

**Ph.D. in Information Technology
Thesis Defense**

October 30th, 2026

At 02:00 p.m.

Room Schiavoni - Building 20A

Lorenzo Italiano – 38th Cycle

**SMART ROAD INFRASTRUCTURES FOR CONNECTED AND AUTOMATED
VEHICLES: LOCALIZATION, PRIVACY AND SERVICES**

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Abstract:

Connected and automated vehicles (CAVs) are expected to play a central role in the evolution of mobility systems, enabling safer, more efficient, and sustainable transportation. Their deployment requires cooperation among vehicles, roadside infrastructure, network entities, and service platforms through reliable communication, shared situational awareness, and data-driven decision-making. In this context, connectivity is a fundamental enabler for cooperative perception, infrastructure-assisted driving, and advanced mobility services. Nevertheless, despite decades of research and standardization, the large-scale adoption of vehicle-to-everything (V2X) technologies remains limited, highlighting the need for effective methodologies and compelling services that demonstrate tangible benefits by leveraging smart road infrastructure. This thesis investigates advanced technologies and innovative services for connected and automated mobility, focusing on fifth generation (5G) and beyond systems, smart road infrastructure, and V2X applications. It adopts a holistic approach spanning different layers of the connected mobility ecosystem, from physical-layer techniques and privacy-preserving mechanisms to application-level services for road operators and end users. Combining theoretical analysis, simulations, real-world datasets, and experimental field trials, the thesis aims to bridge the gap between technological capabilities and their practical exploitation in future smart road deployments. The first part focuses on high-accuracy positioning (HAP) technologies to meet the stringent requirements of CAVs and cooperative intelligent transportation systems (C-ITS). While global navigation satellite systems (GNSS) remain the primary source of location information, their performance degrades in challenging environments such as tunnels, urban canyons, and complex highway infrastructure. To overcome these limitations, the thesis investigates radio-based localization techniques leveraging 5G and beyond networks, exploiting their wide coverage, large bandwidths, multi-antenna capabilities, and native positioning support. Standardized 5G positioning solutions, hybrid 5G-GNSS approaches, and infrastructure-efficient localization methodologies are analyzed. A central contribution concerns single-anchor localization in harsh and GNSS-denied environments, with particular emphasis on tunnels, where satellite positioning is unavailable and multipath propagation dominates. Rather than treating multipath solely as an impairment, the proposed approach exploits its geometrical information to localize vehicles using a single roadside anchor, reducing the need for dense and costly infrastructure deployments. The thesis also addresses the privacy risks associated with high-accuracy radio

localization, which may enable unauthorized user tracking. To mitigate these threats, physical-layer privacy-preserving mechanisms based on pilot and precoder design are developed to perform defensive spoofing against malicious localization attempts while preserving communication performance. Finally, the thesis investigates advanced V2X services to enhance the practical value and adoption of connected mobility technologies. Moving beyond conventional safety messaging, it proposes and validates, using real-world data, services for dangerous goods vehicle management, anomalous driving behavior detection, and operational design domain awareness. By exploiting infrastructure-generated data, vehicle connectivity, and field measurements, these applications provide tangible benefits for road operators and drivers, including in challenging environments such as tunnels. Overall, this thesis contributes to the evolution of smart road infrastructures by combining enabling technologies with service-level applications. The presented contributions demonstrate how cellular connectivity, radio localization, privacy-aware signal design, and advanced V2X services can jointly support future CAV deployments, bridging physical-layer innovations and application-level services and transforming 5G and beyond networks from communication infrastructures into active enablers of connected and automated mobility.

PhD Committee

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