ARDOT 2023 • ISSUE 1

# RESEARCH INFORMER

A Newsletter by the Arkansas Department of Transportation Research Section

*Attendees gathered in the Transportation Conference & Equipment Expo Exhibitors Hall*

## INSIDE THIS ISSUE



# New Devices for Innovative Traffic Detection

BY KIM ROMANO, P.E.

The Research Section recently purchased and is testing Hawkeye and Wavetronix radar traffic sensors. With the help of the Traffic Information Systems (TIS) Section and Maintenance's Intelligent Transportation Systems (ITS) staff, the Hawkeye sensor (see photo) was installed above the I-430 dynamic message board and Pan-Tilt-Zoom (PTZ) camera, north of the Arkansas River. Engineering Interns joined the System Information & Research and ITS teams for the installation. Two Wavetronix traffic data collection devices were later installed near the Hawkeye sensor to compare data.

Data from the Hawkeye sensor is displayed on a dashboard featuring analytics that quickly visualizes traffic flows and speeds. See figure 1 on page 2. Graphics are also available for vehicle types and speeds by lane, configurable by the time of day and day of the week. A fixed camera shows real-time traffic. This fixed camera, in

*Installation of traffic counters on I-430*

## New Devices for Innovative Traffic Detection

**Continued from page 1...**

addition to ITS's PTZ camera, can be accessed via IDriveArkansas. The Wavetronix device provides continuous traffic data in an Excel-type workbook format. The Hawkeye can be configured to alert the Traffic Management Center (TMC) to slow traffic or other specific events, but the Wavetronix device does not have this ability.

Historically, Weigh-in-Motion (WIM) stations installed in pavements collect traffic data 24 hours per day, 365 days per year. They are currently the most trusted traffic count method and the only continuous count data accepted by FHWA for Highway Performance and Monitoring Systems reporting. WIM stations can be damaged and require lane closures to replace. In-pavement sensors nearly always need to be replaced after pavement rehabilitation projects.

Most traditional traffic counts are axle based and collected when the tire passes over a pneumatic hose or an in-pavement sensor. Most short-term vehicle classification counts on Interstates and high-volume highways are collected and processed by contractors using video-based technology. Because both methods are time and resource-intensive, these 48-hour traffic counts are typically collected only once each year. Axle and seasonal adjustments are then applied to estimate the Annual Average Daily Traffic (AADT) for each location.

The Hawkeye and similar non-invasive technology could supplement WIM traffic counts by continuously recording vehicle classifications using vehicle length instead of axles. Their use would also reduce the need for field personnel and contractors on high-speed, high-volume routes to collect traffic counts.

High-definition radar detectors like the Hawkeye and Wavetronix devices provide continuous traffic data. Also, they can be programmed to detect and alert the TMC to real-time incidents. Traffic sensors like these will be important components in the next generation of freeway performance measurements and operations.

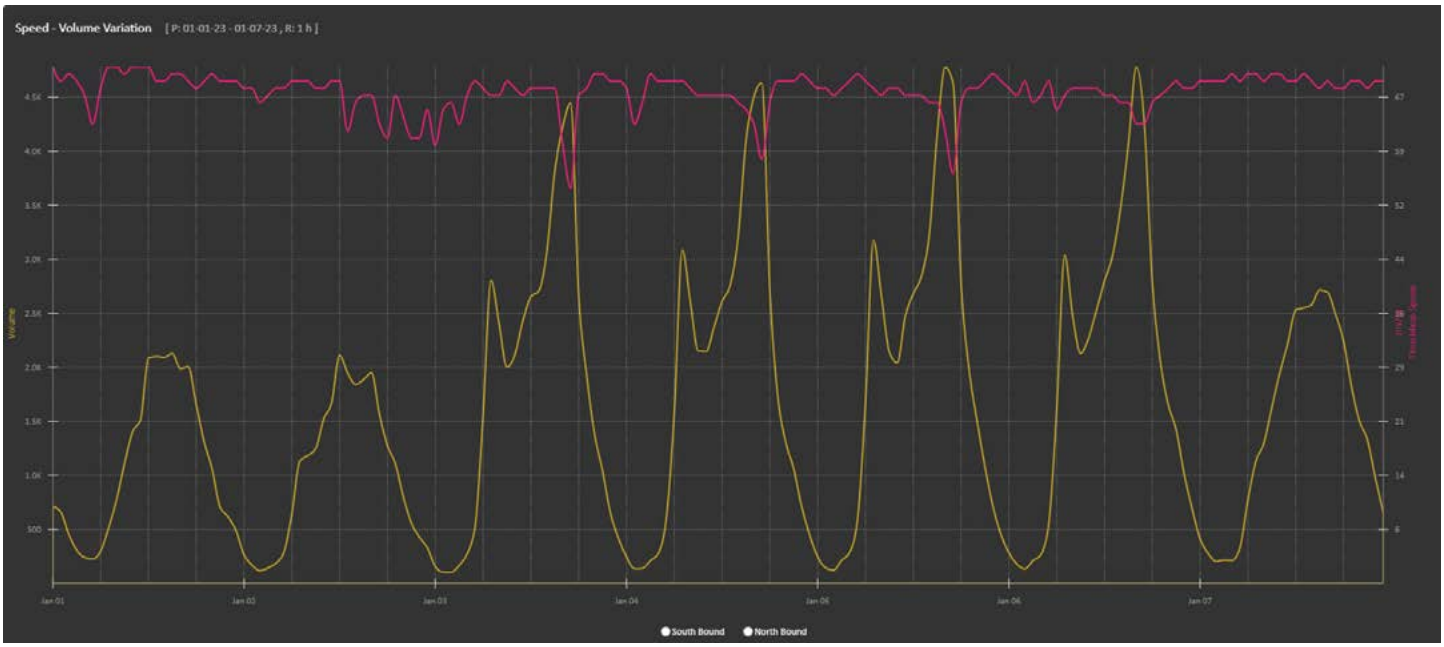


Figure 1: I-430 northbound traffic flow in vehicles per hour (yellow) compared to average travel speed (magenta).

# PORTLAND LIMESTONE CEMENT

## A Smaller Carbon Footprint

BY MARK SIMECEK, P.E.

Many people may not be aware that the Arkansas Department of Transportation (ARDOT) has taken steps to use a 'greener' concrete. The switch to using more environmentally friendly cement is being encouraged by the concrete industry and supported by ARDOT. On Nov. 9, 2021, the ARDOT Specifications Committee, that creates and modifies ARDOT's highway construction specifications, changed the specifications for cement used in concrete. In a mix design, previous specifications allowed up to a 5% maximum of limestone in a Portland Cement (PC), while the new specifications will allow a 15% maximum of limestone in a Portland Limestone Cement (PLC) type 1L . The changed specifications are in the Blended Cement Category of Sections 307, 308, 501, and 802 of the Standard Specifications for Highway Construction, Edition of 2014. Arkansas now joins the vast majority of states that have adopted the use of PLC. Regular Portland Cement has to be heated during manufacture, which takes a considerable amount of energy and has a large carbon footprint. Portland Limestone Cement, used in concrete mixes, contains raw limestone powder that is not heated. A considerable amount of carbon is saved by using limestone powder as a cementitious agent. There is almost no change in strength, and the replacement is approximately a 1:1 trade-off. Adding limestone to cement is not a new practice and has been noted as far back as 1965 in Europe by Heidelberg Cement and in the 1970s in France[1]. Due to new reduced carbon regulations, it is expected that PLC will be the only cement available for use in concrete in the US in the near future.

**1.** Cement Association of Canada, SN3053, Portland-Limestone Cement: State-of-the-Art Report and Gap Analysis for CSA A 3000 by R.D. Hooton; M. Nokken, and M.D.A. Thomas

# I-430 Managed Lanes

BY GLORIA HAGINS


If you have traveled along I-430 during peak hours, you have most likely encountered congestion and bottlenecking between Highway 10 and Highway 100 across the Arkansas River Bridge. Thanks to the hard work and group effort from the ARDOT's Bridge, Roadway, IT, Environmental, Program Management, and Planning Divisions alongside ITS Management and Traffic Services of the Maintenance Division, slow traffic in this area has become a thing of the past.

In 2017, ARDOT's Planning Division began a study on the benefits of part-time shoulder running. The study showed that using the shoulder as a fourth lane during peak hours would increase traffic capacity and reduce delays. To add a fourth lane, the existing 12-foot lanes were reduced to 11 feet, and the 10-foot shoulder was increased to 11 feet wide plus a 2-foot shoulder. ARDOT saved an estimated 250.6 million dollars by utilizing this method instead of building a new bridge with increased deck space.

The managed lanes have planned hours of operation, 6:30 am to 9:30 am South Bound and 3:30 pm to 6:30 pm North Bound but are subject to change due to several factors including, but not limited to, weather, visibility, and debris in the roadway. The managed lanes may also have extended hours for special events, such as local road closures resulting in large volumes of traffic being rerouted to I-430. Regardless of planned hours, the public should always pay attention to the lane control signal signs to determine if they are in operation. A green arrow indicates the lanes are open. A red X indicates they are closed. The managed lanes will be restored to their original purpose as a shoulder when not in operation as a travel lane.

The TMC will conduct a visual sweep of the lanes using twelve strategically placed cameras and review data from two weather stations installed by ITS staff to determine if the managed lane can be safely opened to traffic. If debris is in the lane, the TMC will notify District 6 and request removal. The TMC will continuously monitor the managed lanes and can open or close the lanes as needed. In the event of an accident, the TMC can close the managed lane to allow emergency vehicles a clear path through the traffic. Arkansas State Police will be the top legal authority, followed by a partnership with Arkansas Highway Police and local authorities. When it is closed, vehicles in the managed lane are expected to exit the lane and return to the regular lanes of traffic as soon as safely possible. Managed lanes have proven successful in other states. New Jersey DOT reportedly saw as much as a 50% reduction in congestion when shoulder running was used on a section of US 1 through South Brunswick Township in the central part of the state. ARDOT ITS staff have already noticed an improvement in traffic flow across the bridge during the rush hours. With proper public education on how to use them, they can be a success in Arkansas.

# 2023 Transportation Conference & Equipment Expo

BY GLORIA HAGINS

The 2023 Transportation Conference & Equipment Expo was once again a huge success. The conference continues to grow each year, with approximately 380 attendees and 39 vendors in 2023. That is up from 320 attendees and 37 vendors in 2022. The conference was held again in Hot Springs, Arkansas, on May 23-25, 2023, at the Hot Springs Convention Center. The conference not only provided a variety of sessions with knowledgeable presenters providing engaging content but also provided great networking opportunities. Prior to the kickoff lunch, an informational session targeted at ARDOT employees, "ARDOT 101 Employee Informational Session", covered topics including, but not limited to, Human Resources, Retirement, and Insurance with presentations by Crystal Woods, Robyn Smith, and Ronda Walthall. The General Session followed lunch and provided a variety of informative content. ARDOT Director Lorie Tudor started the session with a State of the Department address. Vivien Hoang provided an update from FHWA on the implementation of the Infrastructure Investment and Jobs Act (IIJA) and updates from around the agency. The remainder of the conference included sessions on the following subjects: Concrete Innovation, Resilient Infrastructure, Pavement Recycling, Maintenance/Traffic, Constructing the Future, and Environmental.


If you missed a presentation that interests you, you can view all available presentations on the Research Section's website.

If you had the pleasure of attending this year, you might have noticed the elaborate table decorations at lunch. Each table was decorated with the theme of Unique Town Names Around Arkansas in mind. If you didn't get a chance to see each table, you can view them here.

With the close of each Transportation Conference & Equipment Expo, preparation for the next year's event begins. We look forward to improving the annual Transportation Conference & Equipment Expo and being able to provide intriguing content each year. If you attended this year, we would love to receive your feedback, so we can improve next year.

# Using Photocatalysis Process in Concrete to Treat Air Pollution

BY HALA ELIA, PH.D.

Concrete is a vital building block of modern life - used in homes, roads, airports, skyscrapers, and more. In fact, it is the most common synthetic structural material in the world, with almost 3 tons utilized per person every year[1]. Concrete is considered the most widely used construction material for structure technology because of its appropriate cost and harmony with its surroundings. It has become the second most consumed item on the Earth after water.

Unfortunately, air pollution is another fact of modern life. The Environmental Protection Agency tracks emissions of the most hazardous air pollutants that negatively impact human health and the environment. These pollutants include carbon monoxide, sulfur dioxide, particulate matter, volatile organic compounds (VOC), nitrogen oxides (NOx), and lead. All these air pollutants are increasing worldwide, particularly in crowded cities. As a result, certain health problems are also increasing, such as cardiovascular disease and respiratory issues. Pollution can also affect the nervous system in a variety of ways (e.g., learning, memory, behavior, and IQ loss) and contributes to cancer and premature death[2]. Automobile emissions are a primary source of air pollution; Figure 1 shows other common sources.

By using the photocatalysis process in highways and roads, the dream of making a concrete that has the ability to clean itself and clean the pollutants out of the air around it comes true. By using specific photocatalytic materials in appropriate ratios with cement in concrete mixes, and then exposing those mixes to UV light from the Sun, an environmentally friendly concrete mix is created. These kinds of mixes have the capability to keep their color for far longer than traditional concrete mixes.

The concrete which has been infused with photocatalytic materials is aptly included in an innovative new classification known as smart concrete. One of the most important photocatalytic materials is titanium dioxide ($TiO_2$), that is classified as Generally Recognized as Safe (GRAS) by the U.S. Food and Drug Administration[4]. Around 4 million tons of $TiO_2$ are utilized annually in materials such as paints, plastics, food, papers, inks, medicines, toothpastes, and sunscreens[5]. Three forms of $TiO_2$ particles exist: rutile, anatase, and brookite, with anatase particles becoming rutile at high temperatures[6]. $TiO_2$ is able to help fight pollution as an additive to concrete, with anatase $TiO_2$ having the best photoactivity[7]. When heat and light hit the concrete's surface, $TiO_2$ uses this energy to break down certain pollutants, such as NOx and VOCs, changing them from the harmful phase to the harmless phase, as shown in Figure 2.

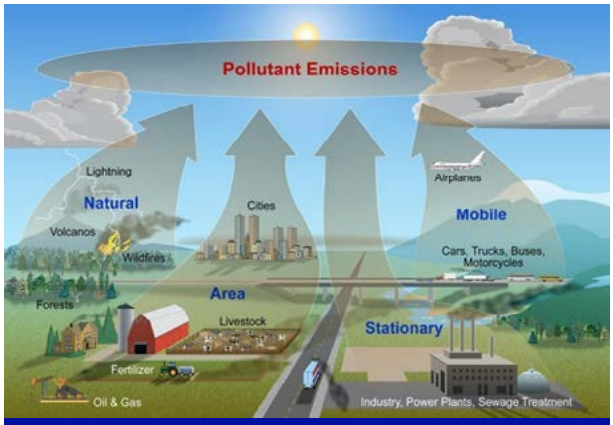

Figure 1: Air Pollution sources.[3]

The essential steps in the process of semiconductor photocatalysis are represented in Figure 2 as follows[8,9]:

1. When the light power in terms of photons hits the surface of concrete which contains semiconductor ($TiO_2$), and the power of the photons are equal or higher than the band gap power of the semiconductor, the electrons in the valence band will be agitated and move to the conduction band of the semiconductor.

2. This process will produce holes in the valence band which can then act like an oxidized compound and react with water to produce the hydroxyl radicals (OH). This is the key of the photocatalytic process because the hydroxyl radicals have very strong oxidizing energy which is able to degrade the pollutants.

$$3H_2O + 3h^+ \leftrightarrow 3\,OH^\bullet + 3\,H^+$$

3. The electrons in the conduction band will react with dissolved oxygen and produce superoxide ions. These electrons will motivate the redox reactions.

$$2\,O_2 + 2\,e^- \leftrightarrow 2\,O_2^-$$

Holes and electrons will go through oxidation and reduction reactions with any material which could be adsorbed on the semiconductor's surface to change the impurities and give the required products[10,11]:

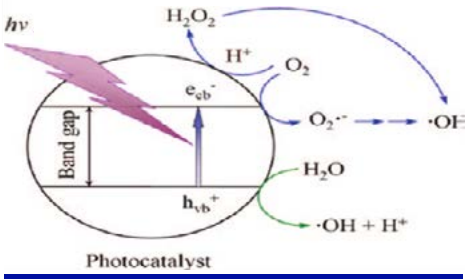

Figure 2: Diagram of Photocatalysis process on the semiconductor photocatalyst.[12]

$$O_2^- + H^+ \leftrightarrow H_2O$$
$$H_2O + e^- \leftrightarrow HO_2^-$$
$$HO_2^- + H^+ \leftrightarrow H_2O_2$$
$$O_2^- + H_2O_2 \leftrightarrow OH^- + OH^\bullet + O_2$$
$$H^+ + OH^\bullet - \leftrightarrow H2O$$
$$H_2O + ½\,O_2 \leftrightarrow 2OH^\bullet$$

In this way, the photocatalysis process can use specially made concrete to remove pollutants from the air around it, thus removing those harmful pollutants from the environment. Someday, maybe this type of concrete can be more widely used, even in transportation related structures, to help clean our environment.


**1.** http://www.wbcsdcement.org/index.php/about-cement/benefits-of-concrete

**2.** Chen B, Kan H (2008) Air Pollution and Population Health: A Global Challenge. Environ Health Prev Med 13: 94-101.

**3.** http://www.nps.gov/subjects/air/sources.htm

**4.** Weir A, Westerhoff P, Fabricius L, Von Goetz N (2012) Titanium Dioxide Nanoparticles in Food and Personal Care Products. Environmental Science Technology 46: 2242-2250.

**5.** Filipponi L, Sutherland D (2012) Nanotechnologies: Principles, Applications, Implications and Hands-on Activities.

**6.** Znaidi L, Seraphimova R, Bocquet J, Colbeau-Justin C, Pommier C (2001) Continuous Process for the Synthesis of Nanosize TiO2 Powders and Their Use as Photocatalysts. Material Research Bulletin 36: 811-825

**7.** Bilmes S, Mandelbaum P, Alvarez F, Victoria N (2000) Surface and Electronic Structure of Titanium Dioxide Photocatalyst. J Physical Chem B 104: 9851- 9858

**8.** Rajeshwar, K.; Osugi, M.E.; Chanmanee, W.; Chenthamarakshan, C.R.; Zanoni, M.; Kajitvichyanukul, P. and Krishnan-Ayer, R.; "Heterogeneous Photocatalytic Treatment of Organic Dyes in Air and Aqueous Media"; Journal of Photochemistry and Photobiology 9 (4): 171-192 (2008).

**9.** Reham, S.; Ullah, R. ; Butt, A.M. ; Gohar, N.D.; "Strategies of Making TiO2 and ZnO Visible Light Active"; Journal of Hazard Materials; 170 (2-3) : 560-569 (2009).

**10.** Devahasdin, S. ; Fan, C. Jr; Li, K. and Chen, D.H.;"TiO2 Photocatalytic Oxidation of Nitric Oxide: Transient behavior and reaction kinetics"; Journal of Photochemistry and Photobiology, 156, 161-170 (2003).

**11.** Szczepankiewicz, S.H.; Colussi, A.J. and Hoffmann, M.R.;"Infrared Spectra of photoinduced species on hydroxylated Titania Surfaces"; Journal of Physical Chemistry B.; 104; 9842-9850 (2000).

**12.** Hoffmann, M.R.; Martin, S.T.; Choi, W.Y. and Bahnemann, D.W.; "Environmental Applications of Semiconductor Photocatalysis"; Chem. Rev. 95;69-96 (1995).

# Ground Tire Rubber: A Look at ARDOT's Past Research Experience and Usage

BY ROSS PHILLIPS, P.E. AND SANGHYUN CHUN, PH.D., P.E.

*Rubber Modified ACHM on Interstate 530, May 2015 (Image Taken from the MMHIS)*

Ground tire rubber (GTR), also called crumb rubber or recycled tire rubber, is created by grinding scrap automotive tires after the tires have been stripped of metal, resulting in a granular rubber product. Grinding used tires to be reused in new applications is a way of recycling a waste material that would otherwise take up space in landfills, be a potential fire hazard, and harbor pests that can carry diseases. Used tires can be recycled in two ways: they can be burned as fuel so that energy can be taken from them, or they can be shredded into small particle sizes to be used in applications such as playground surfaces, mulch, or to create Rubber-Modified Asphalt (RMA). As roads have become a focus for recycled materials in recent years, many state DOTs are looking at RMA as a sustainable alternative to Polymer-Modified Asphalt (PMA). While ARDOT does have a history of researching and using RMA, the product is not commonly used.

ARDOT has sponsored two research projects to date regarding the use of recycled rubber in asphalt mixtures. HRC35 – Arkansas Waste in Municipal Areas Suitable for Highway Construction or Maintenance (1973) describes the RMA mixtures as a promising material that can be used to mitigate pavement cracking. However, there was a lack of technology and knowledge that hindered further development of RMA. More recently, TRC9404 – Effects of Rubber on Asphalt Mixes (1997) primarily sought to develop an understanding of the behavior and performance of asphalt concrete surface mixes that incorporate GTR. Results indicated that the asphalt mixtures with the asphalt-rubber blends showed improvement in the performance properties in terms of resistance to rutting, load-associated fatigue, and thermal cracking for Arkansas Type II surface course mixes modified with crumb rubber modifier (CRM). However, the improvements were not significant, and the results were not sufficient to determine whether or not the benefits justified the additional cost (e.g., cost of dedicated equipment, cost of additional cleaning of equipment due to the increased "stickiness" of the material, additional labor costs due to difficulty in placing, etc.).

In the early 90s, two jobs were let specifying the use of RMA. Job R20082 was let in 1990 and specified the use of RMA using the "wet" process. Job 80020 was let in 1993 and specified the use of the "dry" process. While Job 80020 was considered to be unsuccessful, Job R20082 was considered very successful. Job R20082, paving Hwy. 65 (now I-530) near Pine Bluff, held up well for over two decades (1991-2015), only being removed and replaced due to underlying alkali-silica reaction in the concrete pavement below. Job R20082 was constructed on top of an existing Portland cement concrete pavement using an asphalt rubber stress absorbing membrane interlayer, a tack coat, a rubber modified ACHM binder course, and a rubber modified ACHM surface course. Job R20082 contained an in-depth, 8-page Special Provision specifying mixing equipment and procedure, construction, etc., for the RMA in this job. This is the only known construction project completed where ARDOT specified the use of RMA using the "wet" process.

Based on research done by ARDOT and other entities nationwide, there does appear to be some benefits from using RMA. Increased rutting resistance, increased service life, and reduced reflective cracking are some benefits commonly attributed to pavements containing RMA; however, these stated benefits are minimal to negligible when taking a closer look at the findings (despite having some anecdotal success with Job R20082). What is consistent across the studies is that RMA performs at least as well, and in some cases better, than polymer-modified HMA when incorporated at low replacement rates (i.e., approximately 1% to 5%). The main advantage of using GTR in our mixes comes from a sustainability standpoint. Used tires are difficult to dispose of, have a slow rate of degradation, and take up excessive space (75% of which is dead space). There have been ample studies and projects across the country looking at creative ways to recycle materials; roadways have been a focus for material recycling (e.g., rubber, shingles, plastic, glass, etc.) for years due to the roadway's inert quality.

Adding GTR at certain percentages of replacement to mixes, while not showing any significant advantages to the roadway, has shown to perform at least equally as well as other approved mixes. However, without any incentive to use recycled materials in roadways, contractors opt to use the processes and mixes they are familiar with. Using GTR requires special or dedicated equipment to place due to changes in the asphalt properties and handling issues during the process. GTR mixes are more difficult to place when contractors are not familiar with the product and require special procedures for getting a consistent mix. The specification is also very minimal, providing little to no guidance about mix design, mixing procedure, and placing. Contractors may be more apt to use RMA if there were more incentives and guidance included in the contracts, but RMA cannot currently compete with PMA in Arkansas from a cost standpoint, even though it has shown to perform equally well.

# SPOTLIGHT ON LTAP:

## The Arkansas Local Technical Assistance Program

The Local Technical Assistance Program (LTAP) has been established since the 1980s, focusing on providing services to local agencies. LTAP is a federal aid program available to each state and tribe around the United States, including Arkansas. LTAP provides a needed service to the local governments of each state with their transportation systems by offering training, knowledge transfer, and technical assistance. If there is one thing we all know, you can't stop change. The Arkansas LTAP (AR LTAP) prefers to implement that change more progressively. While LTAP has been established for many years, nationally, a newness is woven into AR LTAP that will be on display for a bright future. Recent progress will take AR LTAP to another level. You can continue to provide the same services if they work, but sometimes, even if something's not broken, you can still remodel it. That's what is being done with AR LTAP, moving forward, first by starting with new management and a new home.

During the 2022 Federal Fiscal Year, AR LTAP introduced a new Program Manager, Patrick E. Thomas. AR LTAP also received increased funding throughout the life of the recently passed Infrastructure Investment and Jobs Act and renewed expiring contracts for training. Not only was a spark of novelty infused into the AR LTAP by way of a change in leadership but also with its partnerships. AR LTAP works with the 75 county judges in Arkansas; 36 of them are newly elected. On December 14, 2022, nearly all the newly elected judges attended the County Judges Association of Arkansas New Elect Seminar in North Little Rock, Arkansas. AR LTAP attended this seminar and gave an introductory presentation to the judges about the program. The presentation included information on requesting training, what the program offered, and other available technical assistance. The new Program Manager was able to deliver this information because of the extensive foundational work completed by his predecessor, Laura DeBro Carter.

| TRAINING | TOTAL HOURS | TOTAL ATTENDEES |
|---|---|---|
| Defensive Driving | 52 | 389 |
| Drug Awareness | 6 | 33 |
| Flagger/Work Zone | 91 | 294 |
| Safety/Heavy Equipment | 179 | 363 |
| TOTALS | 328 | 1079 |

AR LTAP is no longer in the System & Information Research (SIR) Division. The program was a part of this Division for many years, cementing its place in the State of Arkansas and around the nation while living in SIR. It has found a new home in the Local Programs (LP) Division. In this new division, the AR LTAP will continue to provide the established services it always has. Still, new things are being considered for the future.

Before we discuss the future, let's talk about AR LTAP's final year in SIR. The program had a strong finish to the 2023 Federal Fiscal Year. This strong finish was because the new AR LTAP Manager became more comfortable in the role, and outliers that paused the program's progression ceased to be obstacles. These obstacles included not having some contracts for training, understanding the needs of the local agencies, and the uncertainty of the program's future. We were able to maneuver around these obstacles and continue the AR LTAP 's success. The new AR LTAP Manager has finally gained footing and established a rapport with many local agency representatives. A survey will be distributed soon to ensure the local agencies' concerns and needs are being met. Three out of the four expired training contracts were re-established. With those new contracts, training ramped up in March 2023. While this was a slower than usual start for a typical year's initiation of training, AR LTAP still finished strong. The chart above shows the training provided from March 31 – September 30, all within Federal Fiscal Year 2023.

Now for the future. There is still more to be done, and AR LTAP is trending in the right direction. The saying goes, "If it isn't broke, don't fix it." We're not trying to fix AR LTAP. We're just trying to make it better by remodeling it. With a solid inherited foundation, a sense of newness and originality can be at the core of AR LTAP and continue to make it successful well into the future.

# RESEARCH INFORMER

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