

Center for Advancing Research in Transportation Emissions, Energy, and Health Technology Transfer Plan

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**Center for Advancing Research
in Transportation Emissions, Energy, and Health**
A USDOT University Transportation Center



INTRODUCTION

The Center for Advancing Research in Transportation Emissions, Energy, and Health (CARTEEH) focuses on the impact of transportation emissions on human health. CARTEEH is a Tier-1 center funded by the U.S. Department of Transportation's Office of the Secretary for Research and Technology (OST-R) under the University Transportation Centers (UTC) program. The Texas A&M Transportation Institute (TTI) leads the CARTEEH consortium, which includes Johns Hopkins University (JHU), Georgia Institute of Technology (GT), The University of Texas at El Paso (UTEP), and the University of California, Riverside (UCR).



CARTEEH brings together experts from two disciplines — transportation and public health — that have not traditionally worked together. Members of the CARTEEH consortium advance research on transportation emissions in a more comprehensive manner, mapping the holistic tailpipe-to-lungs spectrum, which includes the impact of transportation emissions on the environment and public health. This document serves as the Technology Transfer (T2) Plan for CARTEEH, and contains a blueprint for achieving our T2 goals.

CARTEEH's Vision, Mission, and Goals

CARTEEH's Strategic Plan (found on the [CARTEEH website](#)) identifies our vision, mission, and goals as follows:

CARTEEH's vision is to be a premier University Transportation Center where transportation and public health experts work together to address the impact of transportation emissions on human health.

Our mission is to "...accomplish this vision by advancing transportation research, education, and technology transfer; and by promoting interdisciplinary collaboration and communication."

To this end, CARTEEH has identified three main goals:

1. Conduct impactful research.
2. Support higher education and workforce development.
3. Promote meaningful technology transfer.

CARTEEH's Research Areas

Our research at CARTEEH address the “full-chain,” or “tailpipe-to-lungs” spectrum, between transportation emissions and human health, as shown below. Further, we look into how technological advancements may affect each of the full-chain’s elements.



Our research focus areas are defined to cover this spectrum and include:

- Transportation System — Research focused on how technological advancements (including vehicle, engine, and fuel technologies) affect transportation emissions and their consequences on human air pollution exposure and public health.
- Emissions and Energy Estimation — Enhanced modeling and measurement of transportation emissions and energy consumption, and the assessment of impacts on air pollution and public health.
- Exposure and Health Impacts — Research focused on how exposure to air pollution, including from transportation emissions, affects public health (including specific population groups or occupations), and how these impacts can be mitigated.
- Data Integration — Integrating datasets from various sources and disciplines for improving policy, decision-making, and public health outcomes. Develop and implement methodologies and protocols that leverage data for innovative purposes.
- Policy and Decision-Making — Understanding how energy policy, emissions and air quality regulations affect greenhouse gas emissions, criteria pollutant emissions, and public health outcomes.

CARTEEH's Technology Transfer Goals

Technology transfer is one of the three pillars of CARTEEH, as reflected in the strategic goals for our center. The USDOT Research and Development (R&D) Strategic Plan defines technology transfer as activities undertaken to facilitate the adoption of R&D outputs. In the document *Building a Foundation for Effective Technology Transfer through Integration with the Research Process*, technology transfer is defined as “activities designed to help ensure that technologies created or improved through R&D are widely adopted for use outside or within the research-producing organization.”

Consistent with these documents, CARTEEH views technology transfer as a key part of the research process, and one that must be integrated with our R&D activities and not treated as an afterthought. We place a high value on stakeholder identification and engagement, as well as emphasizing information dissemination and the creation of open-access tools and methods that enable practical application of cutting-edge research findings. CARTEEH’s center director and assistant director for research (who serves as the T2 coordinator) provide oversight of all T2 activities, with TTI’s technology licensing manager advising as needed.

Within our broader, center-level goal of promoting meaningful technology transfer, we have identified the following sub-goals/objectives, to serve as our T2 goals.

1. Facilitate Implementation of Research Findings — The functional application of research findings is an important component of technology transfer. The outputs of CARTEEH’s research program aim to provide greater insight and awareness into the impact of transportation emissions on public health, as well as facilitate understanding of how transportation emissions and energy consumption are linked to health outcomes. Further, CARTEEH’s research program aims to provide greater insight into which policies and technologies are most effective in mitigating the adverse health impacts of traffic-related air pollution. Our envisioned applied research results range from case studies and appraisal of policy interventions and scenarios to models, methods, and analysis approaches to tools, software, and instrumentation. Our goal is to facilitate the application of these research results (or the use of tools developed) into practice by both the transportation and public health sectors.
2. Engage Stakeholders — A significant component of T2 activities is to engage stakeholders early in the process, in a targeted manner, with communication and outreach appropriate to their role, interests, and needs. As discussed further in the following stakeholders section, we will engage stakeholders throughout our R&D process.
3. Share Knowledge — Sharing the knowledge generated with the research and educational communities is another facet to technology transfer. In addition to specific



research outputs, the processes of conducting research and gathering information lend themselves to sharing intellectual capital within the research and educational community. This includes supporting students and helping to develop the future transportation workforce as well as actively promoting the availability of information contained in information repositories. It also includes the creation of curricula and course development materials, presentations at meetings and conferences, and by promoting technology exchange (through the use of CARTEEH's research findings in other entities' research efforts).

4. Collaborate and Leverage Our Work — CARTEEH's activities funded by the USDOT can be leveraged to apply research results and expand the scope of our activities through collaborations with the private and public sectors, tailoring some of the research to their needs and answering open questions. Examples include joint research efforts or initiatives to develop tools, software, devices, systems, or procedures based on research findings. Further examples include providing research support to test the effectiveness of policies and technologies in reducing traffic-related emissions, air pollution, and adverse health impacts.
5. Pursue Licensing and Commercialization Opportunities — CARTEEH's activities can be extended to advance the developed models, methods, analysis approaches, tools, software, and instrumentation into forms which can be commercialized. These products can be utilized by the private and public sector to collect, visualize, and analyze data quickly and efficiently. Further, the CARTEEH educational curriculum being developed has the potential to be commercialized partially or in its entirety, and offered to a wide audience.

CARTEEH'S STAKEHOLDERS

Identification of stakeholders is key to effective technology transfer. CARTEEH has identified and engaged with internal and external stakeholders at different levels, and is maintaining a master list of stakeholders and contacts for information dissemination and outreach purposes. Different types of stakeholders will have different levels of engagement and relevance to CARTEEH's activities, and it is important to understand and tailor our outreach to these audiences accordingly. CARTEEH's stakeholders can be categorized based on the level of potential involvement as follows:

- Champions — Those who are directly involved with CARTEEH's activities, through oversight, research, T2, and educational initiatives. This audience group serves the role of promoting and extending CARTEEH's relationship network. They champion the accomplishments and serve as the informal spokespeople with colleagues, peers, and other institutions.
- Collaborators — Organizations / entities with an interest in CARTEEH's activities, either for informing their policies and actions or to jointly pursue follow-up initiatives.
- Observers — Organizations / entities / individuals that need to be aware of the research initiatives, intended benefits, and importance of ongoing research, though not necessarily taking any action related to the information.

CARTEEH stakeholders can also be categorized based on the organizations they represent, as shown in the table below:

| Stakeholder Type | Description |
|-------------------------------------|--|
| Internal Stakeholders | Includes CARTEEH consortium members, including center leadership (advisory board and executive committee), as well as the network of researchers and students working on center activities. |
| Research and T2 Sponsors | Primarily the USDOT, whose UTC program is providing funding for CARTEEH. Sponsors of matching funds and research leveraged by CARTEEH are also included in this category. |
| Public Sector | Includes transportation-planning organizations (state departments of transportation, metropolitan planning organizations, cities/counties), public health organizations (e.g., the Centers for Disease Control, the American Public Health Association, state and local health authorities), and environmental departments (such as the Environmental Protection Agency and its state-level counterparts). |
| Research/Education Community | Includes university faculty, researchers, and secondary schools (for K-12 programs). |
| Professional Associations | Includes entities such as the Transportation Research Board, the Institute for Transportation Engineers, American Association of State Highway and Transportation Officials, Health Effects Institute, World Conference on Transport Research Society, American Thoracic Society. |
| Nonprofit Organizations | Nonprofit organizations and foundations engaged in work on health and transportation. |
| Private Sector | Private companies, including data, and technology providers. |

STRATEGIES FOR STAKEHOLDER ENGAGEMENT AND IMPLEMENTATION OF RESEARCH FINDINGS

CARTEEH's T2 goals are to

1. Facilitate implementation of research findings,
2. Engage stakeholders,
3. Share knowledge,
4. Collaborate and leverage our work, and
5. Pursue licensing and commercialization opportunities.

We are undertaking a number of strategies to ensure that we meet these goals, with several strategies addressing more than one goal. The table below summarizes these strategies and the applicable external stakeholders who will benefit from each.

| Strategies | Applicable External Stakeholders | | | | | |
|---|----------------------------------|---------------|---------------------|---------------------------|-----------|----------------|
| | Sponsors | Public Sector | Research/ Education | Professional Associations | Nonprofit | Private Sector |
| Solicit research needs statements from sponsors, professional associations and public, private, and nonprofit sectors | • | • | | • | • | • |
| Engage stakeholders in research design | • | • | • | • | • | • |
| Ensure T2 component to all research projects | • | • | • | • | • | • |
| Train students entering the workforce | | • | • | • | | • |
| Develop training courses and curricula | • | • | • | • | | • |
| Develop usable models, methods, tools, and software | • | • | • | • | • | • |
| Engage practitioners through symposia and seminars | • | • | • | • | • | • |
| Present findings at conferences and technical meetings | • | • | • | • | • | • |
| Track usage of research products and solicit feedback | • | • | • | • | • | • |
| Disseminate information through website and social media | • | • | • | • | • | • |
| Leverage funds for additional R&D | • | | • | | • | • |
| Create communication channels with stakeholders | • | • | • | • | • | • |

The remainder of this section discusses these strategies further, with definitions and examples of implementation.

Solicit Research Needs Statements from Sponsors, Professional Associations, Public, Private, and Nonprofit Sectors

This strategy will ensure that the research CARTEEH undertakes and the expansion of our research activities are in line with the needs of the stakeholders, answering questions of practical relevance, supporting research implementation on the ground, and highlighting viable opportunities for commercialization. In addition to traditional research reports and papers, CARTEEH researchers will be required to develop brief, summary documents in the form of project summary reports or policy briefs that can be used for stakeholder outreach, to inform policy-makers, decision-makers, and other lay audiences about the key findings and practical implications of research projects. We will also use the dissemination of the policy briefs/summary reports to solicit input on identifying further knowledge gaps and research needs that can be incorporated into future research cycles.

Engage Stakeholders in Research Design

This strategy will ensure that the research CARTEEH undertakes and the expansion of our research activities is in line with the latest technological advancements, and that research methods used are appropriate to answering important needs of stakeholders, especially in the case of projects utilizing matching funds from other public sources. It will also ensure that existing resources and tools are leveraged wherever possible, for maximum efficiency. CARTEEH researchers actively solicit feedback on research products, and we have started developing a system that provides the opportunities for stakeholders to engage and make suggestions on research design and implementation. An example of a system in place that solicits feedback and suggestions from stakeholders can be found for CARTEEH's open access Transportation Emissions, Air Pollution, Exposures, and Health Literature Library at <https://www.cartteeh.org/cartteeh-literature-library/>.

Ensure T2 Component to All Research Projects

This strategy will ensure that CARTEEH researchers will pay specific attention to and deliver requirement for the T2 component in all their research activities. All projects funded by CARTEEH are required to clearly articulate the T2 component of their research, and researchers are required to present their research findings to the broader research community and other stakeholders. The selection of research projects through CARTEEH's Competitive Research Program takes into consideration T2 objectives as a major selection criterion. Further, CARTEEH initiated six collaborative research projects (each involving at least two consortium members) of strategic importance, selected by the center's executive committee. These projects will have an impact in advancing knowledge and bringing the transportation and health disciplines together, while engaging stakeholders about the findings.

Train Students Entering the Workforce

This strategy will ensure that CARTEEH researchers mentor and train students and junior researchers in the cross-disciplinary area of transportation and health. Examples of such

initiatives include the student internship program, events for K–12 students, and linking to other science programs or student education campaigns. Further, CARTEEH employs numerous students as graduate research assistants, student workers, and summer interns.

Develop Training Courses and Curricula

This strategy is centered on the development of a cross-disciplinary training course in an area of emerging interest to transportation professionals, in which sufficient resources and information currently do not exist. CARTEEH consortium members are jointly working on a course module titled Traffic-Related Air Pollution: Emissions, Human Exposures, and Health. The course will be cross-disciplinary, covering key topics from the transportation, urban planning, exposure assessment, and public health and policy domains. The course is intended to form the basis for a three-credit-hour graduate-level course offered by consortium member institutions, but can also be adapted for complementing other existing academic courses or for professional development and continuing education purposes.

Develop Usable Models, Methods, Tools and Software

This strategy will ensure providing usable, easy-to-implement and time-saving models, tools, software and methods that can benefit all stakeholders. Two noteworthy examples that are under continuous development at CARTEEH are the data hub and an open access literature library. CARTEEH's data hub is being developed through a collaborative project involving all consortium members. The data hub is envisioned as a platform for transportation and health researchers to organize and access transportation-health data — including data from CARTEEH projects — and to house data products and reports. It is envisioned to be a unique repository that will promote knowledge and data sharing between the transportation and health disciplines. The data hub is currently under development and testing. Once complete, the data hub will be made available to external stakeholders through the CARTEEH website and shared through other channels such as the CARTEEH contact list.

Further, CARTEEH developed an open-access Transportation Emissions, Air Pollution, Exposures, and Health Literature Library containing a categorized reference list of over 500 scientific studies. The library provides a repository of current published research studies, categorized by study type and topic area, and serves as a resource for students, researchers, and practitioners interested in the areas of transportation, air quality, and health. It is a unique application available as an online search tool or a downloadable spreadsheet (available at <https://www.cartteeh.org/cartteeh-literature-library/>). The library will be updated on a regular basis, and users are encouraged to provide additional literature sources to include. We have already seen broad use of the library and have received positive feedback from practitioners and students, including several recommendations for additional resources to be added to the repository.

Engage Practitioners through Symposia and Seminars

This strategy will ensure engaging practitioners, who have real-world impact on the ground, at symposia and seminars to hear about the latest research CARTEEH is conducting, provide feedback and input on future research activities, and highlight areas that are under developed but key for practice. Two noteworthy examples for engaging practitioners and increasing the interaction between researchers and practitioners are the CARTEEH webinar/seminar series and the upcoming CARTEEH symposium. CARTEEH's ongoing seminar/webinar series includes presentations from visiting researchers and practitioners. One consortium member hosts the in-person seminars, and each is made available to consortium members and interested stakeholders in both the public and private sectors as a webinar broadcast and a recorded video afterward. Additionally, consortium members host informal brown-bag events within their own institutions on technical and professional development subjects. CARTEEH is also organizing the Transportation, Air Quality, and Health Symposium on February 18–20, 2019, in Austin, Texas. The event will bring together experts from transportation and health disciplines and the public and private sectors to discuss research, policy, and emerging issues related to transportation, air quality, and human health. Practitioner-led sessions and round-table discussions are being planned as part of this event.

Present Findings at Conferences and Technical Meetings

This strategy will ensure the dissemination of and sharing knowledge on research findings, methods, and tools, as well as the engagement of stakeholders at professional events. CARTEEH researchers are required to produce at least one peer-reviewed research paper and conference presentation as part of their deliverables, and are encouraged to present their research findings to the broader research community and other stakeholders through meetings, summary reports, and policy briefs.

Track Usage of Research Products and Solicit Feedback

This strategy will ensure that research outcomes and impacts are monitored, evaluated, and reported. As mentioned above, we have systems in place to track visitors to the CARTEEH website, users of the developed online tools, users who download resources, citations, and mentions, and options to solicit feedback and suggestions from stakeholders.

Disseminate Information through Website and Social Media

CARTEEH maintains a robust website at www.cartteeh.org, highlighting key information about the center, ongoing activities, performance reports, research reports, and related news and events, including a weekly updated list of global news on traffic-related emissions, energy, and health. The website serves as the platform for sharing information with stakeholders and is regularly updated. In conjunction with the website, CARTEEH maintains a robust social media presence by posting on TTI's, consortium members', and CARTEEH staff members' social media pages.

Leverage Funds for Additional R&D

This strategy will ensure that additional resources are leveraged from our partners and collaborators to enable research that is in line with their proprieties and agenda. CARTEEH researchers have established working relationships with multiple potential funders and are encouraged and incentivized to attract these resources into research programs in line with the CARTEEH theme and vision. CARTEEH places a great emphasis on leveraging research funding and support from other private- and public-sector entities, including corporate research support and in-kind support to further promote our T2 goals. CARTEEH has already successfully leveraged additional funding from public sector and nonprofit organizations for research activities that follow up on UTC-funded work. We will also seek additional funding for R&D products that have commercialization potential, but may not be patentable or commercially ready in their current form. For example, with research outputs at lower technology readiness levels, with a proof-of-concept validation, we will seek additional private-sector funding and partnerships to move to the technology demonstration stage.

Create Communication Channels with Stakeholders

Engagement with our stakeholders is key to facilitating technology transfer. To enable this, CARTEEH has assembled a list of over 800 key contacts from among our stakeholder community who have engaged with, or expressed an interest in engaging with, CARTEEH's researchers and activities. These contacts represent CARTEEH's broad and diverse stakeholder group, who are kept informed about major activities and outputs. We will identify segments of this contact list for targeted stakeholder outreach in the near future as various T2 products and initiatives are completed.

DEPLOYMENT AND COMMERCIALIZATION OF RESEARCH OUTPUTS

CARTEEH's intellectual property (IP) research outputs are anticipated to primarily consist of information and data useable by stakeholders to inform policy and practice as it relates to addressing transportation emissions and health. CARTEEH will emphasize broad dissemination of its work to interested stakeholders, including collaborations with K-12 secondary school and university science programs, and via public campaigns and media events related to transportation emissions, energy, and health.

However, there may be potential IP outputs that are commercially viable through the licensing of patentable technologies and/or copyrightable materials. The commercializable outputs may include, but are not limited to, educational and training modules that can be developed into paid courses, software applications for data analysis, or sensors or measuring devices for emissions measurement and characterization (such as low-cost sensors). Such commercial licensing could either be exclusive or non-exclusive, and would most likely be royalty-bearing (based on sales, installation sites, etc.).

The CARTEEH consortium members will develop, and execute a single, high-level intellectual property (IP) management plan that addresses the actions and responsibilities toward

commercialization of IP developed or discovered during the course of CARTEEH R&D. The commercial IP opportunities generated from R&D outputs will be pursued as appropriate through associated CARTEEH university-based T2 offices that exist at TTI, UCR, GT, JHU, and UTEP. The IP management plan will include recommended roadmaps and strategies to allow for the best chance for the successful commercialization of IP, such as

- For an innovation (i.e., IP) solely invented/authored by one or more employees of a single CARTEEH consortium member, that member's university T2 office would logically be responsible for the commercialization of that IP.
- Similarly, for an innovation that is jointly invented/authored (thus, joint ownership of intellectual property [IP] between two or more consortium members exists), then such innovation will be managed via an inter-institutional agreement between the consortium members that is developed specifically for the management and commercialization of the subject IP.
- Expenses for the protection of IP (i.e., patents, trademarks, copyrights) shall be borne by the IP creation member(s) of the CARTEEH consortium. Such past expenses may be reimbursed to that member(s), and future expenses directly paid by a licensee via terms of a commercial license agreement.

Since all or a portion of the funding for CARTEEH may originate directly from the U.S. government (i.e., through federal funding), CARTEEH will comply with the Bayh-Dole Act of 1980 and its 2018 revisions (codified in 35 USC § 200-212) for inventions and discoveries made using such federal funding.

TRACKING AND PERFORMANCE MEASURES

CARTEEH has an existing, established system of tracking and reporting various metrics, as part of the required Annual Performance Indicator Report and the semi-annual Program Progress Performance Report submitted to the USDOT. Several of our metrics relate to T2 actions discussed in this plan, giving us a robust set of baseline data for tracking our research outputs, outcomes, and impacts. Moving forward, our semi-annual Research Report (combined T2 Report/Program Progress Performance Report) will document an enhanced set of measures as described in the table below. These measures collectively address our five T2 goals, namely

1. Facilitate implementation of research findings,
2. Engage stakeholders,
3. Share knowledge,
4. Collaborate with others and leverage our work, and
5. Pursue licensing and commercialization opportunities.

| Measure Description | Type | Target | Tech Transfer Goals Addressed |
|--|---------|---------------------------------|-------------------------------|
| Number of seminars, webinars, conferences, and outreach events conducted | Output | 5 per year | 1; 2; 3; 4 |
| Number of conference presentations and papers based on CARTEEH research | Output | 7 per year | 2; 3 |
| Number of public, industry, and nonprofit organizations engaged by CARTEEH researchers | Output | 20 per year | 1; 2; 4; 5 |
| Number of CARTEEH reports, documents, and products viewed, downloaded, or requested | Outcome | 100 per year | 2; 3 |
| Number of attendees to seminar, webinar, and outreach events | Outcome | 150 per year | 1; 2; 3; 4 |
| Number of visitors to CARTEEH website, literature library, and data hub | Outcome | 700 per year | 2; 3 |
| Invitations of CARTEEH leadership and researchers to speaking engagements to the scientific, educational, or professional communities | Outcome | 10 per year | 1; 2; 3; 4 |
| Citations and references to CARTEEH research | Impact | 50 over the grant period | 2; 3 |
| Number of formal partnerships (including commercial licensing agreements) developed with external stakeholders | Impact | 10 over the grant period. | 1; 4; 5 |
| Research funding leveraged by CARTEEH beyond required match | Impact | \$600,000 over the grant period | 1; 4; 5 |

SUMMARY

This Technology Transfer Plan outlines CARTEEH’s approach to implementing research findings, engaging with stakeholders, facilitating knowledge sharing, and collaborating with the public and private sectors. As seen in this document, technology transfer is emphasized in all of CARTEEH’s activities to ensure the broad reach and practical implementation of our work.