U.S. Population Growth Is Forever Tied to Urbanization

Source: United Nations, Dept. of Economic & Social Affairs, Population Division http://esa.un.org/unpd/wup/CD-ROM/Default.aspx

What's an Urban Center?

- Development offering diverse multimodal spaces
  - Live (apartments, condos)
  - Work (corporate, services, co-working)
  - Play (retail, food & beverage, nightclub)
- Dense and walkable
  - Walk Score ®
- Transportation options
  - Parking
  - Mass transit, bike shares
- Not Just For Downtowns
  - Rise of "Urban Burbs" offering suburban medium-density builds

The Domain, North Austin, Texas

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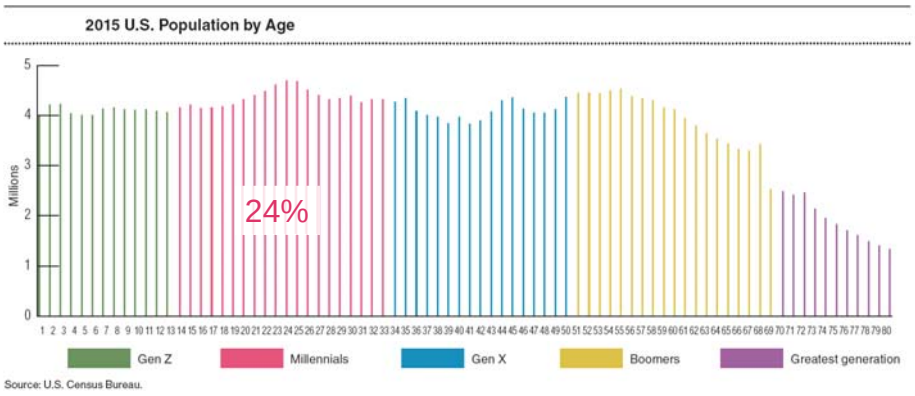
Changing Demographic and Social Patterns



Source: Urban Land Institute http://uli.org/wp-content/uploads/ULI-Documents/Emerging-Trends-in-Real-Estate-2015.pdf

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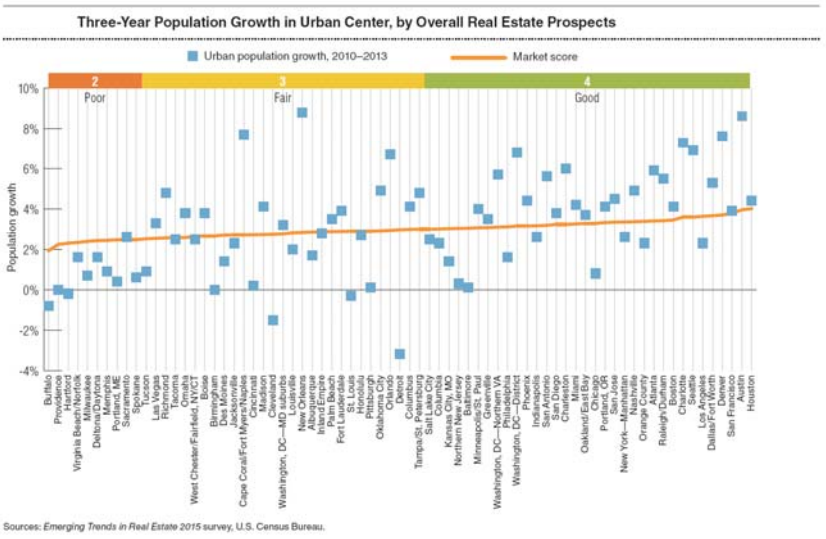
Millennials Are Flocking to Urban Centers

Millennials (62%) prefer to live in the type of mixed-use communities found in urban centers where they live in close proximity to a mix of shopping, restaurants and offices.[xvii] They currently live in urban areas at a higher rate than any other generation. This is the first time since the 1920s where the growth in U.S. cities outpaces growth outside of the cities.[xviii] And, 40 percent say they would like to live in an urban area in the future.[xvii] The "American Dream" is transitioning from the white picket fence in the suburbs to the historic brownstone stoop in the heart of the city.

Source: Neilson Millennial Report, Feb 2014
http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2014%20Reports/nielsen-millennial-report-feb-2014.pdf

Real Estate Market Prospects Tied to Urban Centers



Source: Urban Land Institute http://uli.org/wp-content/uploads/ULI-Documents/Emerging-Trends-in-Real-Estate-2015.pdf

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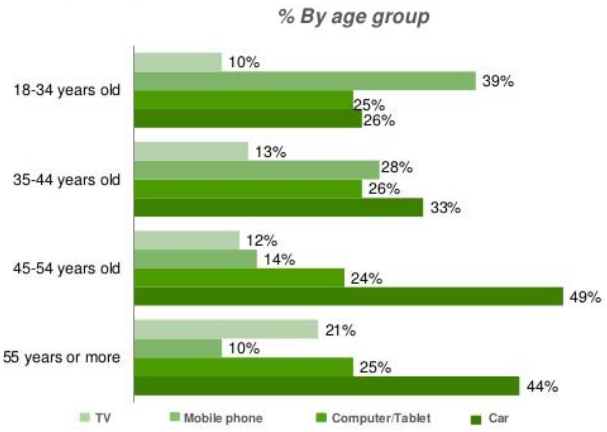
Millennials Place Importance on Connectivity

From a 2014 Survey Commissioned by Zipcar:

In your daily routine, losing which piece of technology would have the greatest negative impact on you?



Source: http://www.slideshare.net/Zipcar_PR/millennials-2013-slide-share

Communication Networks in Urban Centers – Mobile

- Coverage initiated through macro site deployment on exterior location (rooftop)
  - Low-frequency spectrum required to penetrate buildings
- Capacity added through ancillary exterior building locations
  - Building interference, attenuation between sites, radio interface constraints
- Small cells, distributed antennas, and Wi-Fi deployment as an afterthought

- Networks fully integrated with developer and city infrastructure plans
  - Dedicated cable runs, power connectivity, concealed or "plain-sight" antenna mounting, wired backhaul availability
- Small cells offering integrated 3G, 4G, Wi-Fi solutions
- Goal is to eliminate unsightly, ad-hoc, and occasionally "redundant" buildout of networks

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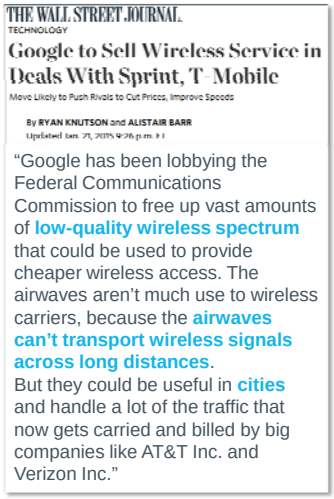
Communication Networks in Urban Centers – Mobile (cont.)

- Does density disfavor the incumbents?
  - Small cells operate with limited range
  - Limited range synonymous with high-frequency spectrum
  - No longer requires expensive "beach-front" spectrum
  - "Flip the script"
    - » Wi-Fi network provider first, cellular network as backup
    - » Is this Google's strategy with the MNVO deals?
- Implications
  - Traditional mobile infrastructure is inefficient at serving dense, walkable centers
  - Access for new entrants is last major impediment
    - » As system builds gradually shift away from providers and towards developers and systems, anyone can "pay to play"



THE WALL STREET JOURNAL.
TECHNOLOGY

Google to Sell Wireless Service in Deals With Sprint, T-Mobile

Move Likely to Push Rivals to Cut Prices, Improve Speeds

By RYAN KNUTSON and ALISTAIR BARR

"Google has been lobbying the Federal Communications Commission to free up vast amounts of **low-quality wireless spectrum** that could be used to provide cheaper wireless access. The airwaves aren't much use to wireless carriers, because the **airwaves can't transport wireless signals across long distances**. But they could be useful in **cities** and handle a lot of the traffic that now gets carried and billed by big companies like AT&T Inc. and Verizon Inc."

Communication Networks in Urban Centers – Wireline & Cable

- Economics for wireline & cable are stronger in urban centers.
  - Cost per unit passed is cheaper as density increases
    - » Cheaper to deploy fiber to a single MDU (vs a suburban single family neighborhood)
    - » Cheaper to leverage existing infrastructure conduit or micro-trench (vs trenching miles of suburban dirt)
    - » Rationale behind AT&T Project VIP's goal of fiber to an additional 1 MM MDU's
  - Data caps on wireless still shaping mobile usage patterns
  - For businesses, enterprise-level security and provisioning starts here

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Communication Networks in Urban Centers – Wireline & Cable (cont.)

- But, the economics are ripe for change.
  - Cities are getting smarter about designing for multiple providers
  - Some aggressively pushing developers or building owners to install fiber as part of new builds, and for redevelopment, eliminating the previous generation copper/coax infrastructure
- Goal is to facilitate end-to-end Gigabit capability
  - Incumbents' Fiber-to-the-node or DOCSIS 3.0 network will not be enough
- Wired Backhaul for Mobile Providers
  - All these small cells require backhaul with large bandwidth capabilities
  - Incumbents that also double as wireless carriers can lose a key defensive mechanism as "middle-mile" provider

FIGURE 16: SEPARATE CONDUIT CONSTRUCTION OUTSIDE UNIFORM BANK

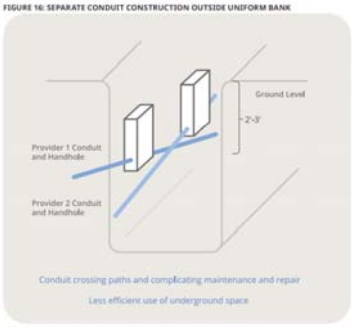
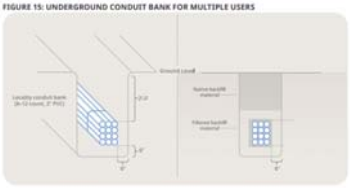


FIGURE 15: UNDERGROUND CONDUIT BANK FOR MULTIPLE USERS



Source: "GIGABIT COMMUNITIES: Technical Strategies for Facilitating Public or Private Broadband Construction in Your Community." http://www.ctcnet.us/wp-content/uploads/2014/01/GigabitCommunities.pdf

Is there a future for traditional cell towers in cities, or are they resigned to the pasture?

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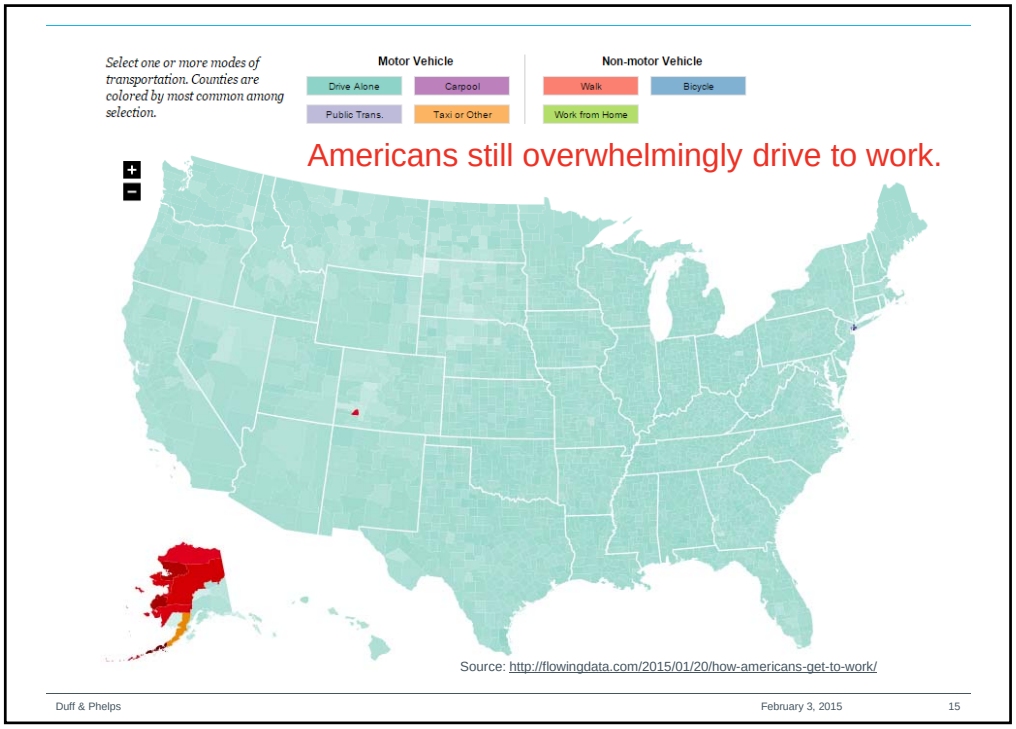

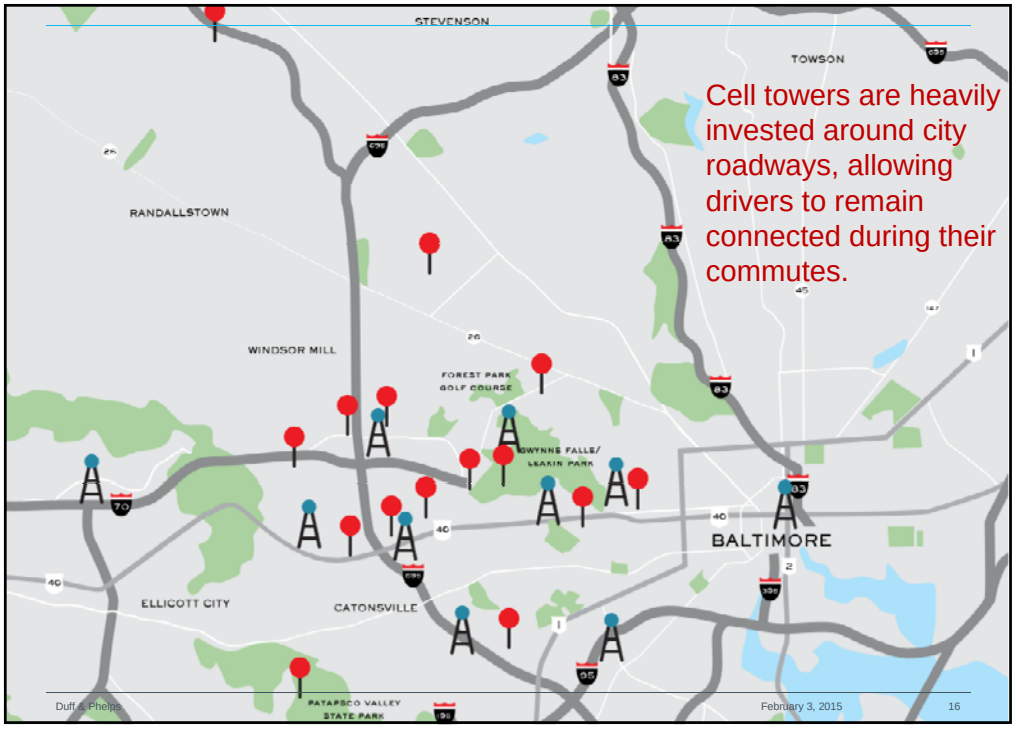

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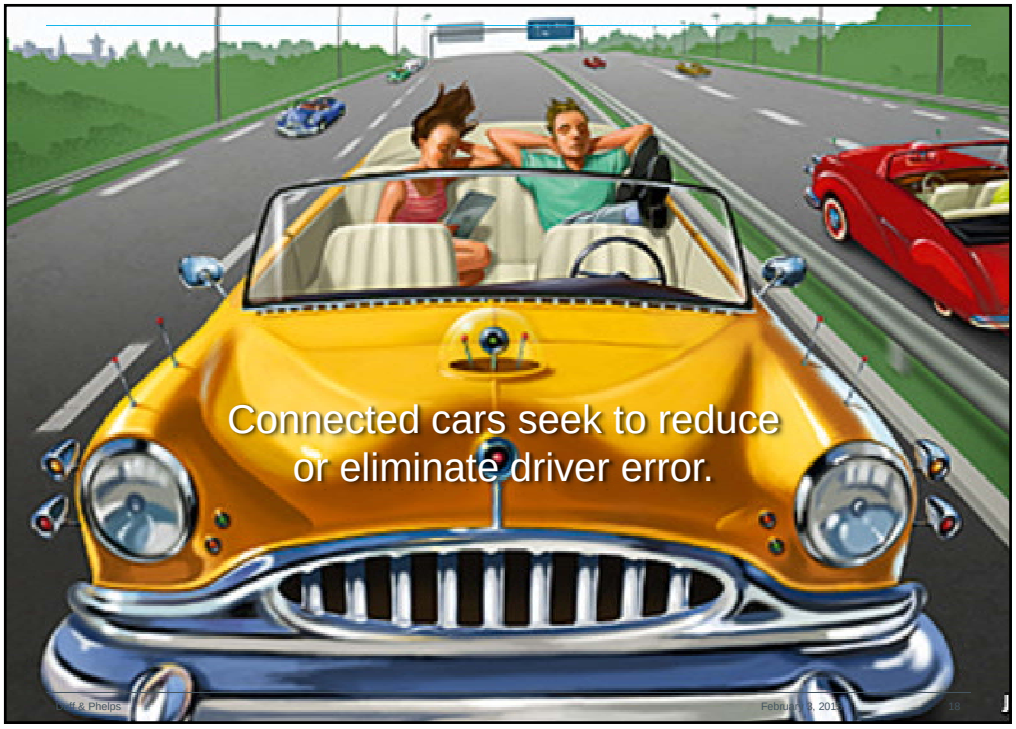
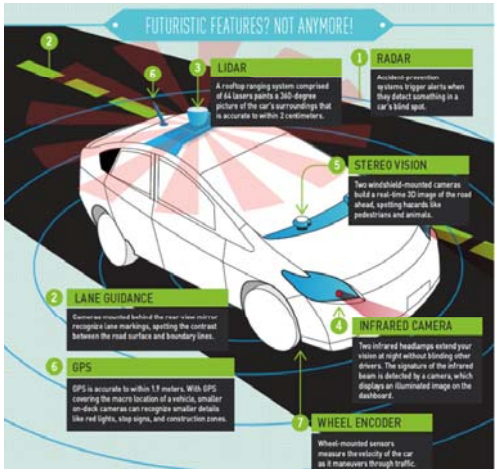
Driver Error Is Responsible
for 93 Percent of All Crashes.
Source: http://cyberlaw.stanford.edu/blog/2013/12/human-error-cause-vehicle-crashes


Connected cars seek to reduce
or eliminate driver error.

Technology Solutions to Reduce Vehicle Accidents

- Connected Cars
  - Direct short-range communication between vehicles and highway beacons to help them coexist
  - Useful tools but still require a human driver
- Autonomous Cars
  - Currently, driverless car technology adds $70,000 to $100,000 to the cost of a vehicle, with mass-market projections of $3,000 to $5,000 [1]
  - Google expects driverless cars to be on public roads in 2 to 5 years [2]
- NHTSA estimates short-range communication technology could prevent, or reduce in severity, as many as 80 percent of crashes involving non-impaired drivers. About a third of highway fatalities are alcohol-related. [3]



[1] http://www.washingtonpost.com/local/trafficandcommuting/driverless-cars-15-things-you-need-to-know/2014/08/25/786c6fbc-d79b-11e3-95d3-3bcd77cd4e11_story.html
[2] http://www.foxnews.com/leisure/2015/01/15/google-expects-public-in-driverless-cars-in-2-to-5-years/
[3] http://www.bloomberg.com/news/2013-05-30/google-s-self-driving-cars-get-boost-from-u-s-agency.html

What Do These Vehicles Require Beyond the Onboard Gizmos?

- The technical term for the infrastructure is **Vehicular communication system.** [1]
  - Both vehicles and roadside units are the communicating nodes, providing each other with information, such as safety warnings and traffic information.
  - Both are dedicated short-range communications (DSRC) devices
  - DSRC works on the 5.9 GHz band with bandwidth of 75 MHz and an approximate range of 3,000 feet
  - Expected to support both private data communications and public (i.e. safety) communications, with higher priority given to the public side.
  - Developed in part of intelligent transportation systems (ITS) which obviously relies on wireless communications but also wired backhaul of the roadside units.
- You also need
  - GPS service
  - Mobile data service (commercial carriers)
  - Mapping service subscription such as Google
  - Other potential cloud services like diagnostics (OnStar, Verizon Vehicle) and security

[1] http://en.wikipedia.org/wiki/Vehicular_communication_systems

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Open Questions on Intelligent Transportation Systems

- Will these systems be build from scratch or will they utilize existing mobile infrastructure on highways?
  - Spectrum frequencies are radically different, with different propagation characteristics
    - » Existing mobile carriers: 700 MHz to 3 GHz
    - » DSRC: 5.9 GHz (currently)
    - » With distance limitations, DSRC may be inadequate at these locations without additional infill investment
    - » If you're going to infill, would you prefer to build the whole thing on dedicated infrastructure?
  - Tower backhaul is already there
    - » Does it need to be bulletproofed?
    - » Does it need to be fiber?
    - » New revenue opportunities for wireline incumbents
      - » ...With regulatory strings attached?

[1] http://en.wikipedia.org/wiki/Vehicular_communication_systems

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