV services
- Dramatic latency improvements
- Path selection enabled from overlapping cells
- Reliability from path selection
- MIMO maximization from overlapping cells

- High service predictability
- Significantly more scalable
- Enables mesh extension
- Ideal for next-gen mobility apps
Smart Pavement in Denver, CO

Brighton Blvd. Proof of Capability

• Demonstrated tech & construction
• 4 Smart Pavement Slabs
• 32 Traffic Sensors
• 16 “Expansion Ports”
• Edge server with 60 rack units
• Ready to deliver in-road AP today
Proposed Antenna Design

Proposed Design Parameters

- 4cm rad x 4cm height
- Software defined fractal antenna
- Multi-segment domed “buckyball”
- ~800 MHz to ~6 GHz
- Top edge at -0z to -2.5cm z

- Full network function virtualization
- Massively MIMO
- Supports most/all 4G, 5G, Wi-Fi bands
- Multi-protocol & multi-tenant
- Beamforming by attenuating segments
Lenexa, KS
Showcase City Center

- 10-year, $250m Smart Infrastructure Program Concession
- Deploy Digital Infrastructure over 10% to 20% of City
- City wants to demonstrate CEAV services
- In engineering now, groundbreaking soon
- Use as services development, testing, early deployment location for the next 10 years

Learn more about Showcase City Center Here
Digital Infrastructure: Multifunctional, Hyperlocal, Hyperscale

- Single-application networks are too costly & outdated architecture
- Next-gen requires distributed density + ubiquitous ULL Edge
- Digital infrastructure is sustainable, extensible, upgradeable framework
- Integrated approach enables 5G, Smart Cities, Fiber, CEAV Services
- Digital Infrastructure is our path to “a trillion connected devices.”

We believe integrated infrastructure for CEAVs represents the best compromise of outcomes, cost, and performance