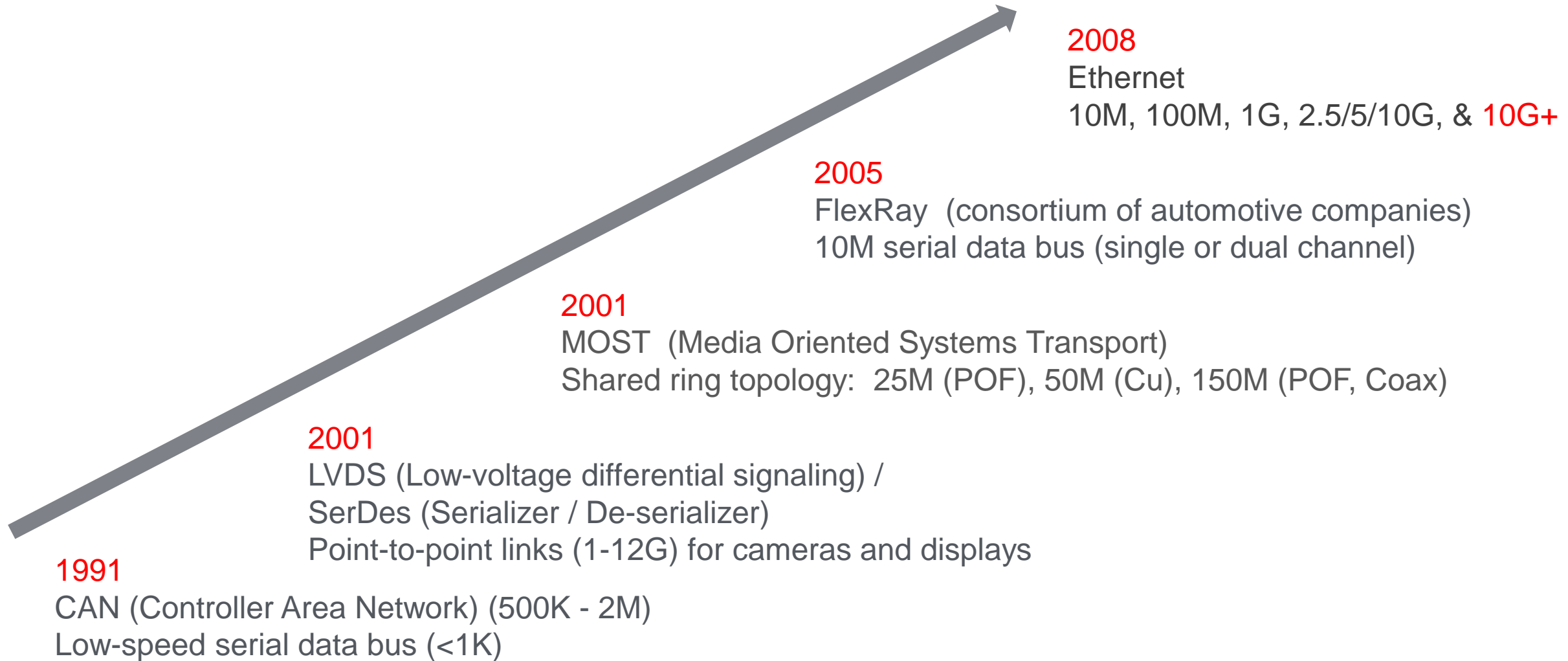# Trends in Automotive Networks
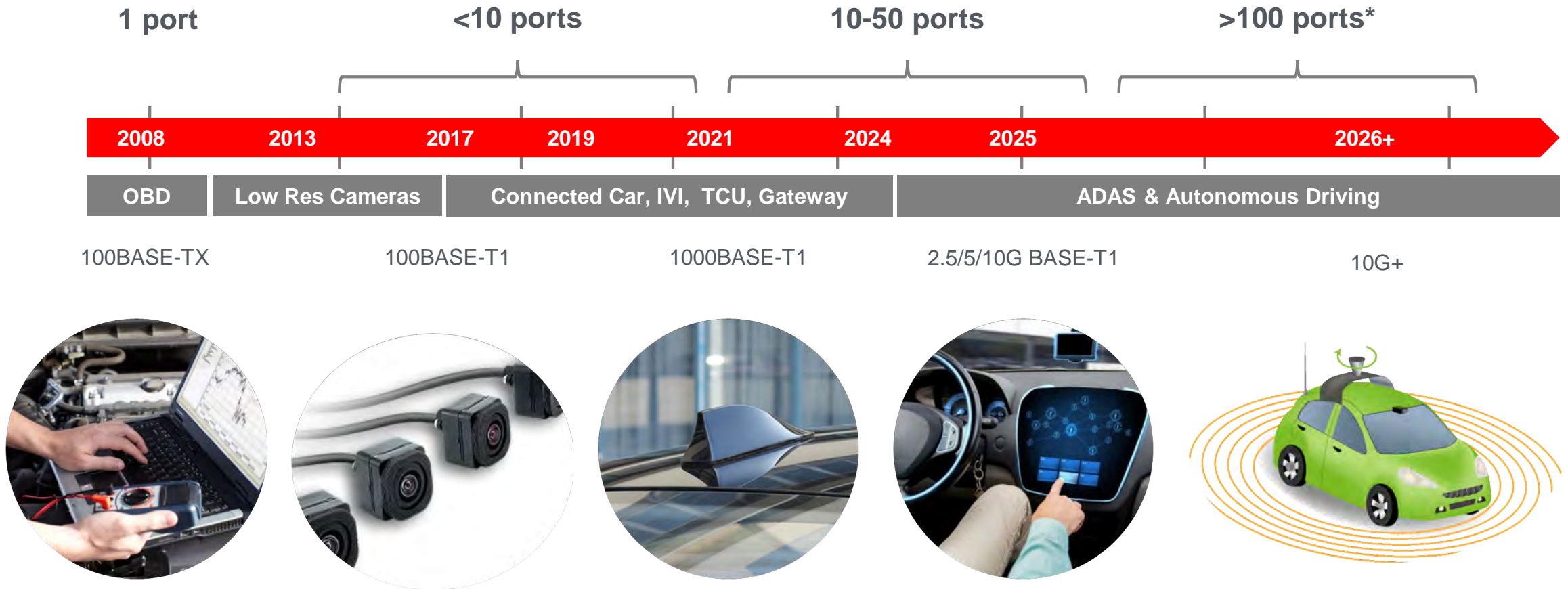
Steve Carlson

High Speed Design, Inc.

In-Car Automotive Ethernet Bandwidth

- Modern automobiles have complex electronic systems that require high-speed networks

- Automotive networks are converging on Ethernet from top to bottom

- Recent trends in autonomous vehicle architecture have radically increased the bandwidth required

- Test vehicles have seen internal traffic in the ~ 4 TB/per average day range

Automotive Networking Evolution

2008
Ethernet
10M, 100M, 1G, 2.5/5/10G, & 10G+

2005
FlexRay (consortium of automotive companies)
10M serial data bus (single or dual channel)

2001
MOST (Media Oriented Systems Transport)
Shared ring topology: 25M (POF), 50M (Cu), 150M (POF, Coax)

2001
LVDS (Low-voltage differential signaling) /
SerDes (Serializer / De-serializer)
Point-to-point links (1-12G) for cameras and displays

1991
CAN (Controller Area Network) (500K - 2M)
Low-speed serial data bus (<1K)

Trends in Automotive Ethernet

1 port	<10 ports			10-50 ports		>100 ports*

2008	2013	2017	2019	2021	2024	2025	2026+

OBD	Low Res Cameras	Connected Car, IVI, TCU, Gateway		ADAS & Autonomous Driving	

100BASE-TX   100BASE-T1   1000BASE-T1   2.5/5/10G BASE-T1   10G+

*Average Ethernet ports per vehicle

Trends in Automotive Ethernet Bandwidth

- 2012: Need for 1 Gb/s --- 802.3bp-2016 1000BASE-T1

  - Advanced Driver Assist Systems (ADAS)

    - Adaptive cruise control

    - Lane-departure warnings

    - Adaptive braking

    - Medium-resolution cameras

    - Infotainment

    - Ethernet backbones between Electronic Control Units (ECU)

    - Level 0 to Level 2 autonomous driving

Trends in Automotive Ethernet Bandwidth

- 2016: Need for 2.5,5 and 10 Gb/s --- P802.3ch Multi-Gig

  - High-performance ADAS

  - More high-resolution, high-frame rate cameras

  - Faster backbones

  - Infotainment, Wi-Fi and cellular backbone

  - Sensor fusion (cameras, radar, LIDAR, sonar)

  - Level 1 to Level 3 autonomous driving

Trends in Automotive Ethernet Bandwidth

- 2019: Need for greater than 10 Gb/s, e.g. 25 & 50 Gb/s

  - Ultra-high resolution cameras

  - Redundant backbone for zonal architecture

  - Flight data recorder

  - Infotainment, Wi-Fi and cellular backbone

  - Software migration between zonal ECUs

  - Sensor fusion (cameras, radar, LIDAR, sonar)

  - Level 3 to Level 5 autonomous driving

  - Level 5 is a fully driverless car

Automotive Ethernet Port Forecast

- Global automobile sales are around 80 million passenger cars (cars, light trucks, SUV) per year for 2018

  - This has been relatively constant since 2016

  - Post – 2026, it is expected that the average number of Ethernet ports per car will be greater than 100

    - Autonomous cars are driving the increase

    - The number of ports per car is a function of vehicle complexity

  - The total number of Ethernet ports could be ~ 800 million/year by the mid-2020s

Automotive Ethernet Forecast

- The number of ports and data rates in the car don't provide any information on data in and out of the car---the impact of connected and autonomous cars on the global network is <u>unknown</u> at this time

Much of the material in this presentation was taken from http://www.ieee802.org/3/cfi/0319_1/CFI_01_0319.pdf