



COLORADO
Department of Transportation
Division of Transportation Development

Research Manual



Applied Research and Innovation Branch

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1. INTRODUCTION

The Colorado Department of Transportation (CDOT¹) Applied Research and Innovation Branch (ARIB), also referred to as the Research Branch, manages a program to address research needs across CDOT. Research can provide solutions to many problems facing today's transportation practitioners. Through ARIB, CDOT leads, participates in, and applies transportation research that takes place locally through research conducted and managed directly by CDOT, regionally through research collaboratively conducted by multiple states through Transportation Pooled Fund (TPF) projects, and nationally through the research conducted through the National Cooperative Highway Research Program (NCHRP). Research addresses methods, materials, technologies, and planning to enable CDOT to promote safety, enhance mobility and sustainability, save money, plan for future technologies, and protect the public investment in transportation infrastructure. At all levels, ARIB brings to bear knowledge and solutions that improve Colorado's transportation system. A brief history of ARIB is presented in Appendix H.

This research manual is intended for an audience of researchers, CDOT staff, academic partners, and others interested in the CDOT research program. It provides information on the research cycle including developing, selecting, funding, performing, managing, and implementing research that benefits the traveling public in Colorado. This research manual also fulfills the United States Department of Transportation (US DOT) requirements specified in 23 CFR Part 420, Subpart B, Research, Development, and Technology Transfer (RD&T) Program Management, to describe CDOT's management process and procedures for selecting and implementing Subpart B RD&T activities. In this manual SP&R refers to state planning and research, and more specifically SP&R Part B applies to RD&T activities and funding. ARIB reviews this manual for major and minor updates at least every two years. At least every 5 years, or whenever major updates are made, it will be re-submitted to FHWA for approval.

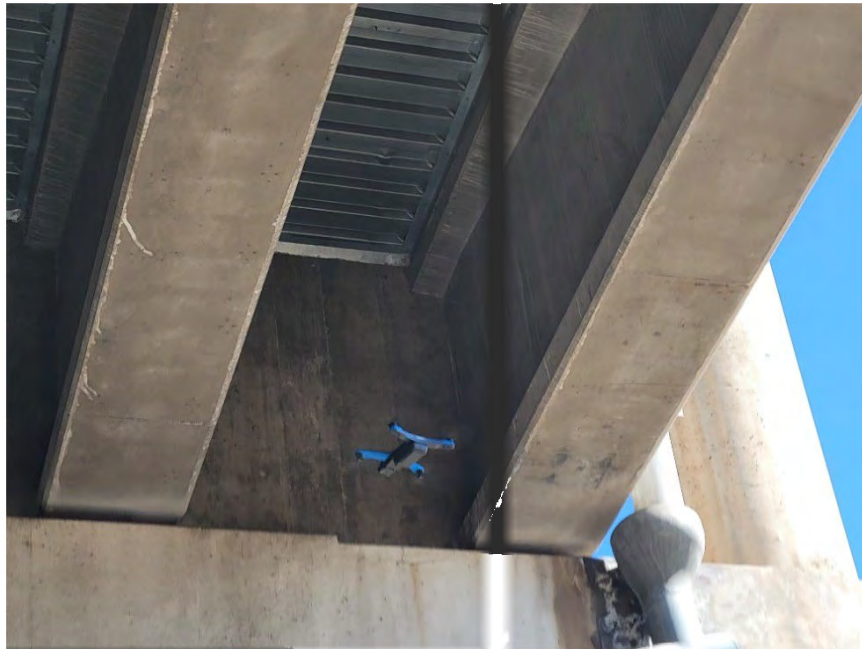


Figure 1. CDOT bridge inspection test with a Small Unmanned Aircraft System (sUAS)

¹ See Appendix A for Acronyms and Definitions.

2. ORGANIZATIONAL STRUCTURE AND GUIDING MISSION AND VISION

The CDOT RD&T program is conducted by the Applied Research and Innovation Branch (ARIB), one of 6 branches of CDOT's Division of Transportation Development (DTD).

ARIB staff have broad internal expertise, and the branch leverages subject matter experts (SME) throughout CDOT. The Branch encourages risk-taking and innovative approaches to investigate research questions, implement results, and study new technology. Most projects lead to recommendations that can change CDOT practices, but some do not. This is the nature of research, and a negative result is a valid and can be as valuable as an actionable outcome. ARIB maintains close interactions with DTD branches and throughout CDOT. The visible support and endorsement of CDOT executives and group leaders is also important to successful research and implementation.

The overall direction of CDOT is set by organizational mission and vision statements. These also guide research strategies and project selection. The current organization charts, and current mission and vision statements of CDOT, DTD, and ARIB are presented in Appendix B. CDOT's Strategic Policy Initiatives change more frequently than vision and mission but also provide guidance. These are also in Appendix B.



Figure 2. Example from the Rock Cut catalog (State Highway 65, milepost 55) developed as part of research into best management practices for rock blasting aesthetics.

3. APPLIED RESEARCH & INNOVATION BRANCH PROGRAM AREAS

Research and development can be defined as “creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.”²

Applied research is “original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.”

Basic research is “experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.”

The ARIB research program focuses on applied research, with an emphasis on uncovering knowledge that is actionable and that CDOT has the capacity to implement or use for future planning.

Core Research Program Areas

ARIB is structured to have the following areas of specialty. Each is considered a research program area which encompasses a set of research projects. For each program area, an ARIB research program manager identifies research needs and their scope, and organizes in-house research or selects consultants to perform research in the area. In all cases, scientific research methods are used.

Environment, Water Quality, and Sustainability and Planning

This area encompasses air and water quality, threatened and endangered species, vegetation management, noise abatement, NEPA³ processes, and sustainability. It also includes transportation planning. Often pursuing an interdisciplinary approach, research in this area will identify value added opportunities to minimize environmental impact of building and maintaining transportation infrastructure, and to ensure the effectiveness of the planning process. This includes two of ARIB’s Areas of Emphasis, “Mitigating Wildlife Vehicle Collisions and Improving Safe Wildlife Passage” and “Construction and Operations/Maintenance Impacts on Air Quality”

Structure, Hydraulic and Geotechnical

This area encompasses bridge and retaining wall design, slope stability and foundations, geology, hydrology, and hydraulics. Research goals often focus on ways to improve the structural integrity of bridges, foundations, structures maintenance, cost-effectiveness of structural design, effectiveness of hydrological analysis, and hydraulic design of culverts and bridges. This includes one of ARIB’s Areas of Emphasis, “Post-Wildfire Effects”.

² The definitions of this section follow [OECD (2015) Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development. The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris. <https://www.oecd.org/publications/frascati-manual-2015-9789264239012-en.htm>]

³ NEPA refers to the National Environmental Policy Act (NEPA) signed into law on January 1, 1970

Safety, Maintenance, and Operations

This area encompasses highway safety, worker safety, traffic operations, geometric design, maintenance, and Intelligent Transportation Systems. Research goals often focus on opportunities to improve safety and mobility, and to optimize how highways are maintained in both summer and winter.

Pavement and Materials

This area encompasses materials, pavement management systems, and pavement design. Research focuses on aspects of design, construction, and preservation of asphalt and concrete pavements, and the use of binders, aggregates, fillers, emulsions, sealants, additives, geotextiles, reclaimed materials, supplementary cementitious materials, and other sustainable materials to improve the workability, performance, durability, safety, and environmental impact of pavement structures.

Research Program Areas of Emphasis

As an overlay to the core research program areas, ARIB develops Areas of Emphasis which are topics of special interest to CDOT. They are topics where focused research has the potential to result in substantial near-term and long-term benefits to Colorado, and where local factors make Colorado a logical choice to lead this research. Examples of local factors are Colorado's natural features (for example, terrain, climate, the built environment, or state government policy), and relevant research strengths within Colorado's universities, consulting firms, or national laboratories. Current Areas of Emphasis are

- Mitigating Wildlife Vehicle Collisions and Improving Safe Wildlife Passage
- Construction & Operations/Maintenance Impacts on Air Quality
- Post-Wildfire Effects

Research Management and Participation at the National Level

ARIB maintains an emphasis on results that meet practical needs of CDOT. Research conducted at the national level produces knowledge relevant to many states. Colorado supports and benefits from national participation through its activities with the Transportation Research Board (TRB), The American Association of State Highway and Transportation Officials (AASHTO), The Federal Highway Administration (FHWA), and National Highway Traffic Safety Administration (NHTSA). National level activities are further described in Chapter 5.

4. RESEARCH FUNDING SOURCES

DTD's primary program funding source is FHWA SP&R funds. Federal law requires two percent of federal-aid funds be apportioned for certain surface transportation categories and be spent on planning and research activities. Of these funds, a minimum of twenty-five percent must be allocated for research-related activities as specified in 23 CFR Part 420, Subpart B. This SP&R Part B allocation, together with a required state match, amounts to approximately \$3 million annually and provides the main funding for ARIB's research activities.

About 65% of the budget directly supports state and national research projects. National projects include the research of the NCHRP and Transportation Pooled Fund (TPF) programs. State research projects are conducted by our university partners, contracted consultants, and by staff within CDOT.

Other than SP&R Part B funds, on occasion ARIB will apply funds from other sources such as

- Funds from federal government agencies other than FHWA, for example United States Geological Survey, for some research projects. Such funds may substitute for the state match or simply provide enhanced resources to pursue research goals.
- Certain studies of limited scope or local interest can be financed with state funds.
- Public-private partnerships that leverage research funding and enhance implementation opportunities are also pursued. Such relationships should benefit Colorado's transportation program and must comply with state and federal laws.
- ARIB may use other funding sources. Research performed by CDOT staff with these funds must still be consistent with the mission and goals of the department. ARIB does not accept funding from sources that may put in question the impartiality of research results.



Figure 3. I-270 air quality sensor for research into the air quality impacts of construction activities.

5. RD&T PROGRAM OVERVIEW

The RD&T program manages activities that lead to high-quality, implementable research results to improve CDOT's current practices and to prepare for the increasingly complex needs of Colorado's transportation future. The research program includes local research projects to solve problems identified by CDOT, as well as multi-state (TPF) and national (NCHRP and TRB) research that CDOT staff help guide and whose results benefit Colorado. It also includes knowledge curation and exchange through activities led by the Research Library and participation in regional and national AASHTO, TRB, and other meetings. The Program also facilitates the implementation of research. This includes implementation of results from local research projects, and participation on the State Transportation Innovation Council (STIC).

Research projects directly managed by ARIB are selected twice each fiscal year through a process that ensures broad input and that directs resources to projects that address priority issues. Research problem statements are solicited from within and outside CDOT. Oversight Teams (OTs) comprised of subject matter experts review these problem statements for their potential to help CDOT and for their tractability. The Research Implementation Council (RIC) then makes prioritized recommendations consistent with CDOT strategic directions. DTD and CDOT leadership incorporate a final set of projects into the DTD Work Program.

The following sections describe the components of the RD&T program:

- Management of local research projects
- Participation in multi-state TPF projects,
- Contributions to national programs (TRB, NCHRP, and AASHTO)
- Oversight of the Local Technical Assistance Program (LTAP),
- Operation of the CDOT Research Library
- Other RD&T Activities

Management of Local Research Projects

Managing local research projects is the largest component of the RD&T program. These projects directly address problems and needs affecting CDOT operations, and advance CDOT approaches and practices as knowledge, technology, and needs change. Chapters 7, 8, and 9 describe the steps for research study identification, development, and implementation of recommendations.

Transportation Pooled Fund Projects

The Transportation Pooled Fund (TPF) program provides a way for several states, the FHWA, and third parties (contractors, universities, other government agencies, etc.) to combine resources and achieve common research goals. Each participating member of a pooled fund project contributes both financial and staff support. If approved by the FHWA administrator, these studies may be conducted using 100% SP&R funds without the usual requirement that states contribute a 20% match. ARIBs processes for leading and participating in TPF projects is outlined in Appendix F.

Typically, the lead agency (a state DOT or the FHWA) is the agency that initiates formation of the TPF by developing the problem statement, soliciting interest from other agencies, and obtaining FHWA approval

of the study. During the project the lead agency may contract with university or consultant research teams to conduct the scope of work using their procurement process. The lead agency agrees to receive, obligate, and manage contributions from participating agencies, both federal and non-federal, and reviews and pays expenses related to the pooled fund project.

The pooled fund members provide technical support to the project. A Technical Advisory Committee (TAC) is formed to provide project direction and oversight. The TAC includes a technical representative from each participating agency and is chaired by the lead state representative.

TPF solicitations are posted on the Transportation Pooled Fund website (pooledfund.org) throughout the year. ARIB monitors these posting and manages CDOT participation. Decisions about which TPF projects merit CDOT participation follow the same process as evaluation of Problem Statements. To initiate the evaluation, a CDOT Problem Statement form must be submitted with an identified RIC sponsor, indicating the pooled fund study benefits to CDOT. The TPF will be considered by the OT, the RIC, and if fully approved it will become part of the DTD Work Program. Commitments to pooled fund studies often recur each year for up to 5 years. Once approved by the OT and RIC, it is not expected that a study will need their consideration in successive years. However, if ARIB determines that a project's progress and direction require reconsideration of CDOT's participation, the study may be brought to the RIC again for their advice.

Contributions to National Programs

ARIB leads, contributes to, and benefits from CDOT's interactions with the Transportation Research Board (TRB) and the American Association of Highway Transportation Officials (AASHTO). Relevant AASHTO programs are the National Cooperative Highway Research Program (NCHRP) and the Special Committee on Research and Innovation.

The Transportation Research Board (TRB)

The TRB is one of seven program divisions within the National Academies of Sciences, Engineering, and Medicine. It conducts activities to solve complex problems and inform public policy decisions, and it provides independent and objective analysis and advice to the nation. The TRB's mission is to promote innovation and progress in transportation by stimulating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research results. The TRB has an obligation to meet the National Academies' standards for objectivity, independence, scientific rigor, and an evidence-basis in all that it does. CDOT contributes funds to support the TRB through the DTD Work Program.

The TRB encompasses several hundred standing committees and task forces, consisting largely of volunteers. Among its activities are the publication of peer-reviewed reports and research papers, management of cooperative research including the NCHRP, operation of the Transportation Research Information Services (TRIS) Documentation (TRID), and hosting the TRB Annual Meeting. CDOT participates in many services provided by the Board. See <http://www.trb.org> for further information.

The Research Branch organizes most of CDOT's interactions with the TRB. The ARIB Manager is Colorado's state representative to the TRB. Responsibilities include:

- Keeping the TRB informed of challenges facing CDOT and our research activities
- Updating CDOT on TRB activities and national research efforts

- Assisting in the identification of qualified people to serve as TRB committee and panel members
- Working with TRB to schedule the annual TRB State Partnership Visit

CDOT supports and relies on the TRB's TRID database. Each of our research reports is submitted for inclusion in this database, adding to the common body of knowledge so other states and other research organizations can access them. The TRID database is also one of the most important sources when our CDOT Research Library conducts a literature review to inform research topics.

Each year, the TRB Annual Meeting provides an opportunity for CDOT research staff and subject matter experts to learn about the latest transportation research results, as well as research in progress. It is also a venue to present and share CDOT ideas and potential solutions, to develop relationships with peers at other state DOTs, and to visit with industry representatives and view their latest products. Many TRB topical meetings and workshops occur throughout the year, providing CDOT specialists opportunities to work with colleagues and researchers on transportation problems in their area of expertise.

The National Cooperative Highway Research Program (NCHRP)

NCHRP is an AASHTO program, managed by the TRB, where states and the FHWA contribute funds to address transportation research problems of national interest. Each state contributes 5.5% of their SP&R funds. No state match is required.

Like research management at the state level, NCHRP research begins by soliciting problem statements. These are invited from state transportation agencies and the FHWA. They are reviewed by subject matter experts from TRB, FHWA, and AASHTO committees. State transportation agencies are then provided with all problem statements, reviews, and author's responses to the reviews, and are asked to rate each problem statement. Considering all states input and all reviews, the AASHTO Special Committee on Research and Innovation then meets to recommend an annual program of NCHRP research projects which is then voted on by the CDOT Executive Director and their counterpart in all states.

CDOT supports this NCHRP process at several stages. The ARIB manager encourages NCHRP problem statement submissions, gathers advice from within CDOT to rate each problem statement, and nominates experts and staff to serve on NCHRP study panels.

The American Association of State Highway Transportation Officials (AASHTO)

AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments throughout the U.S. One of the organization's roles is to serve as a liaison between state departments of transportation and the federal government. AASHTO operates the NCHRP. The AASHTO Special Committee on Research and Innovation organizes activities within the transportation research community and develops research priorities for NCHRP. Within this Special Committee, the Research Advisory Committee (RAC) includes research managers from each state DOT and provides input on needs and priorities. The RAC has four region, with Colorado participating with the western states in RAC Region 4. An important function of the AASHTO-RAC is to facilitate information exchange through surveys that support research and provide a link between research managers. The ARIB Manager represents Colorado on the RAC and ARIB coordinates input to AASHTO surveys by subject matter experts within CDOT.

Local Technical Assistance Program (LTAP)

The Local Technical Assistance Program (LTAP) is an FHWA technology transfer program that provides technical assistance and training to local transportation departments across the nation. CDOT has operated the Colorado LTAP program since 1986. It is currently a run as a cooperative effort between the FHWA, CDOT, and Front Range Community College.

LTAP strives to bridge the gap between research and practice by conducting training sessions and demonstrations and by serving as a clearinghouse for information related to state-of-the-art technology in the construction and maintenance of roads and bridges.

Colorado LTAP manages three training programs offering dozens of courses each year.

- The **Roads Scholar I** program started in 1991 and is designed to provide participants with the training necessary to increase their knowledge of transportation safety, local road maintenance and construction procedures, and improve their technical skills. Four required courses and 5 elective courses are needed for graduation.
- The **Roads Scholar II: Road Master** program is an advanced training program for experienced maintenance workers, equipment operators, and managers. The program includes courses in four focus areas: safety, environment, transportation management, and technical skills. It is designed to provide Colorado's municipal highway personnel in all departments with a knowledge of modern road maintenance management procedures and techniques. Graduation requires 14 hours of coursework in each of the focus areas, as well as prior completion of Roads Scholar I.
- The **Supervisory Skills and Development Program** is designed to help educate, prepare, and provide public works employees with the background necessary to confidently perform in a supervisory position. The courses provide a fundamental understanding of the roles and responsibilities of a supervisor and help students develop tools for succeeding in management. Each of the 9 required classes includes 7 hours of training.

In addition to the three training programs, Colorado LTAP provides access to many on-demand and online resources through a training database, recorded training, and webinars. It also operates an equipment loan program to give local transportation practitioners short-term access to needed tools, and a lending library through which reference materials can be shared.

Finally, Colorado LTAP acts as a conduit to and between the local agencies, with a newsletter, Google Group, and a strong social media presence.

The CDOT Research Library

The CDOT Research Library, operated by ARIB, provides all CDOT employees with transportation-related resources and information. The collection is also available to the public. The library includes both print and electronic resources including technical reports, journals, books, and databases.

CDOT employees have unlimited access to the collections. The library is located in the CDOT Headquarters building in Denver. Items may be requested and delivered to other CDOT facilities through inter-office mail.

The library supports CDOT research activities by

- Providing access to local reference materials
- Providing access to remote databases such as the TRID database.
- Conducting literature reviews on active and potential research topics
- Distributing CDOT research reports to national databases.

Other RD&T Activities

ARIB manages the T2 Process for CDOT. T2 is a set of Technology Transfer activities required of all federal departments by Congress. FHWA partners with state DOTs in the identification and development of innovative technologies and practices, and the implementation of innovation. ARIB facilitates T2 activities in many ways including its operation of the Research Library and LTAP, participation in the STIC and other CDOT committees, professional conferences, outreach related to local and national research results, and tracking and encouragement of research implementation. ARIB manages CDOT's participation in the T2 program's Technology Deployment Funds application process. Applications for T2 funds are reviewed and prioritized by ARIB and the STIC before submission to FHWA. These applications compete nationally for available funds, and winning applications typically receive \$5,000 - \$7,500. T2 funds can be used for outreach activities related to research, development, technology and innovation. Some examples of eligible activities include peer exchanges, scan tours, brochures, training, workshops, demonstration projects, production of graphic or audio-visuals and other outreach.

ARIB participates in and, on occasion, has also managed the STIC. This council facilitates the rapid implementation of technology, processes, procedures, and techniques among transportation professionals to ensure smart and efficient investment in Colorado's transportation infrastructure. The STIC Incentive Program provides funding and resources to foster a culture for innovation and to move innovations into standard practice. ARIB has a seat on the STIC and in some years has coordinated its activities, including applications for and distribution of funds from the Incentive Program. Through the program, funding up to \$100,000 per federal fiscal year is made available to support the costs of standardizing innovative practices in Colorado.



Figure 4. Autonomous attenuator truck testing. CDOT leads the Autonomous Maintenance Technology pooled fund study

6. RESEARCH ROLES AND FUNCTIONS

All CDOT staff have a role in identifying research needs. They may also submit problem statements or seek subject matter experts to help form the need into a problem statement. This chapter describes the main roles and functions at the steps of the research cycle. Beyond these functions, ARIB staff have additional duties that support the overall health and operation of the CDOT RD&T program

Applied Research and Innovation Branch (ARIB) Manager

The ARIB Manager is responsible for oversight of the CDOT RD&T program and for CDOT's participation in the federal RD&T program. Responsibilities of the ARIB Manager include

1. Research Problem Statement solicitation, evaluation, and selection responsibilities
 - a. With broad CDOT and State of Colorado goals as a guide, solicit problem statements from CDOT employees, Colorado universities, Metropolitan Planning Organizations (MPO), the FHWA, and others.
 - b. Distribute problem statements to the appropriate ARIB research project manager for evaluation by oversight teams (OT)
 - c. In coordination with the research project manager, review OT recommendations
 - d. Organize and chair meetings of the Research Implementation Council (RIC) to review and prioritize the problem statements and recommendations forwarded by each research oversight team.
 - e. Compile RIC recommendations and review them with the Director of DTD and the Chief Engineer. Provide information as needed to facilitate final CDOT selections.
 - f. Ensure selected projects are entered into the DTD Work Program for consideration by FHWA
 - g. Ensure active and completed project status is included in the CDOT DTD Annual SPR Accomplishments Report, which is submitted by DTD within 90 days after the ending of a Work Program.
 - h. Distribute fully approved projects to research project managers based on expertise and workload.
 - i. Review the final study plan (typically the SOW) for each project, including the discussion of implementation; and
 - j. Manage research projects of special significance to CDOT executive management
2. Chair and ensure good function of the RIC
 - a. Ensure the RIC membership is balanced and encompasses broad knowledge of CDOT needs
 - b. Together with the DTD Director and Chief Engineer, nominate and promote candidates to RIC membership.
 - c. Call and chair additional RIC meetings, as needed
3. Work with CDOT to set the research program's strategic direction
 - a. Engage RIC members and executive management to set and adjust strategic priorities and call a RIC meeting if discussion is needed.

- b. Develop the annual RD&T Work Program based on RIC recommendations and present it to DTD management. Amend the current RD&T Work Program throughout the year as needed.
- 4. Provide overall management of the RD&T program and staff.
- 5. Coordinate CDOT research activities with other state's research programs, FHWA, TRB, and AASHTO.

Research Project Manager or Study Manager

The research project manager, more commonly called the study manager, is the ARIB staff member directly responsible for the project, and is central to its steps and activities from cradle to grave. The study manager guides the problem statement through the screening and evaluation steps of the OT and RIC. For problem statements that are selected for funding, they coordinate the selection of a research team, and they manage and support the research from its kick-off to its conclusion. They also work with the study champion to track implementation and impacts after the research. Major responsibilities of the study manager are as follows:

1. Research Problem Statement Solicitation, Evaluation, Selection Cycle responsibilities
 - a. Encourage the submission of relevant problem statements within each area of responsibility. Where necessary, work with practitioners and subject matter experts to form nascent ideas into well posed problem statements.
 - b. Assemble the Oversight Team to provide advice on Problem Statements in their area of responsibility. This should include an indication of its practicality, priority, and timeliness. The advice should be suitable for use in a decision to forward a Problem Statement to the RIC for further consideration.
 - c. In coordination with the ARIB Manager, review research oversight team recommendations and prepare them for presentation to the RIC.
2. Research Project initiation and execution. This applies to the set of problem statements selected by CDOT and in the approved DTD SP&R Work Program.
 - a. Become familiar with the research project and related issues through literature reviews and discussions with other knowledgeable people on the subject.
 - b. In consultation with the RIC sponsor, assemble a study panel composed of at least two people from CDOT that are outside the research branch and have an interest in the defined problem. One of the members of the study panel should be the appropriate departmental subject matter expert. FHWA participation should also be solicited.
 - c. With the study panel, develop a SOW which translates the Problem Statement into a Research Project or RFP intended to lead to beneficial outcomes for CDOT.
 - d. Organize, manage, and document the Principal Investigator (PI) selection process. This includes working with the CDOT Business Office to complete appropriate forms, soliciting proposals, coordinating PI selection with study panel input, negotiating the agreement with the PI, and finalizing contract documents.
 - e. Keep the research project on schedule and track the project budget. Review the project's progress and adherence to milestones.

- f. Communicate regularly with the PI and relate any issues of concern to the study panel and RIC sponsor.
 - g. Conduct study panel meetings and keep the study panel informed, as needed.
 - h. Review, approve, and forward for payment vendor-submitted project invoices.
 - i. Maintain documentation and records, including study panel contact information, contract amendments, billing and payment status, etc.
 - j. Ensure deliverables such as require progress reports are received on time.
 - k. Coordinate the review of project final reports and their publication and distribution by the research librarian.
 - l. Coordinate the development of the implementation plan, and updates of implementation status.
 - m. Finalize all financial records and reports, and close out project accounts and records when the project is complete.
3. Building and maintaining a program of fruitful research
 - a. Maintain current knowledge of the problems and opportunities CDOT encounters within each area of responsibility.
 - b. Remain informed of research results and innovations from other states, NCHRP, and other relevant sources, and convey useful information to CDOT practitioners.
 - c. Manage the selection of OT members and facilitate OT meetings.
 - d. Periodically review ongoing and recently completed research outside Colorado, including information available through Research-In-Progress reports, final reports in the TRID database from other agencies, and pooled fund final reports.
 4. Any other activities that may arise and are necessary to lead the research project to a successful conclusion.

Study Champion

Every major research project undertaken by ARIB requires a dedicated champion. The champion has a strong impact on the chance for successful completion and implementation of the project results. The champion fills an important and substantial role and must be committed to the tasks needed for a successful project. They are often a subject matter expert knowledgeable about the technical aspects of the topic, understand the scope of the undertaking, and are a key stakeholder in the success of the project. The champion commits to dedicate the time and resources needed to help the PI and research project manager successfully complete the research and has a critical role in the implementation of its results.

Responsibilities of the study champion include, but are not limited to

1. As needed, work with the individual initiating a problem statement to develop the idea and propose how research could address the problem.
2. In preparation for the OT and RIC meetings, provide a clear rationale for the value of solving the problem
3. For problem statements selected by CDOT and in the approved DTD SP&R Work Program, work with the study manager to form a study panel, finalize the SOW, and select a PI

4. Lead the study panel and work with the panel members to monitor and guide progress of the research
5. Support the PI and act as a liaison to CDOT resources
6. Critically review all project deliverables including Quarterly Progress Reports (QPRs) and the draft and final reports, along with other study panel members
7. Promote implementation of actionable research findings within CDOT groups

RIC Sponsor

Every major research project undertaken by ARIB requires a RIC sponsor. This is to ensure there is management support for the project. The RIC sponsor can be a CDOT Branch/Program Manager or a RIC member. A RIC sponsor is also required for CDOT participation in TPF studies.

Responsibilities of the RIC sponsor include supporting ARIB and the study champion, and

1. Participate in assembly of the study panel, if needed
2. Monitor progress of the research to help ensure it continues toward meeting a CDOT need
3. Review and approve the RFP or in-house proposal drafted by the study panel, if needed
4. Review the research project final report and implementation plan
5. Support the champion in promoting implementation of the research findings

Oversight Teams

The oversight teams (OTs) review and provide advice on problem statements submitted for research study. They may address the need for the research, likelihood it will result in conclusions that can be applied within CDOT, and its alignment with CDOT mission, vision, and strategic goals. The OT's responsibilities include

1. Review all research problem statements assigned
2. Recommend whether to endorse, enhance, combine, modify, or reject the problem statements, and whether to forward to the RIC for further consideration
3. Create additional problem statements, especially when needed to address a CCOT strategic need

Research Implementation Council (RIC)

RIC members bring a broad knowledge of Colorado and CDOT transportation research and development needs. The RIC recommends an RD&T program to meet these needs. Research projects are prioritized by the RIC through a process that ensures the CDOT mission, vision, and strategic goals are considered.

The members of the RIC are selected by the ARIB Manager and approved by the DTD Director and Chief Engineer, with the objective of maintaining a proactive RIC that broadly represents the transportation program. A representative from the Colorado Division of the FHWA is invited to attend and participate in RIC meetings. For many project areas, the RIC will include a member who has the subject area authority within CDOT and will serve as the RIC sponsor for research projects in that subject area.

RIC members activities include,

1. Review problem statements that are supported by the OTs, participate in discussions at RIC problem statement evaluation meetings (2 each year), and provide recommendations and prioritization for funding.
2. Participate in meetings with ARIB to exchange information and updates, and to provide advice on future directions for CDOT research and ARIB research administration.
3. Advocate for, maintain, and enhance the engagement of all CDOT staff with the research process.

Study Panel

Each research project has a study panel formed by the study manager and champion to guide and support the research. Study panel members bring subject matter expertise, relevant knowledge, and often are stakeholders in the research outcome.

The functions of the study panel are to

1. Assist the study manager with the project definition and contracting steps. This includes assisting with
 - a. Development and review of the SOW and RFP. Note that significant change to the approved problem statement requires approval of the ARIB Manager. In addition, funding changes require FHWA approval.
 - b. Advice on strategy for identifying qualified researchers. For example, projects may be undertaken by CDOT staff, at local public universities and state agencies, or by researchers found through a broad search of all universities, consultants, and private research groups.
 - c. Review of criteria used to evaluate proposals, including the ability of the PI to produce an implementable product on schedule and within budget.
 - d. Selection of the PI based on the proposals received and selection criteria.
2. Participate in overseeing and guiding the research
 - a. Participate in panel meetings and provide technical advice.
 - b. Review progress reports and notify the study manager of emerging concerns.
 - c. Review deliverables, including draft and final reports; and
 - d. Provide advice on implementation paths and review the final implementation plan.
3. Advocate for implementation of usable results.

Principal Investigator (PI)

The functions of the PI include

1. Complete the research according to the contracted SOW, as scheduled and within budget
2. Identify any issue that could impact the SOW, expected outcome, schedule, or cost of the project and promptly communicate it to the study manager
3. Fully and proactively participate in all panel meetings
4. Provide progress reports to the study manager at the end of each calendar quarter (or other agreed interval)

5. Throughout the research, consider how results and conclusions can be implemented
6. provide a draft final report to study manager at least two months before the project is expected to conclude, address all study panel and editorial comments on the draft report, and submit a final report that follows the required report format. The final report should be submitted as a digital file, with all editorial and formatting corrections completed. It should conform to the required research report formatting (see Appendix C).

Director of the Division of Transportation Development (DTD)

Functions of the Director of DTD as they relate to the RD&T Program are to

1. Participate in the development of strategic directions for research
2. Review project recommendations of the RIC and make necessary adjustments in cooperation with the ARIB Manager and Chief Engineer
3. Review and approve the RD&T section of the DTD SP&R Work Program
4. Submit the DTD SP&R Work Program, in cooperation with the CDOT Executive Director, to the FHWA Division Office for approval

Chief Engineer

Functions of the CDOT Chief Engineer as they relate to the RD&T Program are to

1. Participate in the development of strategic directions for research
2. Review project recommendations of the RIC and make necessary adjustments in cooperation with the ARIB Manager and DTD Director
3. Provide general oversight of the implementation of research findings that are the responsibility of the Chief Engineer,
4. Support the implementation of research, especially for a major change or high-risk change, and
5. Communicate relevant research findings to engineering staff

CDOT Research Librarian

The CDOT research librarian is responsible for the CDOT library, which houses the most comprehensive collection of transportation reference materials in Colorado. The librarian has access to national and international transportation reference resources. The library is open to CDOT employees and to the public, and its catalog is accessible online. Library staff perform customized literature searches on request.

The librarian supports research through

1. Maintaining an up-to-date, accessible inventory of transportation reference materials
2. Maintaining the ARIB portion of the CDOT website, at <https://www.codot.gov/programs/research>
3. Ensuring CDOT research final reports are properly formatted and publishing them online and in national databases (Refer to Appendix C for report formats.), and
4. Conducting literature searches for ARIB projects.

7. RESEARCH STUDY IDENTIFICATION

Research study ideas are gathered through the solicitation of problem statements. Studies may also be proposed and requested by the ARIB Manager based on interest from CDOT management, CDOT staff, or FHWA personnel.

The three overarching stages in a research project's life cycle are (1) the review and selection steps, which occur between problem statement submission and the incorporation of the project into the DTD Work Program, (2) the research project management steps, which occur from project approval through publication of a final report, as described in Chapter 8, and (3) implementation of results following the project, as described in Chapter 9.

Steps for study identification and development are (dates are approximate):

1. ARIB accepts research problem statements throughout the year and conducts an evaluation and selection process twice each fiscal year. Colorado's fiscal year begins on July 1. Problem statements are submitted via the [ARIB Research Problem Statement web page](#). Deadlines are set, approximately at mid-February (the Spring cycle) and mid-August (the Fall Cycle), and problem statements submitted prior to the deadline enter the review process. Approximately 2 months prior to the deadlines, ARIB will publicize the submission opportunity. The required forms (see Appendix C) consist of basic information in a Google form, the problem statement form, and a short PowerPoint summary to aid in the review.
2. Each problem statement must have an identified CDOT champion. If requested by the champion or the ARIB manager, a preliminary literature search for other completed or ongoing research related to the problem will be performed through the CDOT Research Library.
3. In consultation with ARIB staff, the ARIB manager may elect to decline submissions that are not practical. Submissions may also be deferred to a future evaluation cycle, with recommendations for further development.
4. The ARIB manager distributes each problem statement to the ARIB research program manager that leads the OT most suited to evaluate the topic. Oversight Teams will consider and discuss each problem statement (its relation to previous research, need, timeliness, feasibility, application, relation to strategic directions of CDOT), and provide ARIB with opinions on the overall value of the topic.
5. ARIB will consider the views of each oversight team and determine the subset of problem statements to be considered by the RIC. This subset will be passed to the RIC prior to the RIC evaluation meeting.
6. RIC meetings will be scheduled approximately 6 weeks after the problem statement deadlines. The RIC will meet and provide recommendations on the priority of the problem statements, as well as supporting comments.
7. A final set of Problem Statements are determined by the ARIB manager in consultation with and approval by the DTD Director and the Chief Engineer. For the Spring cycle, decisions will be entered into the DTD SP&R Work Program for consideration and approval by FHWA. Once in the approved Work Program, Spring cycle projects can become active on July 1. Fall cycle problem

statements are submitted for FHWA approval through an Amendment to the current-year Work Program.

8. Sometimes there is a compelling need for a research project to be undertaken sooner than the next RIC evaluation cycle allows. In this situation, a decision is made jointly by the ARIB Manager, DTD Director, and Chief Engineer. FHWA approval is then sought through an amendment to the DTD Work Program. This is a rare occurrence.

In evaluating projects for the Work Program, the OTs, RIC, and those in the approval chain will evaluate the problem statements based on research need or importance and implementation potential, using organizational strategic priorities as context.



Figure 5. Debris flow damage to Interstate 70 through Glenwood Canyon, CO following heavy rain on the Grizzly Creek fire burn scar.

8. ACTIVE RESEARCH STUDY STEPS

Research project management steps take place following the projects approval in the Work Program and end with publication of a final report.

Once projects are fully approved and in the Work Program, ARIB staff and CDOT subject matter experts develop the problem statements into well-defined research projects. Generally, a SOW is developed for use in an RFP. State procurement processes are followed to engage the best qualified proposer to conduct the research (see Appendix E). A research project is rarely completed within the same fiscal year it is budgeted. The research program consists of both new studies budgeted in the current fiscal year and ongoing studies that are carried over from previous fiscal years.

The following are key steps when undertaking a research project

Assign a Study Manager

For each approved research project the ARIB Manager designates a study manager from the Research Branch staff. Typically, this is the person who led the problem statement through the OT evaluation, and the study manager remains involved with the research project for its full duration.

Assemble a Study Panel

The study manager and study champion will assemble a study panel composed of at least two people from CDOT who are outside the Research Branch and have relevant expertise. One of the members of the panel should be an appropriate CDOT subject matter expert. Most often, the champion is designated as the study panel leader. study panel members and the study manager will develop a SOW based on the problem statement. (See also Functions of the Study Panel in Ch 6. Research Roles and Functions).

Initiate RFP or Procurement Process

Working with the CDOT Procurement and Contract Services Office the study manager will determine the best procurement method for the research project. Generally, this will be through an RFP to relevant universities and consulting companies. Appendix E outlines common procurement methods for research projects. Following procurement rules, the study panel will review proposals and recommend a PI.

Negotiate the PI Contract

The study manager and CDOT Procurement and Contract Services office will negotiate the final agreement with the PI. Along with work specific to conducting the research, this agreement will require a standard set of deliverables including

- Quarterly progress reports (or another period as agreed) to the study manager, using the required format (see Appendix C);
- A final presentation to the study panel;
- The final report in the required format (see Appendix C), including a written implementation plan;

- A research brief. A recommended format is provided (see Appendix C);
- A concise executive summary of the final research report including a recommendation of implementation

Contract Start

Once the proposal is approved and the contract is in force, the study manager will issue a Notice To Proceed to the PI. The PI will proceed with the study, generally beginning with a study panel kickoff meeting.

Progress Reports and Budget Tracking

The study manager and champion are the primary points of contact between the PI and CDOT. The study manager has responsibility for reviewing progress reports and invoices to ensure the project stays on track both in its progress and its use of funds. Periodic progress reports are required of each study. The study manager will follow-up with the PI to ensure the timely submission of these reports in CDOT format (Appendix C). Progress reports also support the study manager's verification of work done when approving submitted invoices.

Tracking the Research

The study manager will use progress reports and other information to monitor the progress of the study and determine if the PI is following the scope of work and is within the budget. The study manager will work with the PI to correct or clarify any variances, informing the study panel and the ARIB Manager if the study appears to be behind schedule or not following in the direction and budget of the study proposal and contract.

Payments

The study manager will approve invoices for payment that are consistent with the progress reported, and ensure invoices are forwarded to the CDOT business office for payment. The study champion will also review and approve invoices. If either the study manager or champion are not available then a second cognizant person will review and approve invoices so there are always two approving signatures.

Changes to the Study

If changes in the schedule, budget, or Work Program are necessary, it is the responsibility of the PI to submit an amendment in writing to the study manager following the terms of the contract. If amendment of the contract is needed, the study manager will work with the CDOT Procurement and Contract Services Office to enact the changes following state fiscal rules. Changes should be in consultation with the study panel and require the approval of the ARIB manager.

Final Report Review

The PI shall submit a draft final report no less than two months before the end of the project. This draft must be in good form, including its spelling and grammar. The study panel members review the draft final report and provide any necessary feedback. The study manager may also request that other subject matter experts, from both inside and outside the department, review the report. This review should address the technical merits of the report, as well as editorial review. All comments from the reviewers must be addressed by the PI to the satisfaction of the study manager prior to publishing the report.

Presentation of the Research to the Study Panel and Interested Parties

The PI will present the finding and recommendations of the research, typically through a PowerPoint presentation, to the study panel members and other interested parties who are invited by the project manager. The PI will incorporate all comments and suggestion received during the presentation into the final report.

After the PI has addressed all comments and completed final content and editorial review, the revised report will be given to the reearch librarian for a final review. The librarian will review the cover, the front matter, the executive summary, and conclusions for grammatical and spelling errors and conformance to established guidelines, including compliance with federal requirements of accessibility to people with disabilities (Section 508 of the Rehabilitation Act (29 U.S.C. § 794d), as amended by the Workforce Investment Act of 1998 (P.L. 105-220))

Final Report

Final reports should be prepared in a timely manner for each research project and must follow the ARIB research report format (Appendix C). A completed "Technical Report Documentation Page" must be included in the report. Conclusions should be well justified, and research findings by others should be referenced appropriately.

The PI should submit an electronic Microsoft Word file of the final report to the study manager. The report will be converted to PDF, published the Research Branch web site, and submitted to the TRID database.

Project Closeout

Once the final report is accepted as complete, the project manager will ensure closeout steps are completed. These include

- Publishing the report to the CDOT ARIB website and its intake to the CDOT Research Library, forwarding it for inclusion in the TRID database and other transportation libraries.
- Forwarding the report to Study Panel members and other interested stakeholders.
- Checking that all contract deliverables are received, that all invoices have been paid, and closing the project subaccount.
- Archiving key project information and files on the ARIB internal shared space.



Figure 6. CDOT has a long history of avalanche research. A 2020 research report examined the design and use of snow sheds to protect traffic, such as this one near Rogers Pass in British Columbia.

9. RESEARCH STUDY IMPLEMENTATION

Although implementation occurs after the research is complete, it is considered throughout the research process. In fact, because of its importance, it is a responsibility of nearly all roles outlined in Chapter 6.

Implementation Focus During the Research

Consideration of how the research will be used by CDOT, or implemented, is present as early as Problem Statement submission. A question on the Problem Statement submission form asks how the research findings may be used in the planning, design, construction, maintenance or operation, and safety improvement of Colorado's transportation system. Because each submission requires a CDOT study champion, even ideas that originate outside CDOT will have a CDOT subject matter expert thinking about how the research will be used.

The feasibility and potential impacts of the research idea are considered by the OT and the RIC as part of their evaluation, and if the idea progresses this is also considered during approval by the ARIB Manager, DTD Director, and Chief Engineer.

The project SOW developed by the study panel will include contractual requirements for consideration of implementation. The Final Report is required to include an Implementation Statement that identifies which recommendations should be implemented by CDOT, describes an implementation strategy, and discusses how CDOT would benefit. This information should also be included in the final presentation by the PI to the study panel.

As a final step in the research phase the project, the study manager or champion works with the study panel, PI, and others to develop the Implementation Plan to translate research recommendations into practice within CDOT (the implementation plan format can be found through Appendix C). The plan identifies the expected implementation product and the steps needed to put the findings into standard practice at CDOT.

It is the nature of research to uncover new knowledge or understanding. Not every project will end with implementable results. In fact, that is expected. However, the majority of funded projects produce results that can be considered for implementation.

Implementation Following Completion of the Research

Once the research is completed, primary responsibility for the implementation of recommendations remains with the champion. For most projects, the Chief Engineer, the RIC sponsor, and sometimes other RIC members have a role in supporting the champion.

Implementation typically includes an effort to communicate findings to appropriate staff (through presentations or training) and incorporating the findings into CDOT operating documents (Standard Specifications, Design Manual, Materials Manual, etc.). It can sometimes include pilot projects and steps to formally approve changes. Typically, implementing research outcomes will improve or impact one or more of the following: design and construction methods, design and construction specifications, planning processes, maintenance practice, content of manuals. They may also lead to initiation of new programs, or may provide new technology. In some cases, such as research projects that result in negative results, no implementation will be appropriate.

Following the creation of the Implementation Plan, ARIB assists with tracking the progress of the project’s implementation to evaluate its benefit for CDOT. ARIB requests that the champion annually report progress. This can be an update of the “Research Outcomes Implementation Plan” (Appendix C).

The information collected is partly used for annual reporting in the FHWA-Colorado Division and CDOT Stewardship and Oversight Agreement (Chapter 11). Performance Measure #97 applies to ARIB and measures the percent of recommendations implemented or adopted using 5 years of data with a two-year lag following publication of the research report (i.e. using a lookback period of between 2 and 7 years).

Finally, ARIB conducts activities that, while not applicable to every project, can promote implementation. These include communicating research findings through the Research Brief, participation on the State Transportation Innovation Council incentive program (STIC), and managing the Technology Transfer program (T2).



Figure 7. Mule deer approaching the new wildlife underpass for State Highway 9. CDOT research documented a 92% reduction in wildlife-vehicle crashes following the addition of wildlife crossings, fencing, escape ramps, and other treatments at key locations along SH9.

10. PEER EXCHANGE PROCESS

Peer exchange of management practices helps maintain the good performance of state DOT research programs. This external review process is intended to provide new ideas, exchange information with similar programs, and generate recommendations to enhance ARIB's performance. 23 CFR 420.209 requires that a peer exchange be completed periodically. FHWA interprets that to mean that a peer exchange shall be completed approximately every five years.

Peer Exchange Panel

A panel with knowledge of state research programs will be invited to learn about the CDOT RD&T management process, present their processes, and provide recommendations for areas of potential improvement. The Peer Exchange may take place virtually or in person. ARIB will budget SPR-B funds for contracted support, and in the case of an in-person meeting, for travel expenses for the peer exchange panel. The external panel may consist of

- Research managers and senior staff from other state DOTs
- Representatives from the FHWA
- Representatives from other federal, state, regional, or local transportation agencies
- Representatives with research management responsibilities from private consulting companies, government laboratories, or universities
- Others whose participation the ARIB Manager believes will be valuable

The ARIB manager and ARIB staff will participate and interact with the panel. Other CDOT staff will be invited to learn and to present as appropriate.

Agenda

The peer exchange panel typically spends about two days with ARIB staff and research program stakeholders. The focus of a peer exchange is at the discretion of the host program, but it must address management practices.

The Peer Exchange discussion items may include the following:

- Discussion of the research program's current management practices and ideas for adjustment or improvement.
- Discussion with executive management of the strategy for research and its relationship to broader strategy and priorities.
- Discussion of the scope of the research program, including activities in the Work Program
- Review of example projects as they advance through the system, including the solicitation, selection, choice of principal investigator, project progress, and implementation activities
- Discussion with researchers and customers of the RD&T program, which may include RIC members, OT members, study panel members, champions, CDOT researchers, past or ongoing PIs and contractors, and CDOT planning, design, maintenance, or operations personnel

Peer Exchange Panel Report

The panel will prepare a draft report that summarizes the meeting and provides recommendations and actions that address the efficiency and effectiveness of the RD&T program.

After discussing their findings and recommendations with CDOT staff, the panel will finalize the report. The written report is shared on the AASHTO Research and Innovation website.

Participation in Reviews with other state DOTs

CDOT research staff participate in reviews of other state DOT research programs, provided travel expenses (if needed) are paid by others. As well as supporting these programs, reviewers should bring back new ideas, insights, and new perspectives to the Colorado research program.



Figure 8. Participants in the Autonomous Maintenance Technology Pooled Fund Annual meeting (October 2021).

11. STEWARDSHIP AGREEMENT

The CDOT – Federal-Aid Highway Program (FAHP) Stewardship and Oversight Agreement (SOA) documents the roles and responsibilities of CDOT and the FHWA’s Colorado Division, and the methods of oversight used to effectively deliver the FAHP.

It outlines a risk-based approach to effectively and efficiently manage public funds, ensure the FAHP is delivered in accordance with applicable laws, regulations, and policies, and ensure it is consistent with good business practices.

The current SOA, which is available at <https://www.codot.gov/business/designsupport/cdot-fhwa-stewardship-agreement>, includes two performance measures that indicate the health of the CDOT research program. The section relevant to ARIB is reproduced in Appendix G.



Figure 9. The CDOT Research Library provides access to Colorado transportation reference materials and is a gateway to national and international resources for transportation research.

APPENDIX A – DEFINITIONS AND ACRONYMS⁴

AASHTO - American Association of State Highway and Transportation Officials

AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all transportation modes, including air, highways, public transportation, active transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system.

Areas of Emphasis

Areas of Emphasis are topical areas of special interest for research at CDOT. They are areas where focused research has the potential to result in substantial near-term and long-term benefits to Colorado, and where local factors make Colorado a logical choice to lead this research.

ARIB – Applied Research and Innovation Branch

ARIB manages the Research, Development and Technology (RD&T) program to address research needs across CDOT. Research addresses methods, materials, technologies, and planning to enable CDOT to promote safety, enhance mobility and sustainability, save money, plan for future technologies, and protect the public investment in transportation infrastructure. ARIB is also referred to as the Research Branch.

Applied Research

Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.

CDOT – The Colorado Department of Transportation

The Colorado Department of Transportation (CDOT) exists to ensure that Colorado has a safe and efficient highway system by building and maintaining interstates, U.S. highways and state highways.

DTD – Division of Transportation Development

The Applied Research and Innovation Branch is one of 6 branches within the CDOT Division of Transportation Development.

FHWA - Federal Highway Administration

FHWA is an agency within the U.S. Department of Transportation that supports state and local governments in the design, construction, and maintenance of the Nation's highway system (Federal Aid Highway Program) and various federally and tribal owned lands (Federal Lands Highway Program). FHWA provides stewardship over the construction, maintenance and preservation of the Nation's highways, bridges and

⁴ Acronyms used only in appendices are not included here

tunnels. FHWA also conducts research and provides technical assistance to state and local agencies to improve safety, mobility, and to encourage innovation.

Final Report

Research project Final Reports document all technical data, analyses, and findings for an entire project and demonstrate fulfillment of the conditions of the contract.

Implementation

Implementation is the process of putting research recommendations into practice. It is the adoption of a product for use, and includes Technology Transfer activities that promote adoption, such as information dissemination, training, demonstration, and deployment.

LTAP – Local Technical Assistance Program

The Local Technical Assistance Program (LTAP) is a Federal Highway Administration (FHWA) technology transfer program that provides technical assistance and training to local transportation departments across the nation. LTAP strives to bridge the gap between research and practice by conducting training sessions and demonstrations and by serving as a clearinghouse for information related to state-of-the-art technology in the construction and maintenance of roads and bridges. LTAP is funded by the FHWA, with matching funds from state governments, universities, state highway agencies, and other organizations.

Metropolitan Planning Organization (MPO)

A Metropolitan Planning Organization (MPO) is the policy board of an organization created and designated to carry out the metropolitan transportation planning process. MPOs are required to represent localities in all urbanized areas with populations over 50,000, as determined by the U.S. Census.

NCHRP - National Cooperative Highway Research Program

NCHRP is a transportation pooled fund program directed toward the study of problems of national significance that affect highway planning, design, construction, operation, and maintenance nationwide. NCHRP is administered by TRB and voluntarily sponsored by the state DOTs and other member departments of AASHTO. Each state's contribution amounts to 5.5 percent of its SP&R apportionment. These funds can be spent only for the administration of problems approved by at least two-thirds of the states.

OT - Oversight Team

Oversight teams of experts and stakeholders established by ARIB provide technical guidance and oversight for research in specific subject areas (refer to Chapter 5, “Research Roles and Functions”)

Peer Exchange

Peer exchange means “a periodic review of a state DOT's RD&T program or portion thereof, by representatives of other state DOTs, for the purpose of exchange of information or best practices. The State DOT may also invite the participation of FHWA and other federal, state, regional, or local transportation agencies; the Transportation Research Board (TRB); and academic institutions, foundations, or private firms that support transportation research development or technology transfer activities.” (23 CFR 420.203)

PI - Principal Investigator

The PI is the lead researcher who is responsible for the technical direction of the work on a research study. The PI has the primary responsibility and is expected to be available and actively involved in the research efforts for the full duration of the project. In some research studies, more than one person shares responsibility of research as Co-Principal Investigator(s).

Proposal

A Proposal is a document submitted by a prospective researcher to CDOT in response to the RFP (see below). It defines the scope of work, budget, project schedule, deliverables, and qualifications of the research team.

Problem Statement

The problem statement is a concise description of a problem or innovative idea that needs to be addressed through research. It must include the potential benefits of performing the research and implementation methods for the results. (Refer to Appendix C)

RFP – Request for Proposals

An RFP refers to the general process CDOT uses to select a PI to conduct a research project and write a final report. It can refer to the formal process managed by the procurement office where a panel of experts and stakeholders review proposals and select the one that is most beneficial to the state. It can also refer to a less formal process where ARIB solicits university proposals to select the best PI. The less formal process is sometimes called the Research RFP or RRFP.

RD&T – Research, Development & Technology

RD&T activity means a basic or applied research project or study, development or technology transfer activity (CFR 23 420.203). The state's RD&T program is funded through SPR Subpart B funding.

RIC – Research Implementation Council

The RIC is composed of CDOT senior managers selected jointly by ARIB Manager, DTD Director, and Chief Engineer. It includes one or more representatives from the FHWA. The RIC reviews, evaluates, and provides recommendations of research projects for funding based on CDOT's mission, strategy and strategic goals. RIC members also ARIB provide advice on future directions for CDOT research and ARIB research administration.

SME - Subject Matter Expert

The SME is recognized statewide by peers to be an expert in a specific area of the transportation program.

SOW – Statement of Work (sometimes Scope of Work)

The SOW is a formal document that describes and defines the research work activities, deliverables, cost estimate, and schedule needed to address the problem statement or research idea.

SP&R - State Planning and Research

SP&R funding is the major source of funding for state transportation research. Federal law requires that two percent of the federal-aid funds given to states be apportioned for SP&R activities. Of these funds, a minimum of twenty-five percent must be allocated for research, development, and technology (RD&T). RD&T activities involve research on new areas of knowledge; adapting findings to practical applications by developing new technologies; and the transfer of these technologies, including the process of dissemination, demonstration, training, and adoption of innovations by users.

Study Manager

The study manager, usually a staff member from the research branch, is responsible for overseeing the research study and coordinating activities with the study panel, the PI and various institutions. (Refer to Chapter 5, “Research Roles and Functions”)

Study Panel

The study panel is an ad hoc committee consisting of experts and stakeholders, established to oversee a research study. It develops the directions of the study to best meet the needs of CDOT, reviews study progress, products, and reports, and develops the implementation plan for research findings. (Refer to Chapter 5, “Research Roles and Functions”)

Technology Transfer

Technology transfer consists of activities that promote adoption of a new technique or product by users, often involving information dissemination, demonstration, deployment, training, and other activities.

TAC – Technical Advisory Committee

Each Transportation Pooled Fund project has a TAC to provide overall project direction and oversight. The TAC includes a technical representative from each participating agency and is chaired by the lead state representative.

TRB - Transportation Research Board

The TRB is one of seven program divisions within the National Academies of Sciences, Engineering, and Medicine. It conducts activities to solve complex problems and inform public policy decisions, and it provides independent and objective analysis and advice to the Nation. The TRB’s mission is to promote innovation and progress in transportation by stimulating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research results.

Transportation Pooled-Fund Studies

The Transportation Pooled Fund (TPF) Program, administered by FHWA, is a means for interested states, FHWA, and other organizations to partner when significant or widespread interest is shown in solving transportation-related problems. Partners may pool funds and other resources to solve these problems through research, planning, and technology transfer activities. (Refer to Chapter 6, “RD&T Program Overview” in this manual).

TRID - Transport Research International Documentation

The TRID database is an integrated database that combines the records from TRB's Transportation Research Information Services (TRIS) Database and the Organization for Economic Cooperation and Development (OECD) Joint Transport Research Centre's International Transport Research Documentation (ITRD) Database. The TRID database provides access to more than 1.3 million records of transportation research worldwide.

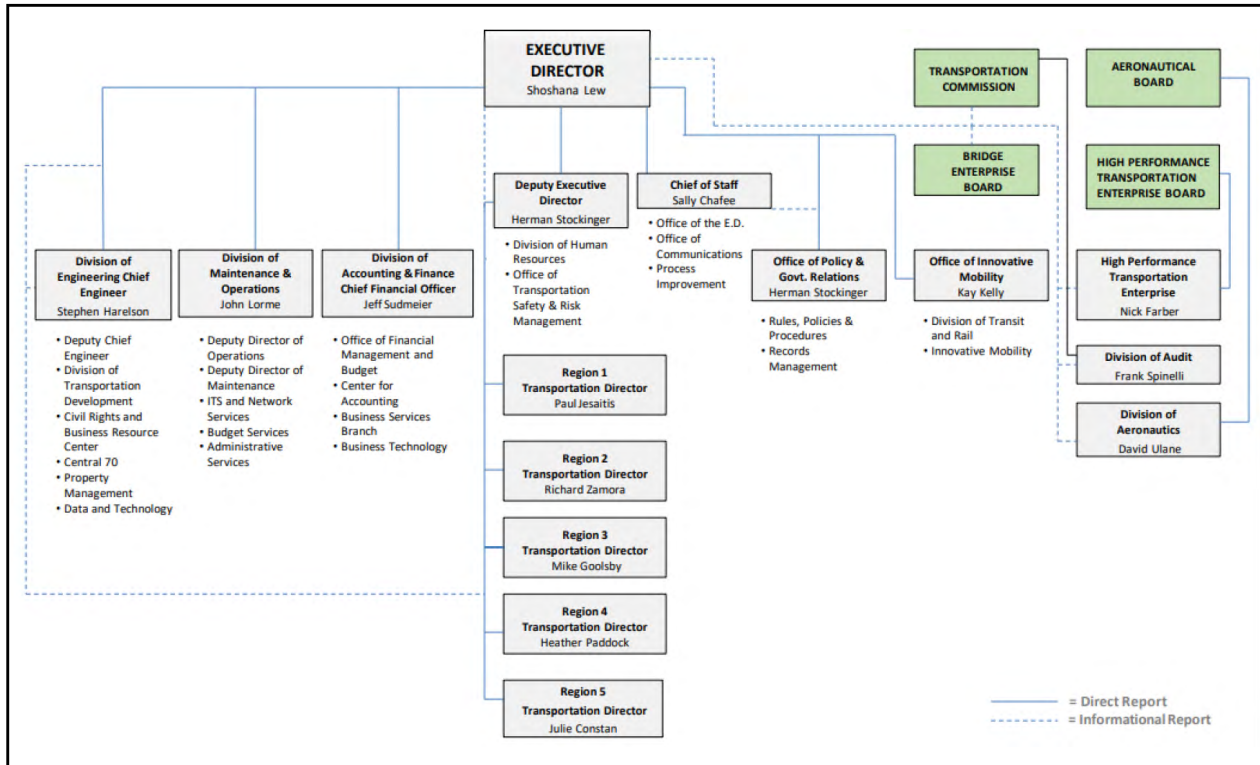
TRIS - Transport Research Information

TRB's Transportation Research Information Services (TRIS) includes the TRB Library and the TRB Databases which are available on the TRB website.

Work Program

The DTD Work Program is a document that describes the budget and projects undertaken in each state fiscal year. The ARIB part of the Work Program includes each research study. The Work Program is updated and approved by CDOT and FHWA annually.

APPENDIX B – ORGANIZATIONAL STRUCTURE, MISSION, VISION, AND INITIATIVES



CDOT Mission and Vision

Mission: “To provide the best multi-modal transportation system for Colorado that most effectively and safely moves people, goods, and information.”

Vision: “To enhance the quality of life and the environment of the citizens of Colorado by creating an integrated transportation system that focuses on safely moving people and goods by offering convenient linkages among modal choices.”

CDOT FISCAL YEAR 2021-22 STRATEGIC POLICY INITIATIVES

Whole System, Whole Safety:

Improve the safety of Colorado’s transportation system

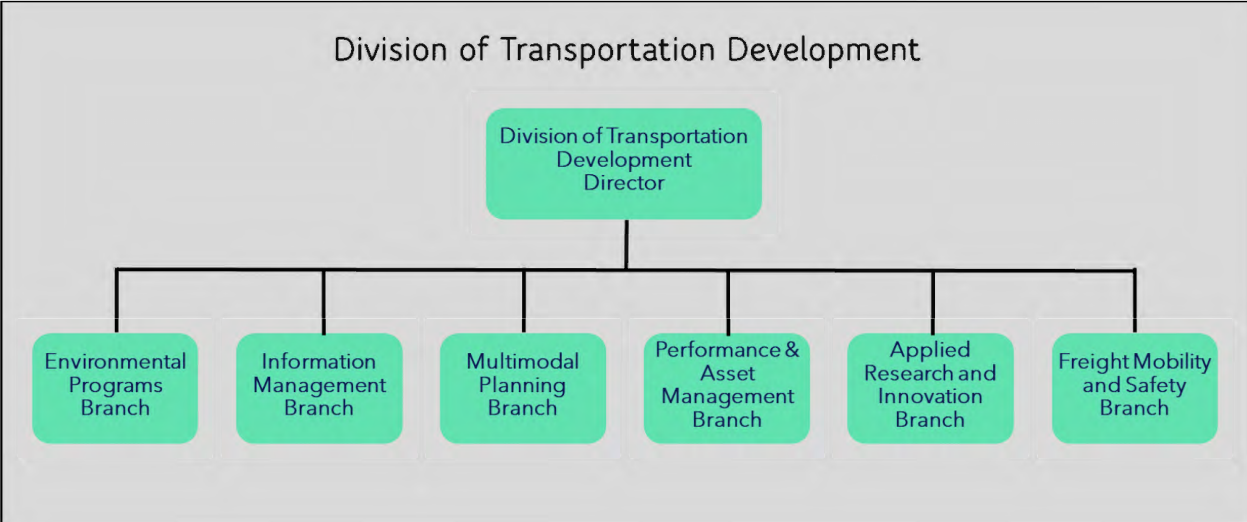
Clean Transportation:

Reduce pollution in our air and congestion on our roads

Accountability & Transparency

Respond effectively to our internal and external customers’ needs

Colorado Department of Transportation (CDOT) Organization Structure, Mission and Vision, and Strategic Policy Initiatives (2022)

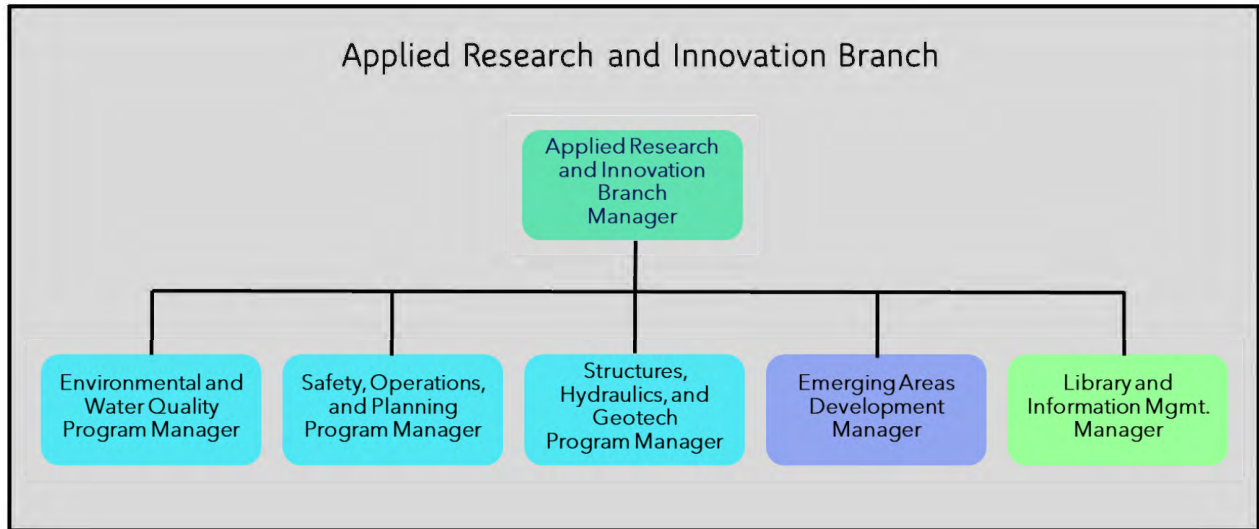


DTD Mission and Vision

Mission: “DTD is dedicated to preparing Colorado’s transportation system for the future through planning, analysis, and innovation.”

Vision: “Transforming Colorado with BIG IDEAS to create a sustainable, equitable, and connected transportation system.”

Division of Transportation Development (DTD) Organization Structure, Mission, and Vision (2022)



ARIB Mission

Mission: “To conduct a program of high-quality, applied research, advancing solutions to the increasingly complex needs confronting Colorado's transportation future.”

Applied Research and Innovation Branch (ARIB) Organization Structure

APPENDIX C – FORMS AND TEMPLATES, THE ARIB FORMS LIBRARY

Forms and templates, along with other guidance for researchers can be found on the ARIB website. The Forms Library is maintained at this link

<https://www.codot.gov/programs/research/form-library>

This appendix describes key forms found within the Forms Library

Problem Statement Form

A Problem Statement is a concise description of a problem or innovative idea that can be addressed through research. A good research problem statement should identify an existing gap in knowledge in the field and lead to further research. CDOT accepts problem statements initiated by CDOT staff, universities, and other stakeholders to develop its annual research program. The problem statement is not a grant application or a contract document. Submitted problem statements may be publicly shared and may be the basis for an open Request for Proposal (RFP).

Problem statements are submitted via a website. Input consists of the completion of a short Google form with basic intake information, and the upload of both a Microsoft Word document and a PowerPoint document. Templates for these two documents are found in the Forms Library. Submissions are initiated from this website:

<https://www.codot.gov/programs/research/problem-statement>

Quarterly Progress Report Template

The Quarterly Progress Report (QPR) is a description of progress made on a study during a calendar quarter or other designated period. QPRs are written by the PI and submitted to the CDOT Study Manager. They are required for every calendar quarter after the Notice to Proceed through study completion. In some cases, monthly progress reports or another interval may substitute with the approval of the study manager.

QPRs will be shared with external parties, including but not necessarily limited to the study panel, FHWA, and other stakeholders. They are used to keep the study manager and study panel apprised of progress toward deliverables and tasks, significant events, anticipated events, schedule changes, preliminary observations, or other elements. In some cases, QPRs may be used to track progress tied to invoicing.

The first part of the form contains basic project information unlikely to change over the course of the study, such as contracting information, budget, description, and a list of study panel members. The PI can request this information from the study manager if needed. The latter part of the form contains entries tracking progress toward notable milestones, tasks, and deliverables. Entries should be listed with the most recent events first.

When submitting the Quarterly Progress Report, files should be named following this convention:

StdyXXX-XX_Study Title_YYYYQ1

Example: **Stdy115.01 SH 9 Wildlife Monitoring_2019Q3**

A QPR template can be found in the Forms Library.

Research Report Formatting Instructions

Research Project final reports must conform to a strict format. Instructions for this format can also be found in the Forms Library. Among the requirements, it is extremely important to ensure the document follows Accessibility (“Section 508”) provisions. Reports will be submitted to national databases and risk rejection if these requirements are not met.

Research Report Front Matter Instructions

In addition to formatting instructions, Research Project final reports must use a uniform format for the Front Matter (Cover Page, General Statement Page, and Technical Documentation Page). Instructions and a template for these pages are also in the Forms Library.

Implementation Plan Form

At the conclusion of the research project, the Implementation Plan Form is used to identify recommendations that can lead to specific implementation products, and the steps to put findings into standard practice at CDOT. This form can be referenced over time to track the progress of implementing recommendations. The form is present the Forms Library.

Research Brief

The Research Brief is a one to two-page “brochure” designed as a stand-alone synopsis of the study for distribution to CDOT leadership and other interested parties. It should be written for a public, non-specialist audience, and should summarize the project approach, goals, and findings in a visually appealing format. Most projects are asked to complete a Research Brief near the start of the project focusing on study goals and methods, and a Final Research Brief at the project completion focusing on results and recommendations.

We encourage PIs to use the ARIB template for this Brief but will accept style and formatting modifications suitable for the project, that make it more readable, better suited to distribution, or otherwise improve the goals of summarizing research findings for non-specialists. Any modification to the template must be approved by the research project manager. The Research Brief template can be found in the Forms Library.

APPENDIX D – CDOT ARIB STUDY NUMBER PROCEDURE

The Research Branch will assign Study Numbers to identify projects according to the general subject area, and the fiscal year. Subject areas are coded according to the table below.

Subject Area	Code
Environmental, Sustainability, Water Quality, and Planning	1
Structures, Hydraulics, Soils, and Geotechnical	2
Safety, Maintenance, and Operations	3
Pavements and Materials	4

Numbers will be of the format: **YYY.NN**, where,

A is the subject area code (1 – 4) defined in the table below

YY is the last two digits of the state fiscal year

NN is a sequential number assigned by ARIB

For example, the fourth study (04) within the Safety, Operations, and Planning area (Subject Area 3) in Fiscal year 2022 (22) will be assigned: **322.04**

Subject Area Code = 3
Last two digits of fiscal year = 22
Count = 04
Resulting Study Number = 322.04

APPENDIX E – PROCUREMENT METHODS

This appendix summarizes the CDOT/State of Colorado procurement methods that a research project manager typically uses to get a research project underway. The formal requirements are documented by CDOT and more fully described by the CDOT Procurement and Contract Services [Purchasing Order Toolkit](https://sites.google.com/state.co.us/cdothub/teams/procurement-contract-services) (website: <https://sites.google.com/state.co.us/cdothub/teams/procurement-contract-services>)

In all situations, the research project manager must act in the best interests of CDOT and the State of Colorado.

Public University or Government Agency:

Contracting directly with any public university⁵ or government agency in the United States is often the easiest contracting mechanism. This does not apply to private universities or non-profit research institutes which follow the same procedures as a private consultant (see next section). Universities are allowed to hire subcontractors following their procurement method and will be responsible for managing that process.

Solicitation method via email - If the research project manager (guided by the study panel) believes the research is best done by a public university or government agency, they can solicit proposals from one or many of these entities. In some cases, they will request a formal proposal from the institution where the problem statement originated. The research project manager can do this via email, sending a solicitation with a Statement of Work (SOW) based on the Problem Statement. The SOW will clearly describe all requirements including the minimum set of deliverables.

Once CDOT has a formal proposal that addresses all aspects of the SOW, the CDOT Procurement and Contract Services Office will decide on the best contracting mechanism. Options are:

1. A standard Purchase Order (PO⁶). This will apply [Purchase Order Terms and Conditions](#) that generally cannot be modified. The benefit of a standard PO is it can be enacted quickly and is easy to manage.
2. An Inter-Agency Agreement (IAA) or Inter-Government Agreement (IGA). A customized IAA can be used for agreements with entities that are part of the State of Colorado government. These are generally used with public universities in Colorado and Colorado state agencies (for example, the Colorado Department of Public Health and Environment). For contracts with other government agencies, an IGA will be used. This is generally used for work with federal agencies, other state governments, and local governments or governmental organizations within or outside Colorado (for example United States Geological Survey, and Metropolitan Planning Organizations).

Private Consultant (including Private University):

If the research project manager decides that hiring a private consultant or private university is in CDOTs best interest, then the contracting process uses a competitive solicitation. This does not exclude public

⁵ Although this Manual refers to Universities, the rules described will apply to all Institutes of Higher Education (IHE).

⁶ Procurement acronyms used only in this appendix do not appear in Appendix A.

universities or government agencies from participating. The solicitation process follows the procurement steps described in the [Purchasing Order Toolkit](#). This list summarizes the pathways.

1. Agreements under \$5,000 can be entered into without a competitive bid. A valid quote is needed and contracting uses a pCard (CDOT's commercial card).
2. Agreements under \$150,000 may follow one of several paths. A standard PO may be used as the contracting vehicle.
 - a. Invitation for Bid (IFB) – this is a competitive solicitation and can follow a one-step or two-step process
 - b. Non Project-Specific (NPS) Services \$5k-150k – This procurement method can be used when an NPS agreement is already in place between CDOT and the vendor.
3. Agreements greater than \$150,000 require a Request for Proposals (RFP). The RFP process is more involved than the IFB process.
4. Sole Source procurement is used only when there is only a single vendor that can reasonably meet the requirements. This method is rarely used and generally takes considerable justification.

There are additional procurement solicitation methods such as Request for Information (RFI), and Invitation to Negotiate (ITN) but they are seldom used in the research process and are not described here.

APPENDIX F – TRANSPORTATION POOLED FUND PROCEDURES

1. ARIB Process for State Lead Pooled Funds

ARIB follows the following process when leading pooled funds. These steps are developed in accordance with guidelines available at the [TPF Program website](#).

Pooled Fund Project Initiation

- ARIB requests the FHWA division office to establish a new pooled fund project.
- ARIB ensures that the project is incorporated and approved in the DTD/ARIB work program.
- ARIB enters the solicitation into the TPF Program website and develops a plan for marketing the study to solicit partner interest.
- ARIB submits a [waiver request letter](#), containing the solicitation number and the request to use 100 percent SPR funds, to the local FHWA division office. If approved ARIB uploads the match waiver approval memo to the TPF study webpage.

Solicitation Stage

- The ARIB project manager notifies all potential participants to make their commitments to the solicitation on the TPF Program website. Non-DOT's work with the FHWA TPF Program Manager set up an account for their agency.
- Once the funding level is met, the ARIB project manager indicates on the post/update solicitation tab of the TPF Program website that sufficient commitments have been received and waits for a TPF project number to be assigned by the FHWA TPF Program Manager.

Project Administration

- The ARIB project manager sets up a [technical advisory committee \(TAC\)](#) to provide technical support to the project. Usually, each contributing partner provides a TAC representative.
- The ARIB project manager works with the local FHWA division office to create a TPF Program project in the Financial Management Information System (FMIS).
- The ARIB project manager prepares an [acceptance memorandum](#), agreeing to accept funding transfers from partner agencies and emails the acceptance memo, along with a link to or blank [1575-C Funding Transfer Form](#), to the local FHWA division office, the FHWA TPF Program manager, and funding contacts at partner agencies. ARIB also uploads the acceptance memo to the TPF study page.
- Partner agencies, in conjunction with their local FHWA division office finance manager, ensure that funds are available, complete the [1575-C Funding Transfer Form](#), and begin the transfer process through FMIS.

- The CDOT CFO's office transfers funds from partner agencies in FMIS. ARIB then has the funds for the project's use.
- Partner agencies that require invoices and are not using FMIS to transfer funds will work with CDOT to send payment via check or electronic transfer. All non-DOT's will require an invoice and some DOT's not using SPR funds may also request this transfer process.
- Throughout the project, the ARIB project manager awards contracts, obligates funds, pays contract invoices, and tracks funds to ensure proper accountability and balancing of obligations, expenditures, and fund balances.
- The ARIB project manager submits quarterly progress reports and other deliverables to the TPF Program website.

Pooled Fund Close Out

- At the end of the project, the ARIB project manager ensures that all deliverables have been submitted and awards closed. The ARIB project manager changes the TPF status to "objectives fulfilled".
- The ARIB project manager and CDOT business office complete and submit the [closeout funding spreadsheet](#) to the FHWA TPF Program manager to account for all obligations, expenditures, and any remaining funds.
- The FHWA TPF Program manager prepares and distributes a closeout memo and the closeout funding spreadsheet to all partner agencies and local FHWA division offices of the lead and partner agencies. The FHWA TPF Program manager changes the status to "closed" and the CDOT business office closes the project in FMIS.
- The CDOT business office completes a 1575-C Funding Transfer Form and submits it to the local FHWA division office to transfer back to participant agencies any remaining based on their contribution percentage.

2. ARIB Process for Participating in Pooled Funds being led by other Agencies

ARIB follows these steps for the Pooled Fund projects it participates in, but does not lead.

Participation

- ARIB maintains a list of all FHWA Pooled Funds that are paid using SPR funds and enters them for approval in the Annual DTD Work Program.
- To participate in additional pooled fund projects, a CDOT Champion completes a CDOT Research problem statement form. The problem statement is evaluated with the same steps as a those submitted for other research projects.
- Once part of the approved DTD Work Program, ARIB makes commitments on the TPF Program website.

Project Administration

- ARIB and the CDOT business office, in conjunction with the local FHWA division office finance manager, ensures that funds are available, completes the 1575-C Funding Transfer Form, and begins the transfer process through FMIS. This is typically done in October or November once the new Federal Fiscal Year has begun.

Role of CDOT TAC Member

- For each Pooled Fund project the CDOT TAC member acts on CDOT's behalf, participating in and voting on decisions, and acting as the CDOT point of contact for the project.

APPENDIX G – STEWARDSHIP AND OVERSIGHT AGREEMENT

This appendix reproduces the Cover Page and Research Section of the CDOT – Federal-Aid Highway Program Stewardship and Oversight Agreement.

COLORADO DEPARTMENT OF TRANSPORTATION FEDERAL-AID HIGHWAY PROGRAM

STEWARDSHIP AND OVERSIGHT AGREEMENT

April 23, 2020

DEVELOPED IN PARTNERSHIP WITH THE FEDERAL HIGHWAY ADMINISTRATION'S
COLORADO DIVISION AND THE COLORADO DEPARTMENT OF TRANSPORTATION

REVISION HISTORY

Date	Description of Changes
March 31, 2015	Original S&O Agreement
April 11, 2016	S&O Agreement with revised organizational charts and Appendix A
March 21, 2017	Revised Appendix A - Functional Program Areas; Appendix B - Manuals and Operating Agreements; and Appendix D - FHWA organizational chart
May 2, 2018	Revised Section 10.4.4, Appendix A - Functional Program Areas; Appendix B - Manuals and Operating Agreements; Appendix D - CDOT and FHWA organizational charts; and Attachment B - Program Responsibility Matrix
April 1, 2020	Revised Appendix A - Functional Program Areas; Appendix B - Manuals and Operating Agreements; Appendix D - CDOT and FHWA organizational charts; and Attachment B - Program Responsibility Matrix (minor remarks); added Section 18 Innovative Mobility
April 23, 2020	Section 18 Innovative Mobility, pages 81 and 82, added words federal and federalized, respectively

We support the concept of this Stewardship and Oversight Agreement and hereby direct that the stewardship and oversight of the Federal-Aid Highway Program be carried out in the spirit of a true partnership, as described herein.

 May 19, 2020
Shoshana M. Lew Date:
Executive Director
Colorado Department of Transportation

JOHN M CATER Digitally signed by JOHN M CATER
Date: 2020.05.20 09:48:07
+0600
John M. Cater Date:
Colorado Division Administrator
Federal Highway Administration




14. TRANSPORTATION DEVELOPMENT: APPLIED RESEARCH AND INNOVATION

INTRODUCTION

The Applied Research and Innovation (Research) program includes activities related to transportation technology.

PROGRAM OVERVIEW AND METHOD OF OPERATION

The role of FHWA is to conduct research of national focus and to transfer those technologies to state and local transportation agencies. The role of CDOT's Research Branch is to conduct research specific to state transportation needs and problems and to transfer technologies developed elsewhere into practice in Colorado.

CDOT ROLES AND RESPONSIBILITIES

The Research, Development, and Technology Transfer program (RD&T) at CDOT is the responsibility of the Applied Research and Innovations Branch (ARIB) of the Division of Transportation Development (DTD). The Structures and Technology Applications Team will handle the Federal-aid operations of research and technology transfer activities.

The primary products are:

1. Applied research: The study of phenomena relating to a specific known need in connection with the functional characteristics of a system to answer a question or solve a problem;
2. Development: The translation of applied research results into prototype materials, devices, techniques, or procedures for the practical solution of a specific problem in transportation; and
3. Technology Transfer: Dissemination, demonstration, training, and other activities that lead to the eventual deployment of a new technique or product.

FHWA ROLES AND RESPONSIBILITIES

FHWA Research Program Manager is the primary liaison for research related activities with CDOT. The Manager will approve the CDOT Research Manual and review final research reports produced by or for CDOT to ensure Federal-aid funds are appropriately used. In addition, the Manager will serve on CDOT Research Implementation Council (RIC) that is responsible for guiding and directing the research and development program. The Manager provides expertise, leadership, and oversight of the Local Technical Assistance Program (LTAP). Also, the Manager serves as the principal advisor to CDOT on federal requirements for a variety of significant national studies, transportation needs, and administrative requirements.

QUALITY ASSURANCE APPROACHES

The purpose of RD&T at CDOT is to save Colorado money, time, and lives, and to improve the quality of life and the environment through the development and deployment of new or innovative methods, products, or materials in the planning, design, construction, and operation of transportation. The ultimate measure of quality is how effectively this is accomplished. To meet this purpose, research must be timely, relevant and valid when applied to priority real-world problems. It must also be cost-effective, and accurately documented and disseminated. The technology must be appropriately transferred to the practitioner so as to be effectively utilized.

Quality is controlled in RD&T through oversight and review by experts and stakeholders. Oversight Teams and RIC are used to help focus the research program into priority areas with urgent problems to be solved. Research study panels composed of subject matter experts and practitioners with an interest in utilizing the research results are used in conjunction with each research study. A peer review of CDOT's research management process will be conducted every three to five years by researchers from other state DOTs after being trained in techniques for performing a peer review. The last Research Peer Exchange occurred in October 2015.

FHWA and CDOT will also develop risk response strategies of CDOT's research process when necessary. This process is documented in the *Colorado Department of Transportation Research Manual (July 2015)*.

PERFORMANCE MEASURES

The following performance measures will be used to assess the health of the Research Program:

Table - Performance Measures (Research)

PM #	Measure	Description	Reporting Mechanism	Reporting Frequency	Target/Baseline
97	Percent of recommendations implemented	Percent of recommendations implemented or adopted within two years of final research report, using 5 years of data The research findings and recommendations will impact one or more of the following: improve design and construction methods, improve design and construction specifications, improve planning processes, impact maintenance practice, update manuals, initiate new programs, and provide new technology	Research Work Plan and Report	State FY	50%
412	Number of projects completed on schedule	The number of projects completed in the fiscal year on schedule	Research Work Plan and Report	State FY	10

APPENDIX H – CDOT RESEARCH BRANCH HISTORY

1962

- U. S. Congress passed highway legislation which included a required 1.5% of federal highway fund to be set aside for planning and research. The Colorado Department of Highways used these funds for various studies and planning activities, but it was not until a few years later that any actual research was funded.

1965

- The Research and Special Studies Section was established within the Planning and Research Division of CDOT.

1966

- The Section undertook its first major research project, working cooperatively with the Asphalt Institute to evaluate the Ordway, Colorado Experimental Base Project. Shortly thereafter, additional roadway research projects were added with staff focusing on detailed evaluation of the roadway condition for the control and test sections.

1970

- With the acquisition of a locked-wheel skid system, the Section started conducting an annual “Sufficiency Study” reporting condition of the 9,000 miles of state highways. Data included skid resistance, roadway smoothness, and a windshield survey of cracking and rutting.

1972

- To meet the requirement of the 1970 Clean Air Act, the section began a noise monitoring and modeling project and developed the program to implement it in the districts, with Richard Griffin leading the effort.

1973

- The Section’s first study that ventured beyond research evaluating roadway experimental features was on high-altitude vehicle emissions. It supported the design of the Eisenhower Tunnel which, at 11,000 feet, was to become the highest power-ventilated tunnel in the world.

1974

- Mark Safford took over the section as BB Gerhardt retired.

1975

- The Noise program developed by the section staff moved to the Regions.
- The section began conducting air quality monitoring and modeling for construction projects to meet requirements of the 1970 Clean Air Act, with Robert LaForce leading the monitoring effort and Richard Griffin leading the modeling effort. Later Keith Burrows led the air quality program.

1977

- Denis Donnelly took over the section as Mark Safford was moved to run the traffic monitoring and analysis program for the division.

1979

- The Technology Transfer program was established in the section led by Lowell B. Steere, later by Rebecca Spain, and then by Beth Moore as the CDOT library was folded into it. The library had been in existence at CDOT since 1949, providing information and knowledge services for projects and research activities.

1980

- The Air Quality program developed by section staff moved to Environmental Branch.

1986

- The section made Colorado the 39th state to establish a Local Technical Assistance Program (LTAP). The Transportation Information Center, as it was originally called, began serving local Colorado agencies in 1986 as a cooperative effort between the FHWA, CDOT, and Colorado State University. The program provides low-cost training and technical assistance to local road and bridge agencies.

1988

- The Strategic Highway Research Program (SHRP) was established by Congress. Colorado's involvement was coordinated by Denis Donnelly.
- The section became the Research and Development Branch.
- Steven Horton was hired to work in the branch to establish and develop CDOT's Pavement Management System (PMS).

1990

- Denis Donnelly was placed on special assignment for one year to work directly for the SHRP program in Washington, D.C. and Richard Griffin became the Acting Research Coordination Engineer.
- CDOT became the second state in the country to be approved by FHWA to operate under the Research Management Option where only very large projects required FHWA approval.
- After its initial development in the Branch, the PMS program moved to the Materials Laboratory.

1991

- Through Colorado legislation the Colorado Department of Highways became the Colorado Department of Transportation (CDOT).

- Based on a federal initiative, the Intelligent Vehicle Highway System (IVHS) was established and developed within the branch.
- Denis Donnelly, shortly after returning from his special assignment in Washington, D.C., was promoted to Materials Engineer and left Richard Griffin again as the Acting Research Coordination Engineer.

1992

- With Ralph Trapani (Manager of the Glenwood Canyon Project) as the Director, the Colorado Transportation Institute (CTI) was established with the branch providing primary support.

1993

- Congressional action required that 25% of the State Planning and Research funds be set aside for research.
- Joan Pinamont became the CDOT librarian.

1994

- The IVHS research staff and responsibilities were transferred to the new Intelligent Transportation System (ITS) Branch under the Chief Engineer.

1995

- The research program was strengthened by expanding the use of technical expertise for identifying research needs, broadening the scope of the program, and raising the level of membership of the Research Council.
- The Traffic Monitoring and Analysis Section was placed within the branch.

1996

- Even with many accomplishments, including 2 patents, CDOT funding priorities changed, and CTI was dissolved.

1998

- As part of a Division of Transportation Development reorganization, the Traffic Monitoring and Analysis Section moved out of the research program and the branch became dedicated solely to research.
- The University of Colorado at Boulder replaced Colorado State University as the implementing contractor for the Colorado LTAP.
- With research as its sole role, the branch continued expanding its focus from just pavement research in the earlier years to hydraulics, structures, traffic and safety, environmental, and alternative transportation modes.

2006

- The Research Coordination Engineer, Richard Griffin, retired. Jake Kononov, Region 6 Traffic Engineer, became the Research Director and because of his background moved the branch toward more traffic and highway safety research and renamed Research Branch to the Applied Research and Innovations Branch (ARIB).

2009

- David Reeves joined the Research Branch.

2011

- Bryan Roeder transferred from Environmental Programs Branch to ARIB to manage the environmental research program.

2012

- Jake Kononov retired, and Roberto DeDios (Pavement research program manager) became the Acting Director of ARIB.

2013

- Roberto DeDios retired. Dr. Aziz Khan (Structure, Hydraulic, and Geotechnical research program manager) became the Acting Director of ARIB.
- Amanullah Mommandi became the Director of ARIB after many years as CDOT hydraulic program research manager.

2014

- Joan Pinamont retired as the CDOT librarian.

2018

- Sarah Zepeda came to CDOT as the research librarian to serve ARIB and the CDOT community.

2019

- Amanullah Mommandi and Dr. Aziz Khan retired. David Reeves (Safety, Operations, and Planning program research manager) became the Acting Director of ARIB.

2020

- Dr. Stephen A. Cohn became the Director of ARIB.
- Front Range Community College replaced the University of Colorado at Boulder as the implementing contractor for the Colorado LTAP.

2021

- Thien Tran joined ARIB to lead the Structure, Hydraulic, and Geotechnical program.

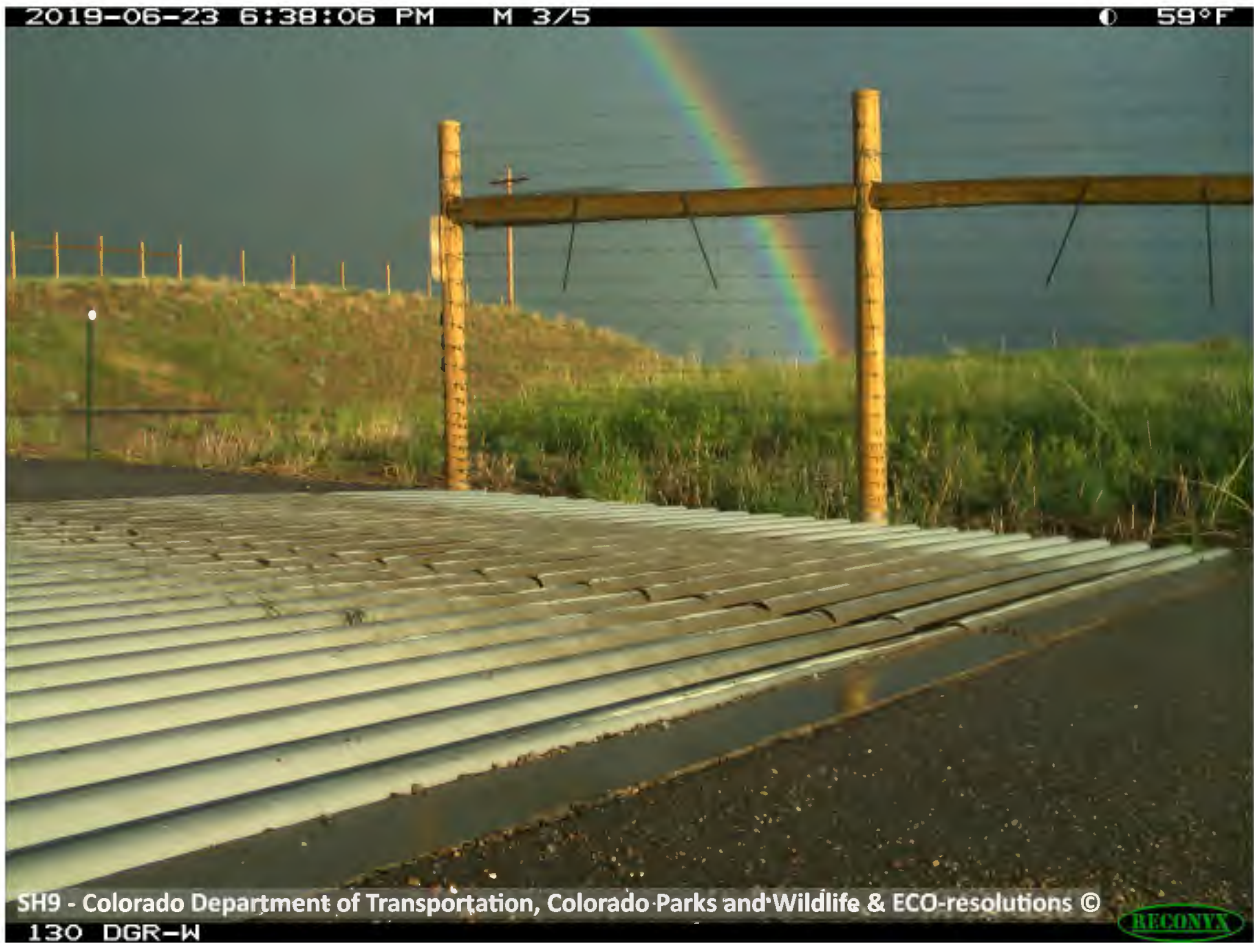


Figure 10. CDOT has tested a variety of wildlife exclusion grates. Is there a pot of gold under this one?