

Th3C-2

# Seatbelt-Embroidered Metamaterials for In-Vehicle Vital Sign Monitoring

Qihang Zeng<sup>#</sup>, Xi Tian<sup>\$</sup>, Dat T. Nguyen<sup>\*</sup>, Xin Yang<sup>#</sup>, Patrick Chia<sup>\$</sup>,  
Changsheng Wu<sup>\$\$^</sup>, John S. Ho<sup>#\$\*</sup>

<sup>#</sup>Department of Electrical and Computer Engineering

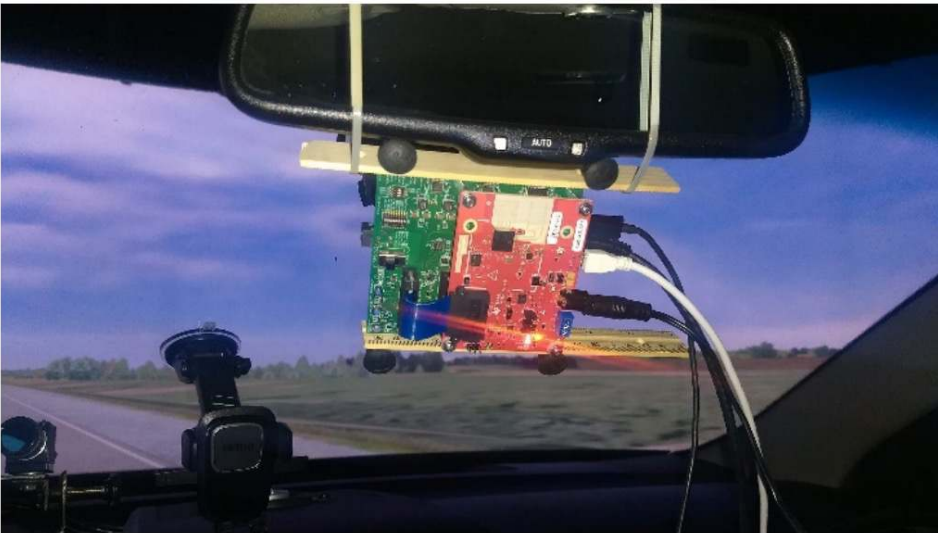
<sup>\$</sup>SIA-NUS Digital Aviation Corporate Laboratory

<sup>\*</sup>Integrative Sciences and Engineering Program, NUS Graduate School

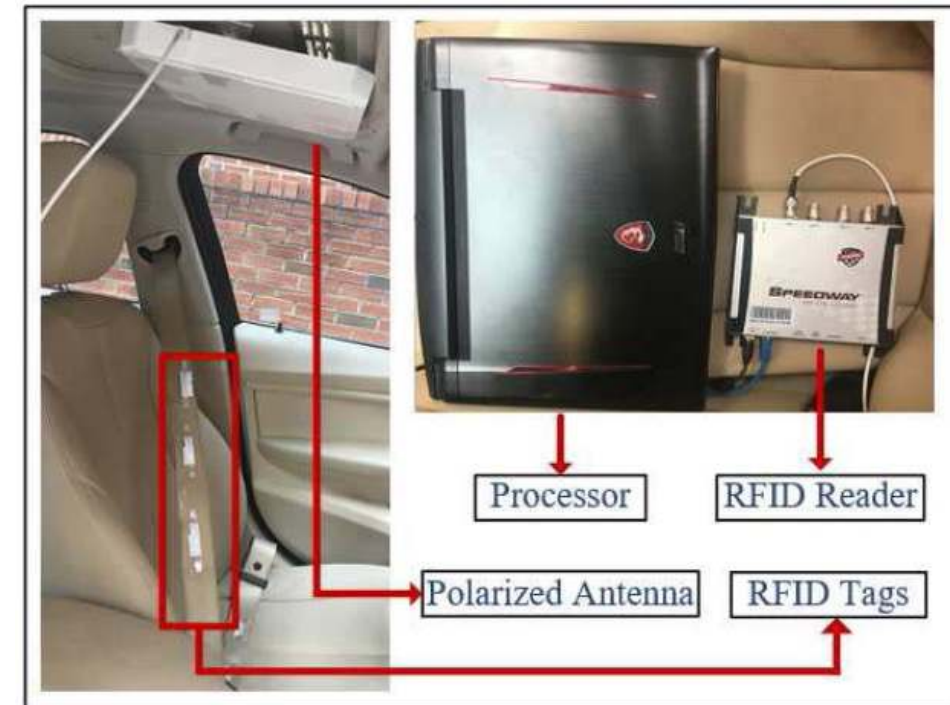
<sup>^</sup>Department of Materials Science and Engineering  
National University of Singapore, Singapore

- Introduction
- Seatbelt-embroidered metamaterials
- Embroidered metamaterial design
- Experimental results
- Conclusion

- Fatigue, asthma, stroke

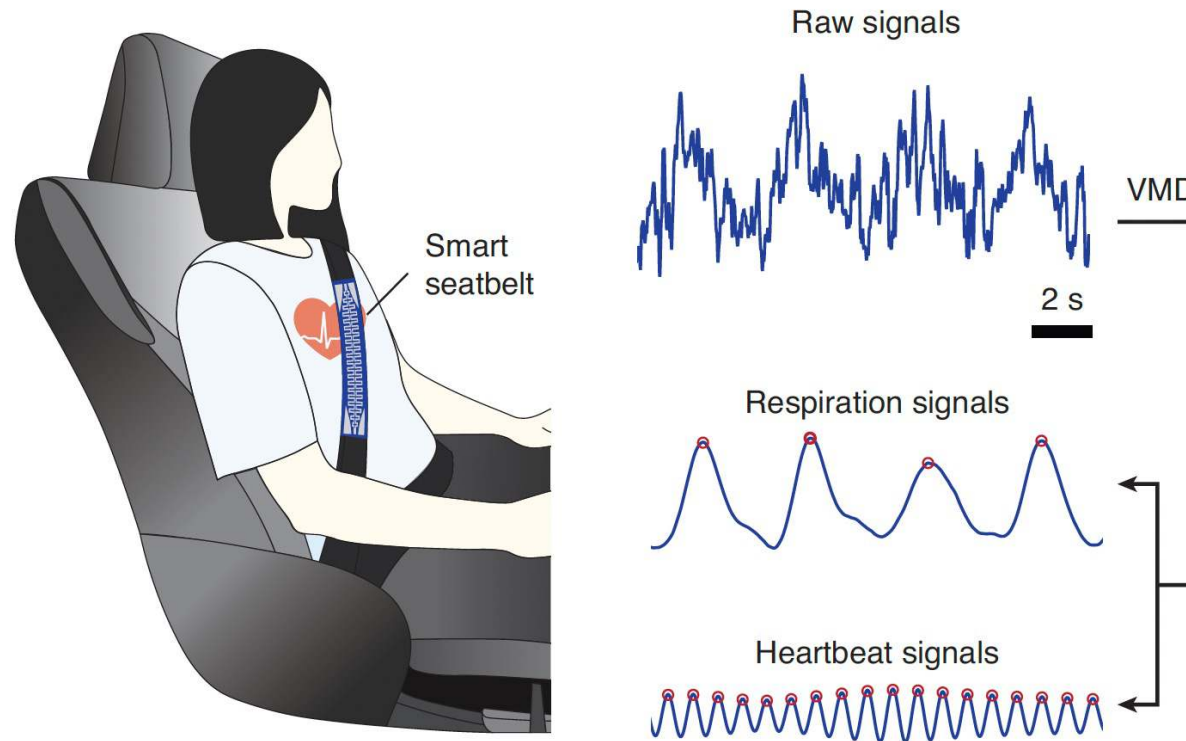


C. Schwarz, et al. in Proc. IEEE Radar Conf., May 2021

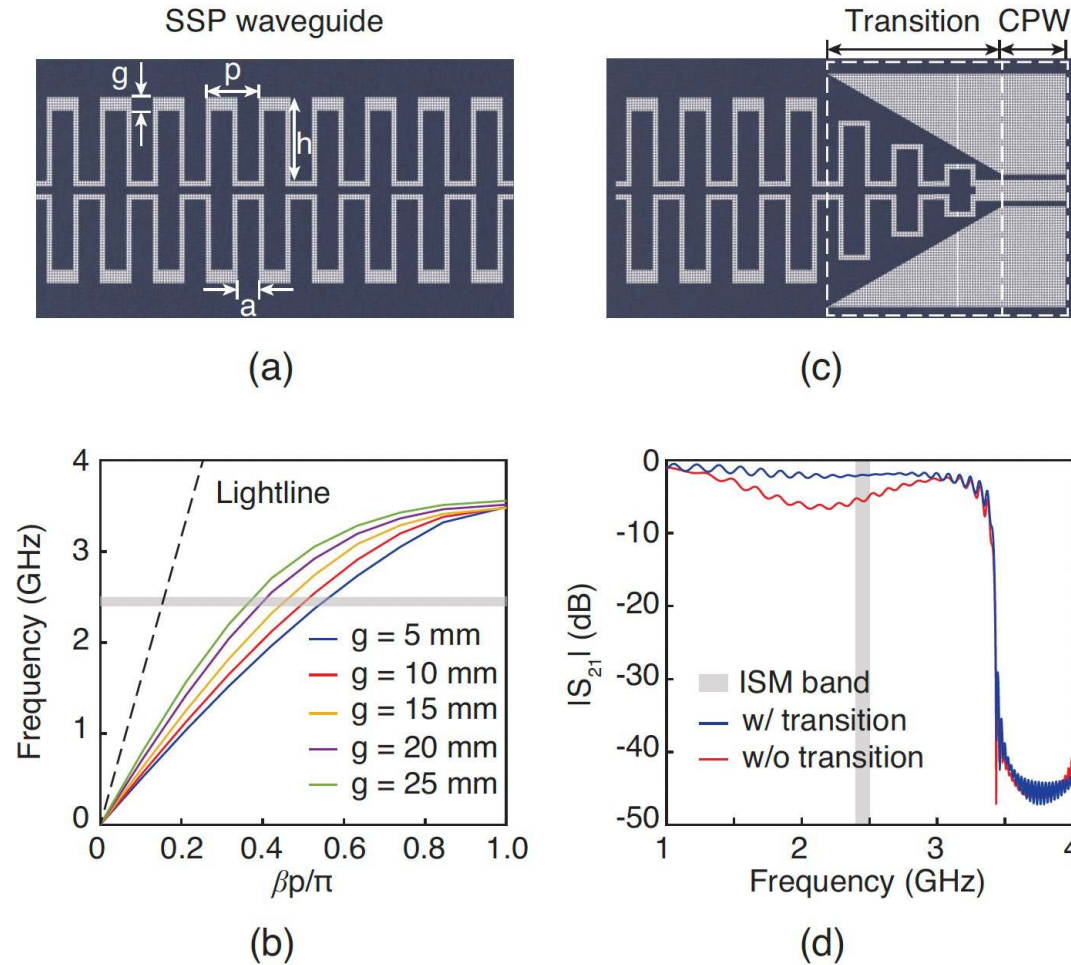


Yang, C., et al. *IEEE J Sel Area Comm* **39**, 500–512 (2021).

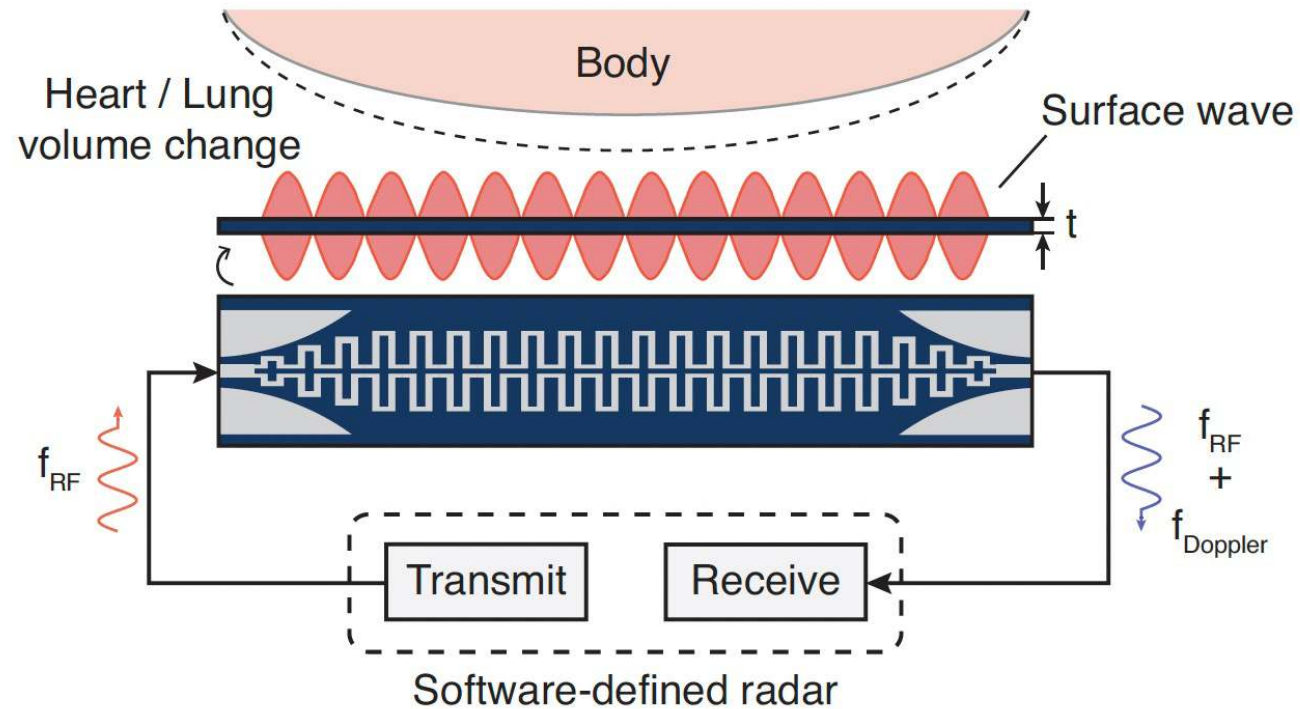
- Sensor integration



- Schematics of the metamaterials

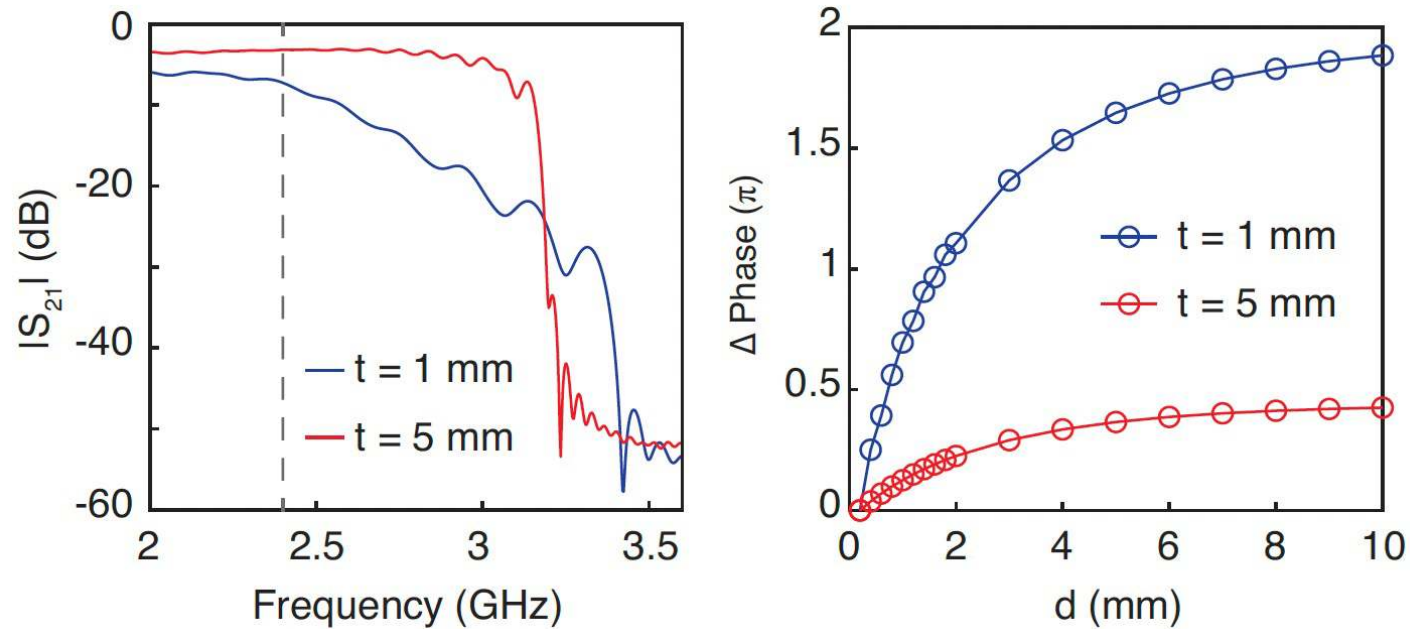


- Sensing mechanism and system design



# Embroidered metamaterial design

- Simulated transmission spectra and phase differences



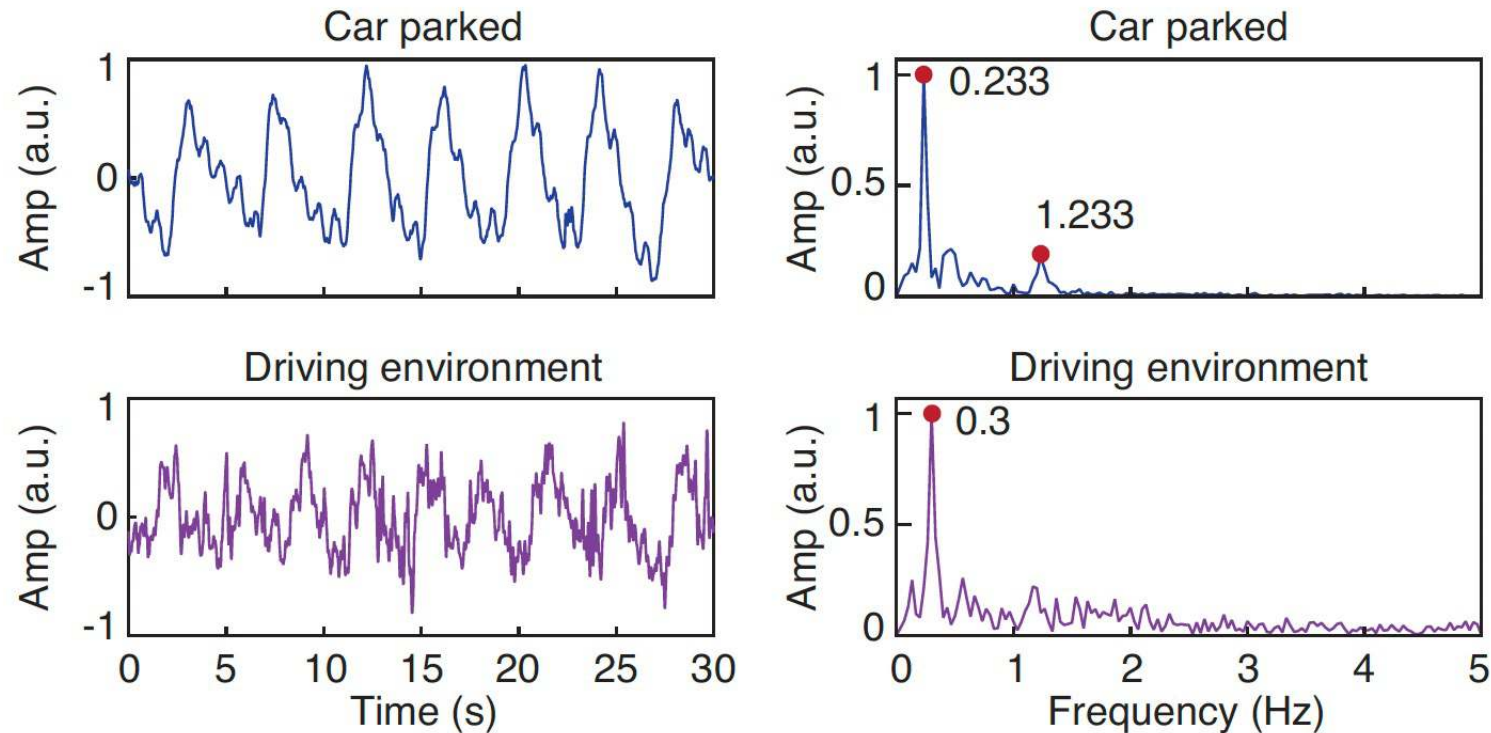
# Experimental results

- Experimental setup inside a vehicle

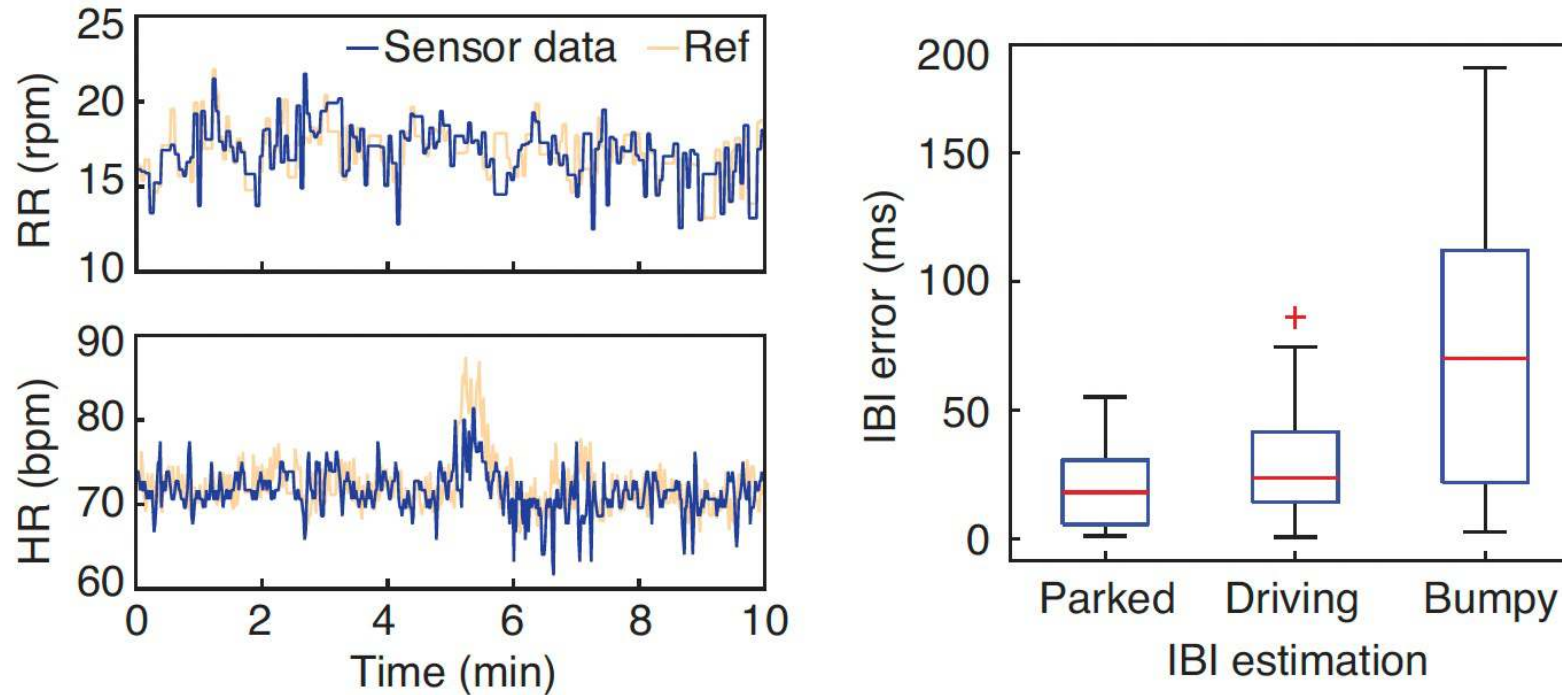


# Experimental results

- Example time-domain waveforms of the sensor outputs



- Extracted respiratory rate and heart rate



# Conclusion

- Embroidered metamaterial for in-vehicle physiological monitoring
- Seamlessly integrated into seatbelts
- Unobtrusive and continuous tracking of respiration and heartbeat
- Experiments in real driving environments