CARNATIONS

Center for Assured & Resilient Navigation in Advanced Transportation Systems

Illinois Institute of Technology

Center Type — Tier 1
**Focus Area — Reducing Transportation Cybersecurity Risks**

Center Vision and Objectives

The Center for Assured and Resilient Navigation in Advanced Transportation Systems (CARNATIONS) is a new U.S. Department of Transportation (USDOT) Tier-1 University Transportation Center (UTC) confronting cyber-physical risks affecting Positioning, Navigation, and Timing (PNT). The Center is explicitly focused on Resilient PNT (R-PNT) and relevant vehicle-to-everything (V2X) communications for all modes of surface transportation.

R-PNT is at a crucial juncture for transportation. Transportation systems have become heavily reliant upon PNT, and the number of occurrences of PNT interference is rising. Jamming and spoofing have caused major disturbances at civilian ports and airports. Interference events can instigate delays and traffic jams on roadways, railways, and waterways, and create dangerous situations for all modes of transport. CARNATIONS is designed to enable the fundamental transformations to infrastructure and technology that will make the U.S. surface transportation systems resilient to existing and impending interference and cyber threats, including those affecting future automated systems.

Today's growing threat of PNT and V2X interference must be addressed. Only then will it be possible to create opportunities for tomorrow's transformation towards a safer, more energy-efficient and cost-effective transportation system. CARNATIONS pursues this goal while also providing support for underserved communities through outreach and education, and restoring trust in government through evidence-based policy-making by developing standards and best practices that promote the responsible use of PNT in transportation.

CARNATIONS' primary research goals are to develop technologies to toughen, augment, and protect transportation PNT against cyber-physical disruption and manipulation. The Center provides resources for transferring these emerging technologies to public agencies and industry through partnerships, dissemination, and leadership in standardization bodies. CARNATIONS also runs a multi-university curriculum to help prepare current and future transportation professionals to tackle R-PNT challenges in transportation.
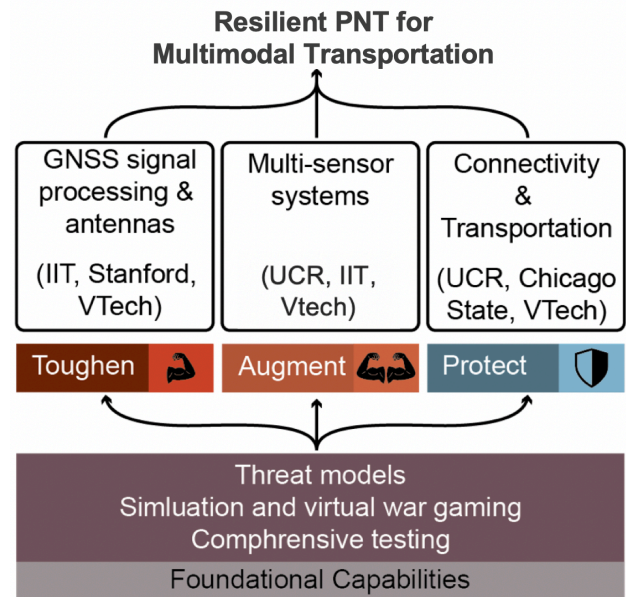
CARNATIONS pillars for resilient PNT

Center Initiatives

Research: The CARNATIONS research vision is founded on three research pillars for multi-modal surface transportation: (1) Toughen PNT through advanced global navigation satellite systems (GNSS) receiver and antenna technology; (2) Augment PNT with non-GNSS sensors (e.g., inertial navigation systems (INS), odometry, vision, LiDAR) and signals from multiple GNSS providers, communication satellites, and terrestrial RF including V2X; and (3) Protect PNT through RFI detection, tracking, and mitigation by leveraging V2X connectivity, community information, and crowdsourcing.

Education and Workforce Development: Resilient PNT systems and technologies are not traditional areas of expertise in transportation professions; however, they have rapidly emerged as critical to the design of future transportation systems. CARNATIONS offers a unique concentration program training future talent to support R-PNT for transportation. The Center especially values outreach to first-generation college students, female, and underrepresented minorities (URM). CARNATIONS' Engineering Research Toolkit (ERT) is a framework organizing inter-university URM student exchanges and hands-on R-PNT

research with experienced faculty mentors from all CARNATIONS institutions.

Technology Transfer: CARNATIONS' five institutions have long-established records of R-PNT solutions adopted by industry, public agencies, and other transportation practitioners. Coordination and standardization with stakeholders are key to the development of consensus technology that is accepted worldwide. CARNATIONS researchers lead and contribute heavily to numerous international PNT committees for all modes of transportation.

Products & Outcomes

The products of CARNATIONS research follow from its mission to toughen, augment, and protect PNT for all modes of surface transportation. Research projects aim to develop advanced anti-jamming and anti-spoofing GNSS antenna and receiver signal processing technology, jam/spoof resistance using integrated multi-sensor and radio-frequency augmentation, resilient V2X communications over 5G/6G networks, multi-vehicle jam/spoof detection and localization, threat models for multimodal transportation, and R-PNT virtual "war-gaming" simulators.
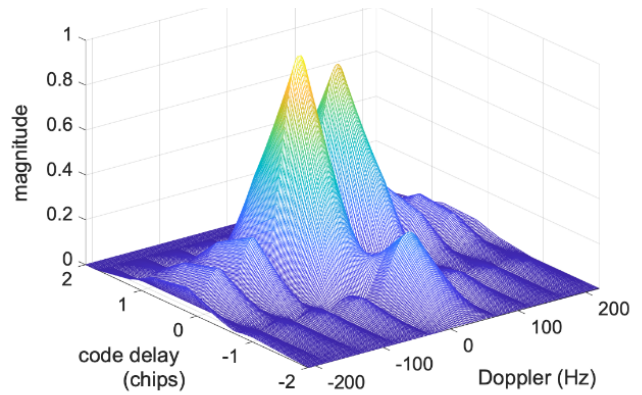

Spoofing detection using GNSS complex correlation function

CARNATIONS is training the next generation of transportation engineers, planners, and policymakers on R-PNT. The Center's cutting-edge research program is tightly integrated with education and stakeholder engagement. Researchers, students, and industry stakeholders are involved in all aspects of the Center. Our engagement efforts place knowledge and tools into the hands of stakeholders and create opportunities for them to shape CARNATIONS' research agenda and educational activities.
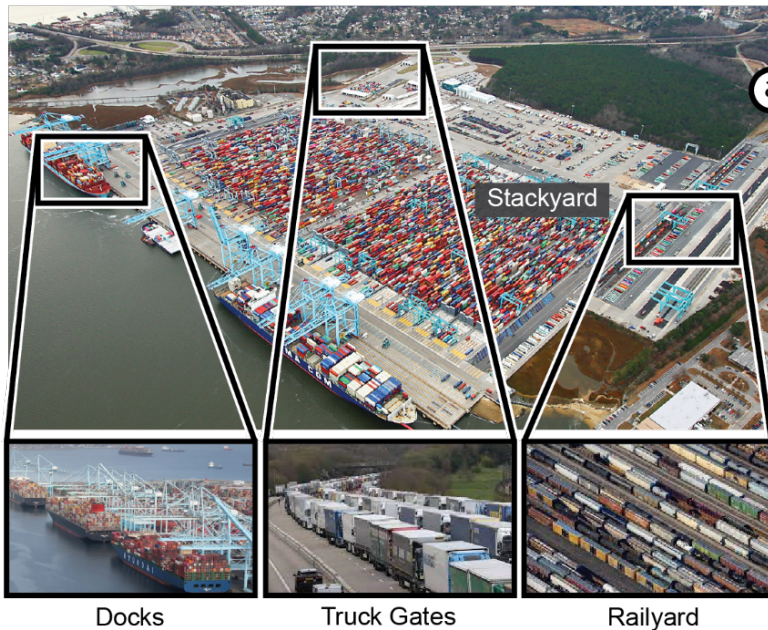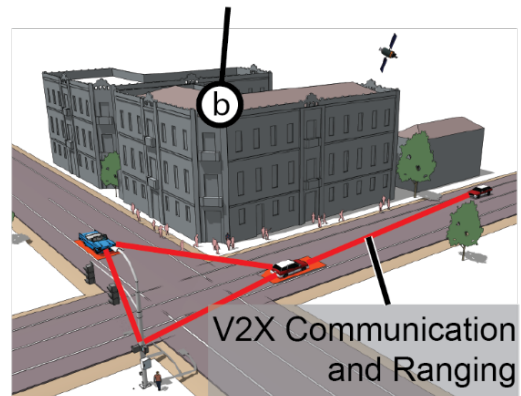
CARNATIONS addresses today's PNT threats in (a) to enable tomorrow's safe transportation systems in (b).

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