5G Multilink for Connected Cars and Autonomous Driving

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- Founded in 2006
- 100s of Top Tier Customers in over 80 countries, serving the Broadcast & Online Media markets
- Inventor and patent holder of “live video over bonded cellular network technology”
- Funded by Pitango Venture Capital, Carmel Ventures, Canaan Partners and Lightspeed Venture Partners
- Partner in EU research projects in 5G cellular, Horizon 2020, FP7, …

50%+
global market share

30+
Patents

3,000
end customers

LiveU is driving the live video revolution, providing 4K HEVC live video streaming solutions for broadcast, sports and online media markets

3000+ CUSTOMERS IN 100 COUNTRIES & GROWING

NEWS

SPORTS

BRANDS

ONLINE

FROM TRADITIONAL TV STATIONS TO ONLINE MEDIA AND USER-GENERATED CONTENT

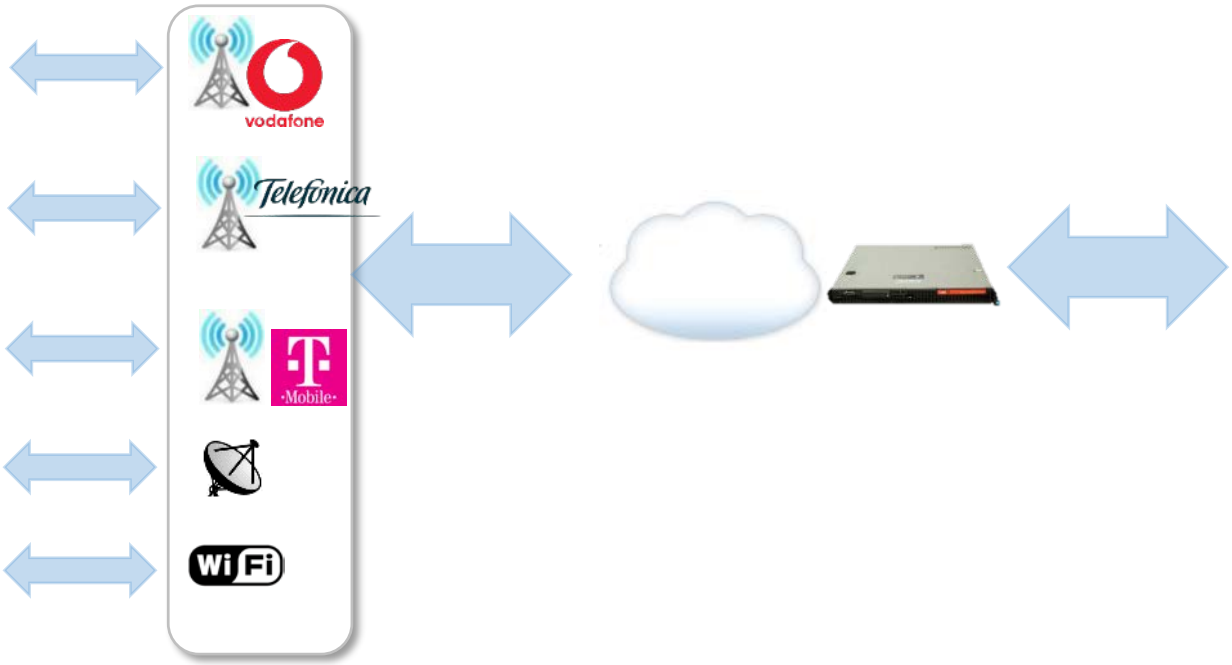
LiveU's Unique Bonding Technology

LiveU multi-link bonding software (from an App to a Dedicated device)

Multiple 5G/LTE/3G, Any IP network

Physical/Cloud Server

Public Internet



Capacity: Aggregates ALL detected networks

Reliability: Dynamic routing and load-balancing of video and data

Transparency: Network and protocol agnostic

The Benefits of Bonding

BONDING = Splitting the encoded video or data over MULTIPLE CELLULAR OPERATORS, MODEMS, TOGETHER, AT THE SAME TIME

Also supports SATCOM (Ka/Ku, BGAN) – standalone hybrid, bonded with cellular

Capacity: Aggregates ALL detected networks: max bandwidth all the time

Reliability & Availability: All networks, transparent simultaneous utilization

Mobility: Man/vehicle-carried, from anywhere, including from moving vehicles and even helicopters

Audio/Video: Sustainable continuous quality live video

Economic: Uses any commercially available network(s): 3G, 4G/LTE, future 5G, SATCOM, WiFi

Main Verticals

Broadcasting	• Audio/Video ingestion/contribution over single and multiple IP links (cellular, satellite, others) • News gathering, breaking news, Sports and entertainment
Online	• Direct to Online, Broadcast- Quality Live Video for the Online & Social Media Markets • Sports, entertainment
Autonomous Vehicles	• Real time communication solution for teleoperation and remote assistance • A/V, data and control channels
Public Safety, HLS	• Real time quality, reliable video link for situational awareness, police, border protection

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REMOTE ASSISTED DRIVING and MONITORING

The need for remote assisted driving

- Challenging scenarios for the AI system:
  - Unmapped constructions zones with problematic markings
  - Police officials that use voice or hand signals
  - Bad weather conditions
  - Rare scenarios for the AI
- Problems in the vehicles or sensors
- Level 3 (& 4) – moving from AD to human driving
- Law requirements
- Passenger safety & trust
  - Increasing trust and passengers confidence
  - Audio and video

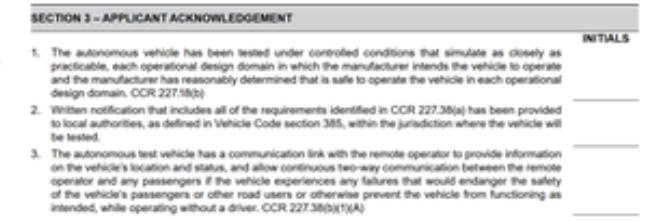


Waymo CEO John Krafcik: self-driving cars will require driver assistance for many years to come, I don't envision a day when the technology operates in all weather conditions and without some sort of user interaction (Bloomberg, 14 November 2018)

California permit requirements for self driving cars

"(b) "Autonomous test vehicle" is a vehicle that has been equipped with technology that is a combination of both hardware and software that, when engaged, performs the dynamic driving task but requires a human test driver **or a remote operator** to continuously supervise the vehicle's performance of the dynamic driving task."

- Second Modified Express Terms, Title 13, Division 1, Chapter 1, Article 3.7 – Testing of Autonomous Vehicle


SECTION 3 – APPLICANT ACKNOWLEDGEMENT

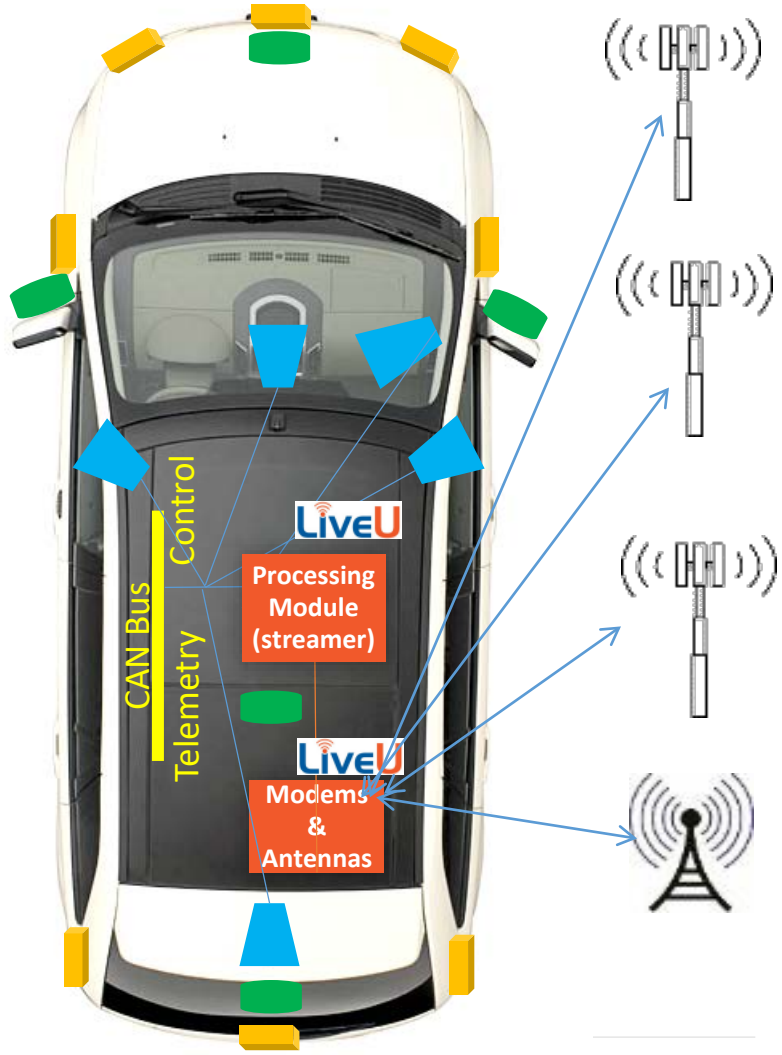
INITIALS

1. The autonomous vehicle has been tested under controlled conditions that simulate as closely as practicable, each operational design domain in which the manufacturer intends the vehicle to operate and the manufacturer has reasonably determined that is safe to operate the vehicle in each operational design domain. CCR 227.18(b)
2. Written notification that includes all of the requirements identified in CCR 227.38(a) has been provided to local authorities, as defined in Vehicle Code section 385, within the jurisdiction where the vehicle will be tested.
3. The autonomous test vehicle has a communication link with the remote operator to provide information on the vehicle's location and status, and allow continuous two-way communication between the remote operator and any passengers if the vehicle experiences any failures that would endanger the safety of the vehicle's passengers or other road users or otherwise prevent the vehicle from functioning as intended, while operating without a driver. CCR 227.38(b)(1)(A)

How to Overcome Rare Scenarios?

Remote operation: Driving, Controlling & Monitoring

- Ultra Low latency: RTT <100msec
  (Glass to glass + return control data)
- Multiple video feeds (6 cameras) +
  other sensors (LiDAR, RADAR) + 2 way data
  (telemetry, control, Internet Access) + Audio
- Integration to vehicle and remote assistance center
- Security (in-car and server-side)



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And 5G?

Does 5G Remove the Need For Bonding?

- NO
  - Bonding still a critical resiliency ingredient: mitigation
    - Availability
    - Sustainability
    - Congestion
    - Mitigate peak-to-deep fluctuations
    - Adaptive video
  - Important in situations where “true” 5G is not available
    - Rural, in-building, on the move, urban-blocked,
    - During build-up (years)
    - Where 5G will fall back to existing frequencies
  - Cross-Company bonding still important
    - network failure
    - network coverage

Quantities (IoT, vehicles) & **Volume** (video, high res), vs. **ROI** vs. **Spectrum** and deployment

Does 5G Reduce the Need For Many Modems?

- **Maybe**
  - 10x more bandwidth per modem sounds great (to LiveU also!)
  - But the networks are moving to 5G for big reasons:
    - IoT, UGC, video, …
    - 10x more bandwidth distributed across 10x more devices results in 1x bandwidth
  - Expect speed increases for 5G, but below the “marketing hype”
  - LiveU bonding will always tune to real-world performance

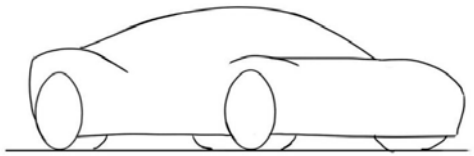
Will 5G Enable New Features?

- **Absolutely**
  - NR: 4K UHD, more cameras (automotive), faster upload
  - Network slicing: eMBB for high bandwidth SLA
  - URLCC: lower latency for automotive teleoperation
  - Broadcast: HD maps? I2V
  - LiveU multi-slice: bond two slices for aggregated advantages

  - Enabling features not possible today, and LiveU can’t wait to collaborate on them with you!

Summary

- **5G** is still cellular technology and deployed networks
  - Reliability, coverage, in-buildings, rural, mobility, fluctuations, interferences, spectrum allocations/availability, ROI, IoT, congestions,
- **Bonding** at the application layer will be required also when 5G is here
  - Verticals: Broadcasting, HLS, Automotive teleoperation and remote-assistance
  - Algorithmic and device adaptations
  - New capabilities due to 5G NR (bandwidth), network slices (SLA), URLCC (lower latency)



THANK YOU!

For more information
www.liveu.tv

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