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January 23, 2020

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
State Capitol, 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: Combined Quarterly Progress Report and Annual Project Report Entitled "iPIPE – intelligent Pipeline Integrity Program," Contract No. G-046-88; UND Project – Fund 43500-UND0022445; EERC Funds 23121 and 23211

Attached is a combined quarterly progress and annual project report on the subject project for the periods of October 1, 2019 – December 31, 2019, and January 1, 2019 – December 31, 2019, respectively.

If you have any questions, please contact me by phone at (701) 777-5260 or by e-mail at jalmlie@undeerc.org.

Sincerely,

Jay C. Almlie
Principal Engineer
Mid/Downstream Oil & Gas Group Lead

JCA/kal

Attachment

IPIPE – INTELLIGENT PIPELINE INTEGRITY PROGRAM

Combined Quarterly Progress Report and Annual Project Report

(for the periods of October 1, 2019 – December 31, 2019 and January 1, 2019 – December 31, 2019, respectively)

Prepared for:

Karlene Fine

North Dakota Industrial Commission
State Capitol, 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Contract No. G-046-88

Prepared by:

Jay C. Almlie

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January 2020

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Key Takeaways

- 2019 technology development activities have yielded additional value to the program. Satelytics' technology has now yielded at least one opportunity for commercial application because of the work completed within iPIPE. Direct-C's technology development will continue through first quarter of 2020.
- iPIPE selected two new technology development projects to pursue in 2020. Contracting is in progress at the time of this report.
- iPIPE success can also be marked by addition of three new members to the programs: Enbridge, Dakota Access Pipepline, and TC Energy. iPIPE has nearly doubled its membership since inception.

EXECUTIVE SUMMARY

This document is a combined quarterly and annual report on the North Dakota Industrial Commission (NDIC)-funded intelligent Pipeline Integrity Program (iPIPE). The goal of iPIPE is to develop and demonstrate cutting-edge technology that can prevent and/or detect gathering pipeline leaks. This goal is supported by accomplishment of the following objectives:

- Select the most promising emerging (near-commercial) technologies for demonstration.
- Assist technology providers in refinement of their products.
- Demonstrate multiple technologies on working gathering pipelines.
- Document results of technology demonstrations.
- Facilitate adoption of technologies into North Dakota pipeline operations.

iPIPE was founded in May 2018 by six founding members: Hess Corporation, Equinor, Oasis Midstream Partners, ONEOK, Andeavor, and Goodnight Midstream. By the end of 2019, three additional members (DCP Midstream, Whiting Petroleum, and Enbridge) had joined the consortium as news of the program's success spread. At the end of 2019, two additional pipeline operators committed to membership starting in January 2020: Dakota Access Pipeline LP and TC Energy.

While this program was designed to be primarily a new technology development program, members recognized potential during late 2018 and all of 2019 to derive further benefits from engaged participation in the program. Members frequently state that an unanticipated benefit of program participation has been that ideas for operational and safety improvements can be discussed within this group easily and without filter. Several members have stated that they have no other forum for these kinds of interoperator discussions. Thus the program has already evolved to address the overarching goal at program inception: achieving zero pipeline leaks.

During 2018 and 2019, the EERC coordinated all field-based demonstration and codevelopment activities with the technology providers and with program members who volunteered operating gathering pipelines on which the selected technologies could be demonstrated and improved. 2019 technology development projects are summarized as follows:

- An extension of 2018 development activities with Ingu Solutions was continued in 2019. These efforts were meant to further demonstrate specific capabilities of Pipers® sensors related to leak detection.

- Development activities for Satelytics Phase II began on June 3, 2019, and continued through October 8, 2019. The focus of these activities was to improve the user interface and to improve the accuracy of the brine detection algorithms.

- Development activities for Direct-C began in April 2019 and will continue into the second quarter of 2020. The focus of these activities was to evaluate the performance of Direct-C nanocomposite sensors on operating pipelines in harsh winter climates.

Summary of Ingu Solutions Pipers Development Work

During 2018 activities with Ingu Solutions, iPIPE's volunteer pipeline operators were not able to adequately simulate a leak in a representative manner. Acknowledging that iPIPE did not adequately create opportunity for Ingu Solutions to demonstrate specifically the leak detection capabilities of Pipers, iPIPE member Equinor agreed to host a specific demonstration of Pipers leak detection capabilities in August 2019. During the August 2019 test on the Equinor produced water pipeline, a leak was detected at the site at which the leak simulation occurred. Equinor and the EERC confirmed the validity of the test.

Pipers represents one example of iPIPE fulfilling its promise to "put new tools in the toolbelt of pipeline operators." iPIPE considers Pipers one of its first successes for many reasons:

1. Data collected during iPIPE development work with Ingu Solutions allowed Ingu Solutions to refine its data processing workflows to increase accuracy and to decrease the amount of time required to achieve pipeline scan results.

2. Ingu Solutions declined to submit a follow-on proposal to iPIPE, indicating that its commercial sales had expanded during 2018 and 2019 to the point that it had to limit staff efforts to fully commercial contracts.

3. At least two members of iPIPE are now contracting commercially with Ingu Solutions for use of Pipers as a pipeline scanning tool.

Summary of Satelytics Development Work

Phase II of iPIPE's work with Satelytics was an extension of the 2018 development project aiming to provide more training data for the Constant Vigilance software as well as introduce a mobile application for iPIPE members. Satelytics was responsive to industry requests and

questions. The hydrocarbon and produced water algorithms have shown recognition improvement throughout the 2018 and 2019 projects.

Satelytics represents a second example of iPIPE fulfilling its promise to "put new tools in the toolbelt of pipeline operators." iPIPE considers Satelytics to be another of its first successes for many reasons:

1. Data collected during iPIPE development work with Satelytics allowed Satelytics to improve its algorithm performance and leak indication accuracy and to decrease the amount of time required to complete weekly analysis of large amounts of satellite data.

2. Several members of iPIPE are now exploring possible basinwide models for commercial adoption of Satelytics. Because remote sensing technologies generally observe large areas containing many assets of many companies, pathways to procurement of these types of services must now be decided among many potential beneficiaries.

Summary of Direct-C Development Work

The EERC has completed laboratory testing of the sensor technology and has helped Direct-C and iPIPE member companies install the sensors at several locations in the field. Fieldwork will continue through the winter months of 2019 and 2020 to determine the performance of the sensors in harsh weather conditions. At this time, the EERC is prepared only to report on the laboratory testing of Direct-C sensors performed by the EERC during 2019. Because the laboratory work is designed only to support understanding of field performance, no conclusions can be drawn at this point. The true assessment of Direct-C sensor performance will be completed by the EERC at the conclusion of field trials in the second quarter of 2020.

iPIPE Success

iPIPE has already demonstrated impressive results in advancing truly emerging technologies for pipeline leak prevention and pipeline leak detection toward commercialization. The consortium members have expressed pleasant surprise at the productive collaboration made possible by iPIPE. Where business-competitive concerns are not present, a great amount of information on issues related to pipeline integrity has been shared in an effort to advance the technologies selected for codevelopment toward commercialization.

iPIPE – INTELLIGENT PIPELINE INTEGRITY PROGRAM

Combined
Quarterly Progress Report October 1, 2019 – December 31, 2019
and
Annual Project Report January 1, 2019 – December 31, 2019

BACKGROUND

During a May 2017 meeting with North Dakota pipeline operators, Governor Doug Burgum challenged industry to apply advanced technologies to eliminate pipeline leaks in North Dakota. In response to the Governor's challenge, industry chose a proactive path and engaged in a 3½-year program to advance development and application of emerging technologies that will prevent and detect pipeline leaks. The program intends to assist in the development of multiple emerging technologies to prevent and detect pipeline leaks by engaging with technology providers to refine not-yet-commercial products specifically for buried gathering pipelines in North Dakota and then demonstrate technology application on working gathering pipelines.

The goal of this project is to develop and demonstrate cutting-edge technology that can prevent and/or detect gathering pipeline leaks. This goal is supported by accomplishment of the following objectives:

- Select the most promising emerging (near-commercial) technologies for demonstration.
- Assist technology providers in refinement of their products.
- Demonstrate multiple technologies on working gathering pipelines.
- Document results of technology demonstrations.
- Facilitate adoption of technologies into North Dakota pipeline operations.

Multiple demonstrations of emerging technologies on working pipelines will simultaneously assist technology providers in refining designs, pave a path toward full commercialization in the North Dakota market, prepare pipeline operators for adoption of the new tools, and improve the performance and economics of gathering pipeline operations in North Dakota. With demonstrated success, additional consortium members (pipeline operators) will join the effort, thus enabling field testing of more technologies and further proliferating new technology among all pipeline operators.

Members of the industry-led consortium include DCP Midstream, Enbridge, Equinor, Goodnight Midstream, Hess Corporation, Marathon Petroleum, Oasis Midstream Partners, ONEOK, and Whiting Petroleum. The consortium has asked the EERC to manage the program on its behalf. As such, the EERC submits a quarterly report and an annual report on behalf of the members of the iPIPE consortium.

The following quarterly report summarizes the program activities from October 1, 2019, through December 31, 2019. After the quarterly report, an annual report is included within this document and summarizes program progress from January 1, 2019, through December 31, 2019.

QUARTERLY PROGRESS REPORT
(October 1, 2019 – December 31, 2019)

ACCOMPLISHMENTS DURING REPORTING PERIOD

- Program-level activities
  - Program briefings
    - On October 30, 2019, iPIPE's program manager presented an update on the program at the Western Dakota Energy Association annual meeting in Minot, North Dakota.
    - On November 4, 2019, iPIPE's program manager presented an introduction to the program to Wei Wang, Executive Director of the Railroad Commission of Texas, and Danny Sorrells, Director of the Railroad Commission of Texas via WebEx.
    - On November 4, 2019, iPIPE's program manager presented an introduction to the program at the Pipeliner's Association of Houston in Houston, Texas.
    - On November 13, Ben Chorpening of the U.S. Department of Energy's National Energy Technology Laboratory received a briefing on iPIPE from iPIPE's program manager in Grand Forks, North Dakota. Mr. Chorpening was primarily interested as a potential technology provider.
    - On December 4, 2019, and again on December 10, 2019, iPIPE's program manager presented an introduction to technical staff at TC Energy. After these presentations, TC Energy committed to become program members starting in January 2020.
    - On December 9, 2019, Brent Lohnes (General Manager, Hess Corporation) and iPIPE's program manager presented the program's proposal for incremental funding at the NDIC Oil & Gas Research Program (OGRP) meeting in Bismarck, North Dakota.
    - On December 16, 2019, iPIPE's program manager presented an update on the program at a meeting of the North Dakota Legislature's Interim Committee on Tribal Taxation Issues in Bismarck, North Dakota. This briefing was made at the request of Governor Burgum, who chairs the Committee.
    - On December 17, 2019, iPIPE's program manager presented a program update at the NDIC meeting in Bismarck, North Dakota. This presentation was made at the request of Governor Burgum, who chairs the Commission.
  - Member recruitment
    - During this reporting period, Dakota Access Pipeline LP and TC Energy both committed to become members of the program in 2020.
    - The program continued discussion with a number of companies regarding membership in the consortium. Some of these companies have approached the program regarding membership requirements and benefits, while others have been approached by the program and/or existing consortium members.
  - Additional resource investment
    - On December 9, 2019, an iPIPE proposal for $1 million in incremental funding to match the growing resources provided by program membership was presented to NDIC OGRP. The request was presented on behalf of all iPIPE members by Hess Corporation. OGRP voted to recommend funding and forwarded that recommendation to the NDIC.

    - On December 17, NDIC unanimously approved the iPIPE request for incremental funding and asked program manager, Jay Almlie, to present a program update at the Commission meeting.
  - Program media mentions
    - iPIPE has now been highlighted in more than 50 public multimedia and printed articles. A partial listing of known media mentions is provided in Appendix A.

- Technology selection
  - On October 22 and 23, 2019, iPIPE held its third technology selection event in Williston, North Dakota. At the 2-day technology selection event, eight companies offering emerging technologies each presented 40-minute summaries of their respective submitted proposals. The iPIPE Technology Selection Committee interviewed each presenting team and then selected technologies that the committee deemed most promising. The Technology Selection Committee selected two technologies in which to invest, for a total of $1.3 million for 2019 codevelopment activities. Companies selected for possible demonstration and codevelopment activities in 2019 included the following:
    - Orbital Sidekick
    - Satelytics, Inc.
  - Following the technology selection event, iPIPE's Technology Selection Committee and Executive Committee both authorized the EERC to attempt to contract with both selected technology providers in accordance with a defined negotiation plan drafted by the EERC and approved jointly by the iPIPE committees. Neither company is yet contracted, but as of the time of this report, contract negotiations are proceeding quickly. It is anticipated that contracts will be signed by the end of February 2020, barring unforeseen circumstances.
  - During this reporting period, the EERC continued its worldwide search for companies offering emerging technologies (not yet commercial) to improve gathering pipeline leak detection and gathering pipeline leak prevention. A wide range of technologies is continuously investigated, explored, and considered. These technologies include a vast spectrum of unique approaches such as direct measurement technologies, remote sensing technologies, nanotechnology sensors, self-healing technologies, multisensor fusion technologies, advanced cathodic protection technologies, and miniaturized inline inspection technologies.

- Demonstration execution – Satelytics
  - On October 8, 2019, the final satellite data capture and data processing event of 2019 was completed. This final capture allowed Satelytics to begin compiling its final report on 2019 activities. This Satelytics report was submitted to iPIPE on October 23, 2019. This report is separate from the EERC independent evaluation report.
  - The EERC began compiling its independent evaluation report in October. An internal draft of the report was provided for review by the program manager on December 20, 2019. At the time of this quarterly report to NDIC, the revised draft of the EERC independent evaluation report of the Satelytics project is being circulated among project partners and Satelytics for comment. This detailed report will be held within program membership, but an executive summary of the report has been included in this annual report to NDIC.

- Demonstration execution – Direct-C
  - Field installations scheduled for September 2019 and October 2019 happened over several weeks in November 2019 and December 2019. The delay was largely caused by extremely wet field conditions in September and October that precluded use of large hydrovac trucks until the soil could support their weight in the rights of way offered by individual iPIPE members to support these field installations. Some delay was also caused by unanticipated manufacturing delays related to trade limitations imposed by the U.S. government on China in the second and third quarters of 2019.
  - During this reporting period, the EERC project manager for the Direct-C project began compiling a report on laboratory testing of the Direct-C sensors. An internal draft of the report was provided for review by the program manager on December 19, 2019. At the time of this quarterly report to NDIC, the revised draft of the EERC laboratory report for the Direct-C project is being finalized. This report will be combined with a report on the EERC's independent evaluation of performance of the field installations in April 2020 and will then be shared with program members. An executive summary of the laboratory report is included in this annual report to NDIC. The executive summary of the independent assessment of overall Direct-C performance and product development will be made available in the 2020 annual report to NDIC, due in January 2021.

MEMBERSHIP AND FINANCIAL INFORMATION

The original budget proposed to NDIC OGRP totaled $3,714,000, as shown in Table 1. To demonstrate additional resources provided by new members, additional financial commitment from NDIC, and significantly increased in-kind cost share provided by technology providers and program members, an updated budget is presented in Table 2. Table 2 demonstrates the rapid growth of this program. Table 3 presents greater detail on expected budget and actual expenses incurred by the program to date.

Table 1. iPIPE Original Budget

Sponsors	2018	2019	2020	2021	Total
NDIC – Cash	403,320	405,226	393,454	398,000	1,600,000
Industry – Cash	264,000	450,000	450,000	450,000	1,614,000
Industry and Technology Provider – In-Kind	125,000	125,000	125,000	125,000	500,000
Total	**792,320**	**980,226**	**968,454**	**973,000**	**3,714,000**

Table 2. iPIPE Updated Budget

Sponsors	2018	2019	2020	2021	Total
NDIC – Cash	403,320	405,226	893,454	898,000	2,600,000
Industry – Cash	352,000*	700,000*	925,000	825,000	2,802,000
Industry and Technology Provider – In-Kind	525,878*	925,719*	1,500,000	500,000	3,451,597
Total	**1,281,198**	**2,030,945**	**3,318,454**	**2,223,000**	**8,853,597**

* Reflects actuals for these years.

Table 3. iPIPE Expected Budget and Expenses to Date

Sponsors	Expected Budget	Actual Expenses as of 12/31/19		Balance Remaining of Expected Budget
NDIC Share – Cash	2,600,000		1,301,638	**1,298,362**
Industry Share – Cash	2,802,000		898,517	**1,903,483**
Industry – In-Kind	375,000	*DCP*	*29,880*	
		Enbridge	*58,415*	
		Equinor	*126,530*	
		Goodnight	*6,800*	
		Hess	*151,983*	
		MPLx	*17,936*	
		Oasis	*19,620*	
		ONEOK	*5,000*	
		Whiting	*9,042*	
		TOTAL	425,206	**66**
Technology Providers – In-Kind	3,076,597*	*Satelytics*	*971,550*	
		Direct-C	*114,933*	
		Ingu	*88,266*	
		TOTAL	1,174,749	**1,901,848**
Total	**8,853,597***		**3,800,110**	**5,053,487**

* Includes budget estimates from proposals for 2020 technology development projects and an estimate of anticipated 2021 in-kind from as-yet-unknown technology providers.

Invoices for CY2020 membership dues were sent in December 2019 and are payable in January 2020. Three companies have paid their 2020 membership dues as of the time of this quarterly report. One of these companies also paid its 2021 membership dues in advance.

The program continues to solicit additional members to contribute to this program. As additional members join the program, Tables 2 and 3 will be updated to show the additional financial resources brought to the program.

Project progress, as represented by the project schedule presented in the original NDIC OGRP proposal, is shown in Figure 1.

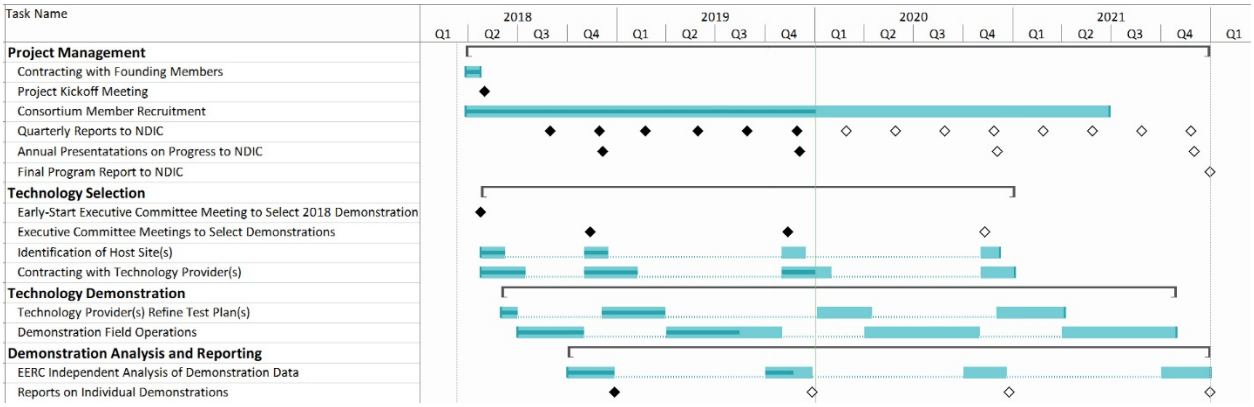

Figure 1. Project progress.

FUTURE ACTIVITIES

The planned activities for the next quarter are detailed below:

- Program-level activities
  - On January 13, 2020, several iPIPE members and the iPIPE program manager will meet in Austin, Texas, with representatives of the Railroad Commission of Texas to discuss possible state of Texas participation in the program.
  - iPIPE will host a booth at the Pipeline Pigging and Integrity Management conference in Houston, Texas, on February 19–21. iPIPE members have decided that they wish for the program to conduct outreach through targeted expo booths at relevant conferences. The program will also host an expo booth at the upcoming Williston Basin Petroleum Conference in Bismarck, North Dakota, in May 2020.
  - Several iPIPE members and the iPIPE program manager will present a panel discussion on the program during the Oil & Gas Pipeline Leak Detection Congress USA 2020 in Houston on January 29–30, 2020.
  - iPIPE will hold its first Members Forum on February 18–19 in Houston, Texas. The purpose of the Members Forum is to share information on shared challenges in pipeline operations and successes and failures in addressing those challenges. An expected outcome of this unique iPIPE effort is to elevate the pipeline integrity-related performance of all members by ensuring transfer of lessons learned. During 2019, members frequently stated that an unexpected benefit of program participation has been that ideas for operational and safety improvements can be discussed within this group so easily and without filter. Several members have stated that they have no other forum for these kinds of interoperator discussions. While the program was designed to foster new tools for the pipeline industry, it is also addressing the overarching goal of eliminating pipeline leaks through this information sharing mechanism. The Members Forum will also serve to hone the consortium's focus on technology development needs for the coming year.
  - iPIPE will continue ongoing and new discussions with potential new program members during the coming reporting period.

- Technology selection
  - The EERC will continue to research and evaluate potential new and emerging technologies for consideration by iPIPE. The EERC will contact several potential candidates for the next technology selection event and will solicit proposals from select technology providers. This is a continuous task that will continue until the next iPIPE technology selection event, anticipated in early October 2020.

- Demonstration execution – Satelytics, Phase III
  - The EERC and Satelytics will complete definition of a detailed scope of work for the 2020 Satelytics Phase III project.
  - The EERC will also complete contracting with Satelytics for 2020 work.
  - Satellite data capture and analytics operations related to the Phase III scope of work will commence in February.

- Demonstration execution – Orbital Sidekick (OSK)
  - The EERC and OSK will complete definition of a detailed scope of work for the 2020 OSK project.
  - The EERC will also complete contracting with OSK for 2020 work.
  - Launch of the Aurora satellite carrying the hyperspectral imager instrument intended for use in the 2020 project is currently scheduled for March 2020.

- Demonstration execution – Direct-C
  - Direct-C will continue monitoring of the sensors installed on pipelines in North Dakota during the coming reporting period, continuing the effort to evaluate performance over harsh winter months.
  - At undisclosed times, the EERC may trigger small, simulated pipeline spills near installed sensors to challenge the sensors. These simulated spills have been tightly coordinated with the environmental compliance teams of the volunteer pipeline operators upon whose pipelines these sensors have been installed. No environmental risk has been identified.

ANNUAL PROJECT REPORT
(January 1, 2019 – December 31, 2019)

PROGRAM OVERVIEW

The intelligent Pipeline Integrity Program (iPIPE) was founded in May 2018 by a core group of six pipeline operators that quickly grew to eight founding consortium members. Cost match for the initial investment by the first six consortium members was provided by the North Dakota Industrial Commission (NDIC) in the amount of $1.6 million for the period of June 20, 2018, through December 31, 2021. The original six members included Hess Corporation, Equinor, Oasis Midstream Partners, ONEOK, Andeavor, and Goodnight Midstream. By the end of 2019, three additional members had joined the consortium as news of the program's success spread. New members included DCP Midstream, Whiting Petroleum, and Enbridge. At the end of 2019, two additional pipeline operators committed to membership starting in January 2020: Dakota Access Pipeline LP and TC Energy.

Initial program operations began in May 2018, before NDIC commitment had been contracted. The goal of the early start to the program was to make an immediate impact to the state of technology available to contribute positively to gathering pipeline integrity in the state of North Dakota and beyond. In May 2018, the first technology selection round was held. Seven technology providers presented their proposals for technology development. Two technologies were selected for iPIPE funding awards and codevelopment efforts.

In October 2018, a second technology selection round was held. Nine technology providers presented their proposals for technology development. Four technologies were selected for iPIPE funding awards and codevelopment efforts, with two of those technologies completing contracting with iPIPE. These technology development efforts were executed during 2019.

A third technology selection round was held in October 2019. Eight technology providers presented their proposals for technology development. Two technologies were selected for iPIPE funding awards and codevelopment efforts to commence in 2020.

While this program was designed to be primarily a new technology development program, members recognized potential during late 2018 and all of 2019 to derive further benefits from engaged participation in the program. Members frequently state that an unanticipated benefit of program participation has been that ideas for operational and safety improvements can be discussed within this group easily and without filter. Several members have stated that they have no other forum for these kinds of interoperator discussions. Thus the program has already evolved to address the overarching goal at program inception: achieving zero pipeline leaks.

This program succeeds because of the high level of engagement of its members. Members direct the program, select the technologies to be developed, offer working pipelines upon which the technologies can be developed and demonstrated, provide field support labor for development activities, and provide feedback on each technology as each technology is developed, thus honing the technologies to something that industry can use.

The EERC's role is to execute the program at the direction of members, promote the program, report on program activities to the NDIC, scout promising new technologies, ensure scientific method is employed in all development and test efforts, coordinate field activities of selected technology providers, and independently evaluate the performance of each technology development effort.

A year-in-review calendar shown in Figure 2 summarizes activities and timing throughout 2019.

ask Name	r	December				January				February				March				April				May				June				July				August				September				October				November				December				January	
	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4
Project Management																																																						
Reporting																																																				
Annual report submitted to NDIC										1/30																																										
Member Meetings										1/30																																									
iPIPE Winter 2019 members meeting (WebEx)														2/12																																					
iPIPE strategic direction meeting with iPIPE members (WebEx)																										5/30																									
Monthly Program Update Meeting with Members (WebEx)																																																		
Member Recruitment																																																		
Enbridge joined the program																										5/28																									
Executive Committee discussion on Texas state participation (WebEx)																																																	11/8	
Technology Selection																																																		
Ongoing technology scouting																																																		
iPIPE RFP sent to potential technology providers																										6/14																									
Third technology selection event meeting (Williston, ND)																																																	
2019 Project Execution																																																		
Satelytics, Phase II																																																		
2019 activities kickoff meeting with Satelytics (WebEx)																				4/2																															
Satelytics Phase II kickoff meeting with iPIPE members (Webex)																										5/20																									
Weekly satellite data capture and data processing for ND and NM areas of interest																																																		
Weekly project update meetings with iPIPE members (WebEx)																																																		
Ingu Solutions																																																		
Ingu Solutions delivered final report on 2018 iPIPE activities										1/29																																									
Ingu Solutions delivered test report on August 2019 leak detection tests with Equinor																																																	
Direct-C																																																		
Received sensor coupons for laboratory testing from Direct-C																																																	
Laboratory testing																																																		
Field installations																																																		
Technology Contracting																																																	
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Orbital Sidekick																																																	
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iPIPE joint Executive Committee and Technology Selection Committee briefing on negotiations progress																																																	
Outreach																																																	
Presentations																																																	
iPIPE featured in Gov. Burgum's State of the State Address (Bismarck, ND)																																																	
iPIPE presentation at Williston Basin API meeting (Williston, ND)																																																	
iPIPE presentation at NDIC Meeting (Bismarck, ND)																																																	
iPIPE update briefing to ND DMR/Tammy Madche (Grand Forks, ND)																																																	
iPIPE introduction presentation at the IOGCC Annual Business Meeting (Oklahoma City, OK)																																																	
iPIPE introduction presenation to ND Petroleum Council's Technical Solutions Group meeting (Dickinson, ND)																																																	
iPIPE/Satelytics case study presentation at the INGAA Workshop (Houston, TX)																																																	
Joint presenation - ND DMR and iPIPE - on regulation vs. innovation at Energy Disruptors Summit (Kohler, WI)																																																	
Gov. Burgum presented an overview of iPIPE at the IOGCC Annual Meeting (Medora, ND)																																																	
iPIPE update presentation at Western Dakota Energy Association annual meeting (Minot, ND)																																																	
iPIPE introduction presentation at Pipeliners Association of Houston (Houston, TX)																																																	
iPIPE incremental funding proposal presentations at the Oil & Gas Research Program meeting (Bismarck, ND)																																																	
iPIPE update presentation at ND Legislature's Tribal Taxation Committee meeting (Bismarck, ND)																																																	
iPIPE update presentation at the December 2019 NDIC meeting (Bismarck, ND)																																																	
Podcasting																																																	
Recorded first two of six podcast episodes - "The Pipeliners Podcast"																																																
Awards																																																
Received the Williston Chapter API Industry Innovation Award (Williston, ND)																																																
Received the IOGCC Chairman's Stewardship Award (Medora, ND)																																																

Figure 2. 2019 year-in-review calendar summary.

SUMMARY OF 2019 TECHNOLOGY DEVELOPMENT ACTIVITIES

During 2019, the EERC coordinated all field-based demonstration and codevelopment activities with the technology providers and with consortium members who volunteered operating gathering pipelines on which the selected technologies could be demonstrated and improved.

- A brief extension of 2018 demonstration and codevelopment activities with Ingu Solutions was continued in 2019. These efforts were meant to further demonstrate specific capabilities of Pipers sensors related to leak detection. It was determined mutually by iPIPE and by Ingu Solutions that 2018 efforts did not fully explore and challenge this asserted benefit of employment of Pipers sensors.

- Demonstration and codevelopment activities for Satelytics Phase II began on June 3, 2019, and continued through October 8, 2019.

- Demonstration and codevelopment activities for Direct-C began in April 2019 and will continue into the second quarter of 2020. As such, only the portion of the work completed at the time of this report is described below. This work was primarily focused on laboratory investigations of the performance of Direct-C sensor technology to develop understanding that can be used in the EERC's independent assessment of field demonstrations of the technology that will continue through winter months of early 2020.

Summaries of the EERC's evaluation of each technology codevelopment effort are provided below.

Ingu Solutions Pipers Sensor Development Activities

Pipers Sensor Description

As reported in the 2018 annual report to NDIC, Pipers is an emerging technology developed by Ingu Solutions, of Calgary, Alberta, Canada. Ingu Solutions claims that Pipers is an affordable and easy-to-deploy screening tool that identifies risks and performance issues in pipelines, especially suitable for small-diameter (less than 8") pipelines. According to Ingu Solutions, the technology detects and locates leaks, defects, magnetic features, and restrictions in all pipelines, with no interruption of service. Pipers sensors employ a tiny sensor and power package, mounted on a small circuit board inside a hermetically sealed sphere. A photograph of the 1.5" Mini-Pipers variant is presented in Figure 3. For a full description of Pipers, please refer to the 2018 annual report, submitted to NDIC on January 30, 2019.

Figure 3. 1.5" Mini-Pipers sensors.

Additional 2019 Development/Demonstration Test

During 2018 activities with Ingu Solutions, iPIPE's volunteer pipeline operators were not able to adequately simulate a leak in a representative manner. This was partially due to the speed with which the program engaged in 2018 activities and partially due to a learning curve that iPIPE members conquered in 2018 and 2019. The simulated leak necessarily needed to mimic an actual leak with forced spray to produce acoustics detectable by the Pipers sensor.

Acknowledging that iPIPE did not adequately create opportunity for Ingu Solutions to demonstrate specifically the leak detection capabilities of Pipers, iPIPE member Equinor agreed to host a specific demonstration of Pipers leak detection capabilities in August 2019. Ingu Solutions agreed to perform up to two additional demonstrations on a produced water pipeline.

Discussion of Project Results

Pipers are equipped with an acoustic leak detection sensor. While moving through a pipeline, Pipers continuously record the relatively quiet flow noise, creating a baseline for the measured sound intensity. When a pipeline is leaking, the jet of liquid passing through the crack or hole generates a characteristic hissing or rushing sound that significantly deviates from the baseline noise in a localized region around the leak. Conversely, if there is no change (or only long-term gradual change) in the average sound intensity along the length of the pipe, no leak is indicated.

During the August 2019 test on the Equinor produced water pipeline, a leak was detected at the site at which the simulation occurred. Equinor and the EERC confirmed the validity of the test. A second planned test was not executed because of technical difficulties on the Equinor pipeline.

Success of iPIPE/Pipers Development Work

iPIPE considers Pipers one of its first successes for many reasons:

1. Data collected during iPIPE development work with Ingu Solutions allowed Ingu Solutions to refine its data processing workflows to increase accuracy and to decrease the amount of time required to achieve pipeline scan results.

2. Ingu Solutions declined to submit a follow-on proposal to iPIPE, indicating that its commercial sales had expanded during 2018 and 2019 to the point that it had to limit staff efforts to fully commercial contracts.

3. At least two members of iPIPE are now contracting commercially with Ingu Solutions for use of Pipers as a pipeline scanning tool.

Pipers represents one example of iPIPE fulfilling its promise to "put new tools in the toolbelt of pipeline operators."

Satelytics Phase II Development Activities

Satelytics is a data and analytical platform that promises to automate broad monitoring of large systems of liquids gathering pipelines. Satelytics employs machine learning algorithms to automatically analyze large amounts of optical, multispectral, and hyperspectral data from satellites, commercial airliner overflights, drone overflights, and fixed sensors to produce alerts on various changes of interest to the pipeline operator. Satelytics employs a Web-based interface as a data-rich information delivery system. Via this interface, current and historical alert locations and details can be displayed, before-and-after comparisons over a time span within the project can be observed, data can be downloaded to support field actions, and feedback can be provided to continuously improve the performance of the algorithms employed.

Satelytics provides a variety of analytical tools to the pipeline operator, including temperature analyses, chemical analyses, leak detections, and change detections. Change detections are further categorized as vegetation changes or encroachment changes. Encroachment changes are further categorized as surface disturbance, vehicle, structure, water, road, facility, shed, or other.

Scope of Work

iPIPE contracted with Satelytics to provide a three-pronged scope of work. The first task was to refine the existing hydrocarbon algorithm developed in the Phase I project. Secondly, the brine leak alert algorithm which was built last year was tested. The final task was to build a mobile application that mirrors the *satelytics.io* Web interface but also allows for off-line monitoring and ground-truthing of suspected leak incidents.

The scope of work monitored infrastructure within an 1100-km^2 area in North Dakota and 200 km^2 in New Mexico. The areas were selected by iPIPE to include gathering pipeline assets

for a majority of members. The North Dakota AOI (area of interest) is shown in Figure 4. The box above Lake Sakakawea was added for inclusion of new iPIPE member assets for 2019. The right side of Figure 4 provides a closer view of the test area. The entire New Mexico AOI is new for the 2019 Satelytics II project and is shown in Figure 5. The right side of Figure 5 provides a closer view of the AOI which is close to the town of Eunice, New Mexico.

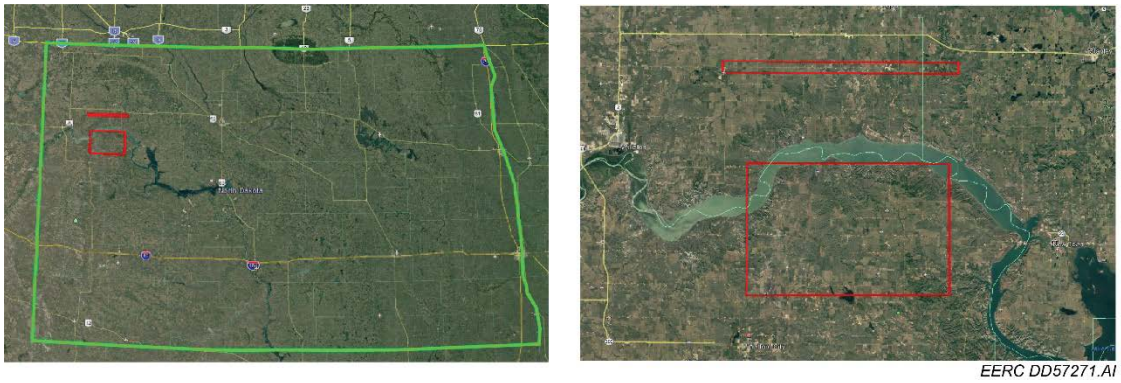

Figure 4. 2019 North Dakota AOI.

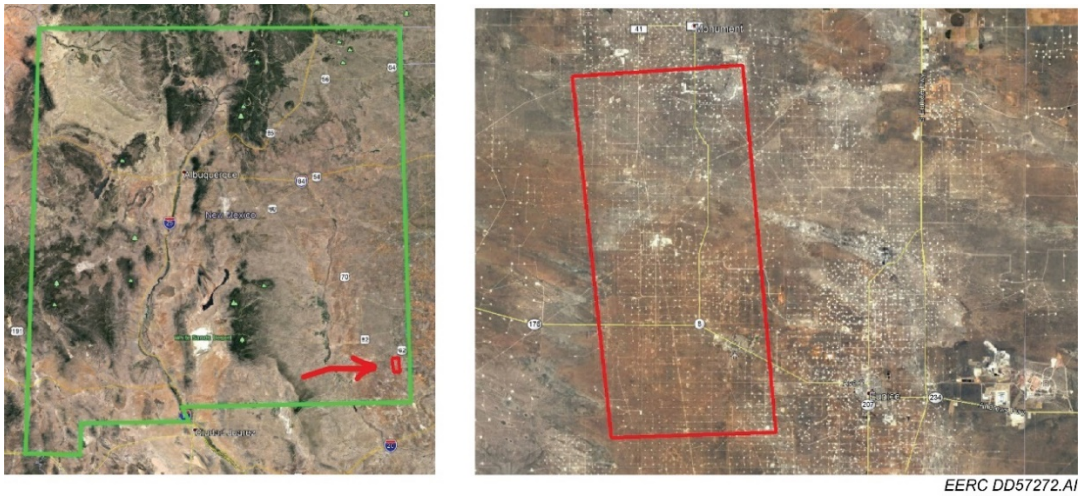

Figure 5. 2019 New Mexico AOI.

Multispectral and optical sensor data were obtained by Satelytics from the Airbus Pléiades-HR 1A and Pléiades-HR 1B satellites. The Pléiades satellites can revisit the area of interest daily and possess similar instrumentation and functionality as those used in the Phase I project. The first and last image captures for North Dakota and New Mexico were as follows:

- North Dakota
  - June 3, 2019
  - October 8, 2019
- New Mexico
  - June 9, 2019
  - September 24, 2019

Sixteen complete sets of images were obtained with the goal of weekly image capture and immediate analysis. Cloud cover conditions resulted in a 2-week extension of the 4-month capture window for the North Dakota AOI. This extension allowed for two additional partial captures covering areas that had been missed during previous weeks.

Project operations can be summarized as follows:

- Satelytics collected baseline imagery, then aimed for subsequent weekly image captures and analysis.

- Satelytics trained iPIPE members in operating the *satelytic*s.*io* interface during weekly WebEx meetings. These meetings also served to inform iPIPE members of project progress and as a forum for Satelytics to gather suggestions for product improvements.

- Satelytics notified iPIPE members immediately upon completion of each new image analysis, which triggered field teams to investigate alerts provided by Satelytics. This was referred to as ground-truthing.

- Based on their investigations, iPIPE field teams provided feedback on alerts to Satelytics. This information was used by Satelytics to train the machine learning algorithms to distinguish true hydrocarbon and produced water signatures from other nonhydrocarbon/nonproduced water false signatures.

- During the Phase II development work, two iPIPE member companies created a combined 13 simulated leaks on their sites to evaluate Satelytics' ability to identify actual hydrocarbon and produced water signatures.

- Satelytics built a mobile application for the iPIPE membership to use for ground-truthing.

Project Results

Alerts Accuracy

A primary task assigned to the EERC was to independently evaluate the accuracy of leak alerts provided by Satelytics' Constant Vigilance algorithms. Leak alerts include hydrocarbon and produced water. A summary of nearly 4000 alerts provided to iPIPE members between June 1, 2019, and October 8, 2019, is shown in Table 4. In total, 155 leak alerts were generated throughout the summer test campaign in North Dakota and New Mexico. iPIPE members endeavored to ground-truth as many leak alerts as possible. Feedback provided improvement opportunity for Satelytics algorithms through comments, pictures, and precise latitude/longitude readings.

Asset owners were able to ground-truth 74% and 99% of the leak alerts in North Dakota and New Mexico, respectively. A "ground-truthed" status was assigned to alerts when members provided some kind of feedback on s*atelytics.io* in response to the alert being issued.

Table 4. Summary of Provided Alerts

	North Dakota	New Mexico
Total Alerts	**3251**	**665**
Leak Detection Alerts	**50**	**105**
Hydrocarbon	45	88
Produced Water	5	17
Ground-Truthed Alerts	37	104
Ground-Truth Accomplished	74%	99%
Encroachment Alerts	**3201**	**560**
Other	1536	218
Surface Disturbance	948	199
Water	405	125
Facility	172	12
Structure	123	5
Road	16	0
Shed	1	1

This was a notable improvement for North Dakota over the 2018 project where only 59% were ground-truthed. It also notable that the 2019 project produced only 50 leak alerts in North Dakota even with an additional 100 km^2 included, while 2018 produced 176 leak alerts. The New Mexico data are new since no effort was executed there in 2018.

iPIPE members made great effort to ground-truth leak alerts in North Dakota and New Mexico. This is likely a result of lessons learned from the 2018 Satelytics project as well as members being more comfortable with the s*atelytics.io* interface. In addition, the *satelytics.io* mobile app was developed and possibly used to provide alert feedback toward the end of the project period. The higher percentage of ground-truthed alerts in North Dakota was perhaps also indicative of better algorithm performance, as the number of leak alerts was reduced by nearly 75% from last year.

As with 2018 activities, a buffer zone was chosen to include 300 ft on either side of member pipeline assets. The 2019 satellite image capture sequence was as follows:

- First capture attempt occurs each Sunday during the period of performance.
- If clouds or some other event prevent a successful capture, then reattempts would occur daily until a successful image were obtained.
- If no image could be captured the entire week, the window was reset and started anew the following Sunday.
- If a partial image (or no image altogether) of the AOI was obtained, then the missed area was added onto the end of the project time line so that 16 complete images could be gathered.
- Satellite overpass happens daily at approximately 12:00 noon local time.

Similarly to the findings of the 2018 report, the general trend in reduction of leak alerts generated by Satelytics in 2019 is observable in Figures 6 and 7. Figure 6 combines 2018 and 2019 results. The trends show a decreasing number of alerts that may be partially attributable to improvements in Satelytics leak detection algorithms.

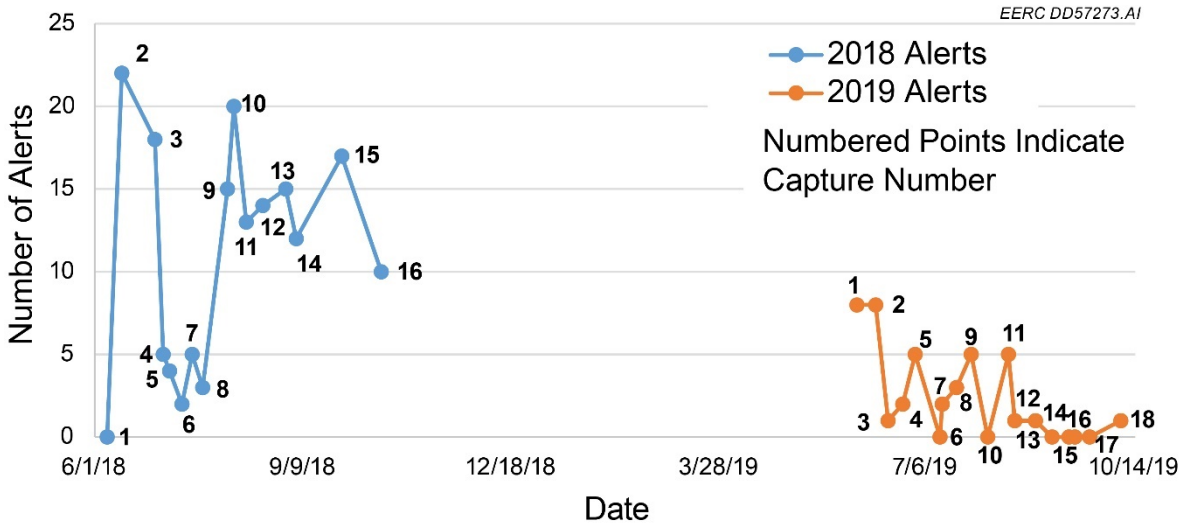

Figure 6. North Dakota leak alerts 2019.

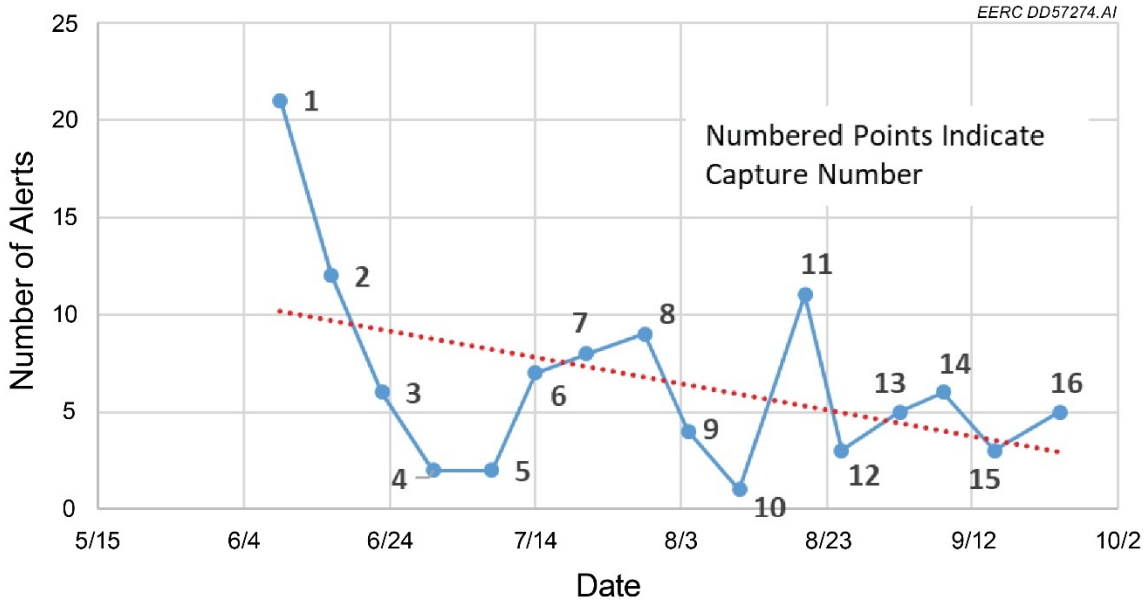

Figure 7. New Mexico leak alerts 2019.

Identification of Actual Leaks

Satelytics identified hydrocarbon and produced water signatures during the 2019 project. In the North Dakota AOI, only member-simulated leaks were identified. Simulated leak results will be discussed in a later section. In New Mexico, potential hydrocarbon and produced water leaks were identified and confirmed by iPIPE member ground checks. These alerts were associated with member and nonmember assets including the following:

- Pump jacks
- Hydrocarbon gathering lines
- Produced water gathering lines
- Gas gathering lines
- Processing plants
- Tank batteries
- Spill sites awaiting cleanup
- Old spill sites
- Truck spills

Figures 8 through 10 show a few interesting leak alerts confirmed by iPIPE members.

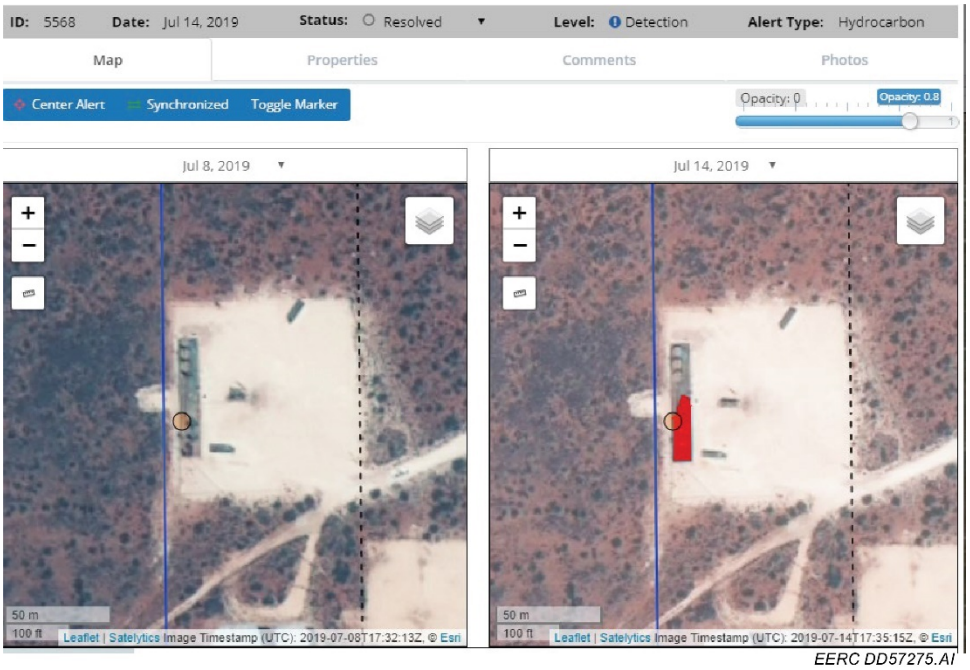

Figure 8. Confirmed New Mexico hydrocarbon leak at a tank battery, nonmember asset (Alert 5568).

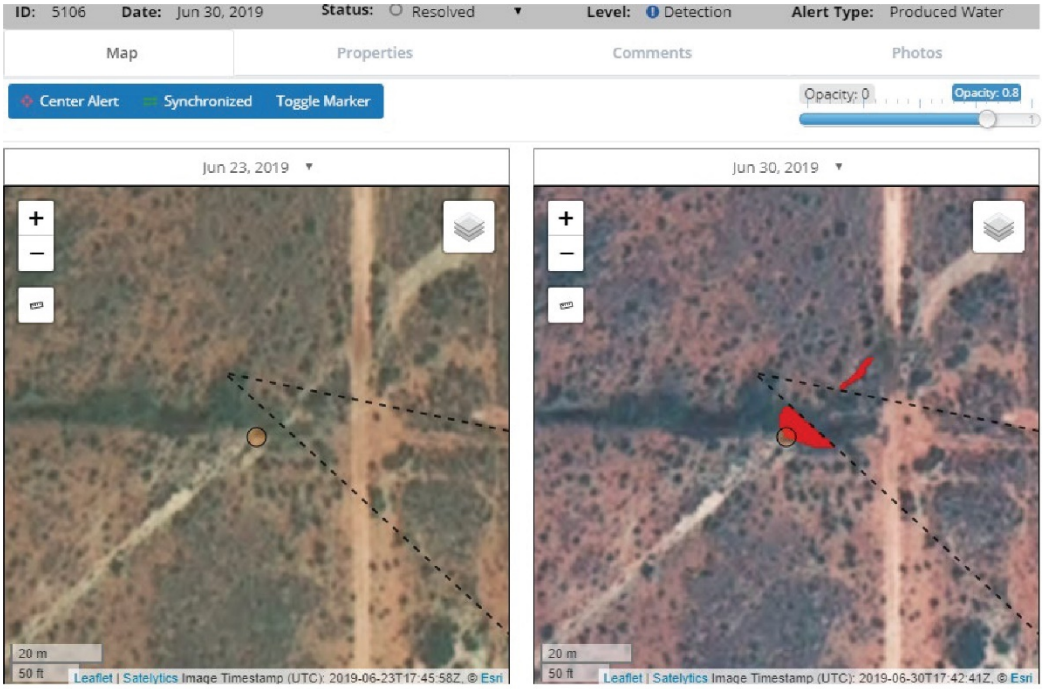

Figure 9. Confirmed New Mexico produced water leak, nonmember asset (Alert 5106).

Figure 10. Confirmed New Mexico produced water leak alerts showing vegetation change, nonmember asset (Alerts 6839, 4805).

Results of Simulated Leaks

Two iPIPE member companies set up simulated leak tests in the North Dakota AOI. The tests were designed to evaluate and improve Satelytics' technology for hydrocarbon and produced water identification. The tests also served to inform members of the minimum leak size detectable by Satelytics.

Satelytics provided alerts for ten of 13 simulated leak tests. Five of the 13 tests were true positive results while five of 13 were false positives, and three were not alerted at all. False positive alerts were tests where fluids were wrongly identified. It is hoped that these simulated spills helped to improve the performance of the Constant Vigilance algorithm and improve iPIPE members' understanding of the capabilities of Satelytics' technology.

Algorithm Development

Satelytics was funded in 2019 to test the produced water algorithm and feed more data to its Constant Vigilance software suite, including hydrocarbon and change detections. Simulated leaks of hydrocarbon and produced water were executed in North Dakota for detection development efforts. In New Mexico, several confirmed produced water leaks were identified in addition to hydrocarbon leaks. These provided valuable imagery feedback for Satelytics.

satelytics.io Interface Improvements and Mobile Application

Satelytics offered several updates to its Web-based software interface throughout the 2019 project. These updates include the following:

- Uploading of alert pictures
- Alert comment deletion
- ID numbers added to pop-up pins on the alerts map
- A distance measurement tool
- Text and e-mail notification by company (in development)
- Photoediting (in development)

Satelytics also built a mobile application version of satelytics.io and a user guide for iPIPE members during the 2019 project. The app is a simplified Web page that is designed for viewing on mobile devices and facilitates use of the app in nonconnected areas of low cellular phone coverage. Capabilities of the application include the following:

- Allows field personnel to check alert updates from anywhere
- Comment creation and deletion
- Alert viewing and editing, image upload, and commenting
- Operates in both online and offline modes after caching data
- Cached data pushed back to the cloud when Internet connection resumes

EERC Analysis of Factors Impacting Efficacy of Satellite Data Capture

The ability to detect releases soon after inception relies on sensitivity of the satellite imaging and image analysis systems, satellite availability, and adequate viewing conditions. Each of these factors is discussed in the following sections.

Issues affecting imagery gathering include sensor ability, satellite availability, image analysis, and viewing conditions. These topics were discussed in detail and in the 2018 Satelytics Phase I report which is available for review on the iPIPE members-only website. The issue of adequate viewing conditions was revisited for the 2019 effort with results discussed below.

Adequate Viewing Conditions

Although many factors can contribute to target view obstruction, weather conditions over the target are the most prominent reason. In assessing the effect of weather on target observation, climatological data from weather-reporting stations surrounding the North Dakota and New Mexico AOIs over the 2019 test period were obtained. The DJ Basin in Colorado was also included in the weather analysis to inform iPIPE members who may have assets there.

In analyzing capture perfromance and relating it to cloud cover, hourly sky condition data were collected for each weather station from NOAA's local climatological data (LCD) database over the past 5 to 10 years, depending on the age of the station. Three hourly observations time-stamped at 11:45 a.m., 12:45 p.m., and 1:45 p.m. DST each day (referred to herein as the PoI or "period of interest") were averaged to represent sky conditions at the station at time of daily overflight. If no observation was recorded during the 3 hours, the date is ignored. Data were sourced from the National Centers for Environmental Information (NCEI) (www.ncdc.noaa.gov/cdo-web/datatool/lcd).

ND AOI	The major conclusion that can be drawn from analysis of these data is that the June–September season represents the period of lowest cloud cover for the area of interest. The potential effect on satellite-based reconnaissance is that cloud cover will likely reduce the opportunity to acquire images in nonsummer months, although not in multiweek periods.
NM AOI	For the New Mexico 2019 test campaign, weather and cloud cover appeared to be much less of an issue for successful captures. The EERC evaluated the entire calendar year for New Mexico weather data and determined that the New Mexico area experiences significantly more clear sky conditions than North Dakota.

Capture Schedule Performance

The North Dakota AOI experienced some image gathering delays because of cloud cover. Out of the 16 scheduled weeks, Satelytics was unable on two occasions to gather a complete image of the AOI during a given week. Three weekly images were obtained on the first attempt and overall eight of the 16 weeks experienced delays of 2 days or less. Capture intervals were less than 14 days except for one miss of 18 days that happened between Weeks 5 and 6, although

this was only a partial incompletion. If a larger area were to be monitored as in a commercial application, partial AOI images would become more frequent and would necessarily be stitched together to fill out a complete image.

In New Mexico, the image captures followed the intended schedule very closely. Three weeks encountered a 1-day lapse and 2 weeks witnessed 2-day lapses. The remaining captures occurred on a Sunday, as planned.

EERC Assessment of Satelytics Technology

Satelytics Phase II was an extension of the 2018 development project aiming to provide more training data for the Constant Vigilance software as well as introduce a mobile application for iPIPE members. Satelytics was responsive to industry requests and questions. The hydrocarbon and produced water algorithms have shown recognition improvement throughout the 2018–2019 projects.

Table 5 summarizes observed strengths of this technology and observations on areas that the EERC believes Satelytics should focus continued efforts. Comments cover current leak alert algorithms as well as suggestions for future development.

Table 5. Summary of EERC Evaluation of Satelytics Performance

Promising Aspects	Aspects Requiring Further Development
Constant Vigilance identified numerous simulated and actual leaks.	False alerts were sent out in both North Dakota and New Mexico, although at a lesser rate than in 2018.
Constant Vigilance was able to correctly distinguish between hydrocarbon and produced water leaks.	False positive alerts for both hydrocarbons and produced water were given. Water on top of dark surfaces generated false alerts. Perhaps more training data will improve this.
Satelytics was responsive to interface suggestions and improvements were made to both the Web and mobile applications.	Satelytics technology has not been challenged by snow cover.
The mobile application was fully functional by the end of the project.	Cloud cover presents an impediment to satellite-based monitoring in some climates. Although delays were generally less than a few days, winter months could cause greater lapses. Industry will have to decide what frequency is needed and perhaps include under-cloud solutions as well.
As in 2018, a diminishing trend for the number of alerts was observed.	Alert notifications specific to company asset needs to be incorporated in *satelytics.io.* This means that companies would be notified of alerts affect their infrastructure only.

Success of iPIPE/Satelytics Development Work

iPIPE considers Satelytics to be another of its first successes for many reasons:

1. Data collected during iPIPE development work with Satelytics allowed Satelytics to improve its algorithm performance and leak indication accuracy and to decrease the amount of time required to complete weekly analysis of large amounts of satellite data.

2. Several members of iPIPE are now exploring possible basinwide models for commercial adoption of Satelytics. Because remote sensing technologies generally observe large areas containing many assets of many companies, pathways to procurement of these types of services must now be decided by the many potential beneficiaries.

Satelytics represents a second example of iPIPE fulfilling its promise to "put new tools in the toolbelt of pipeline operators."

Direct-C Development Activities

Scope of Work

Direct-C, of Calgary, Alberta, has created a leak detection technology based on a nanocomposite-coated circuit. The Direct-C technology is being tested both in EERC laboratories and in the field on live, operating pipelines. At this time, the EERC has completed laboratory testing of the sensor technology and has helped Direct-C and iPIPE member companies install the sensors at several locations in the field. The fieldwork will continue through winter months of 2019 and 2020 to determine performance in harsh weather conditions. At this time, the EERC is only prepared to report on the laboratory testing of Direct-C sensors performed by the EERC during 2019.

Direct-C provided two types of sensors for the EERC to test: coated sensors designed for detection of liquid hydrocarbons and uncoated sensors designed for detection of liquid brines. Both sensors are shown in Figure 11. Both sensors function similarly: exposure to a liquid hydrocarbon or brine solution causes a change in electrical resistivity of the sensor circuit. Based on predetermined criteria, this change in electrical resistivity triggers an alarm denoting the occurrence of a leak.

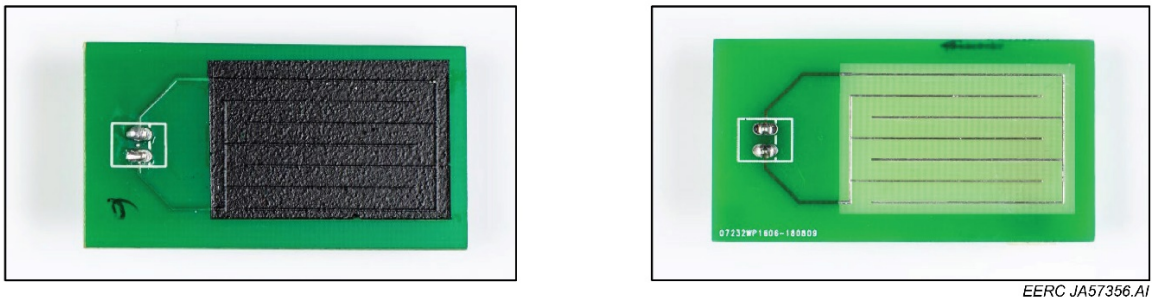

Figure 11. Direct-C hydrocarbon (left) and brine (right)-sensing coupons.

Laboratory testing of both sensor types was performed under various environmental conditions and with different fluid types. These tests were performed on individual sensors called coupons. Hydrocarbon testing was performed by exposing coated coupons to four hydrocarbon fluids (Bakken crude, legacy crude, crude oil condensate, and crude oil emulsion) at three different temperatures (8°, 70°, and 120°F). Brine tests were performed by exposing uncoated coupons to three fluids with varied conductivities (high-TDS [total dissolved solids] produced water, low-TDS produced water, and tap water) at three different temperatures (32°, 70°, and 150°F).

The EERC also laboratory-tested the Direct-C sensors in a field simulation apparatus, shown in Figure 12. In the field, multiple individual sensors (three sensors in our tested device) are assembled on a single circuit board to act as a single device, known as the SubSense configuration. EERC laboratory tests placed a circuit board with three sensors set in a soil matrix and filled the test apparatus with the test fluid until the upper sensor responded, as shown in Figure 13.

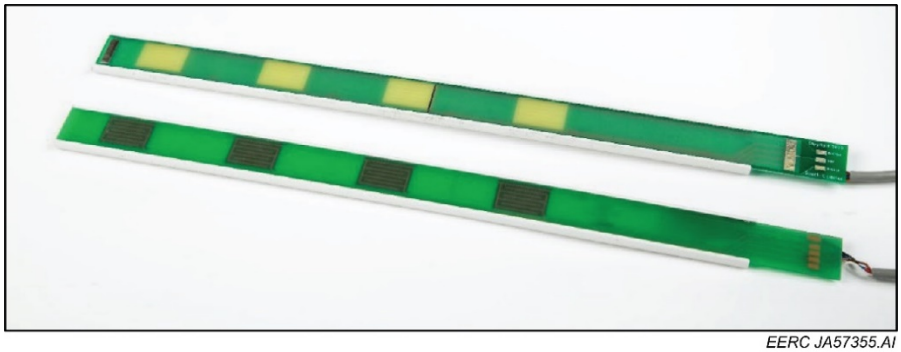
EERC JA57355.AI

Figure 12. Photo of Direct-C SubSense coated and uncoated devices.


EERC JA57354.AI

Figure 13. Photo of Direct-C SubSense field simulation apparatus as tested.

Laboratory Test Results

Laboratory testing resulted in the following observations and assessments:

- Hydrocarbon sensor
  - Coated coupons are considered one-time use devices. Once exposed to a hydrocarbon fluid, the sensor must be replaced with a new sensor.
  - Coated coupons appeared to have a slightly slower response to crude oil versus condensate or emulsion. This is not to say that the response to crude oils was slow.
  - No clear difference in coupon response was observed when coupons were exposed to various hydrocarbon fluids at different temperatures.
  - Although it did not appear to affect the response of the coupon, the integrity of the coating material on three of the coupons was compromised when exposed to hydrocarbon test fluid. This occurred with different fluids so no fluid type could be assigned responsibility.
  - When an uncoated coupon is exposed to a hydrocarbon fluid, no response was observed.
  - The coated coupon does respond to hydrocarbon gas, but the environment around the sensor must be highly saturated with the gas.
  - The magnitude of the response of the coated coupon to a hydrocarbon fluid is proportional to the amount of sensor exposed.

- Brine sensor
  - Uncoated sensors are considered reusable. The sensor does not need to be replaced after expose to a brine.
  - Although not conclusive from the laboratory testing, there was some indication that the magnitude of the uncoated coupon response increased with increased fluid temperature.
  - Because the magnitude of the response of the uncoated coupon is related to the conductivity of the fluid to which the coupon is exposed, the sensor must be "calibrated" to avoid false alarms to naturally conductive fluids present, such as groundwater. Although EERC staff members have not obtained a clear definition of the Direct-C calibration process, this feature does cause some concern. This issue would only be relevant for subsurface installations of the brine-sensing Direct-C devices.

- SubSense
  - Both coated and uncoated sensors reacted as anticipated based on previous individual coupon testing.
  - One unforeseen observation was the reaction of the coated sensors to vapor-phase hydrocarbons.

TECHNOLOGY SELECTIONS FOR 2019 CODEVELOPMENT ACTIVITIES

On October 22 and 23, 2019, iPIPE's Technical Selection Committee entertained presentations from eight providers of emerging technology. From this group, the Executive Committee selected two technologies for possible codevelopment activities in 2020, including:

- *Satelytics, Inc.* – uses machine learning algorithms (artificial intelligence) to identify pipeline leaks using large sets of data from satellites, drones, and commercial aircraft. This will continue a third phase of work previously funded during 2018 and 2019.

- *Orbital Sidekick* – plans to launch a hyperspectral instrument aboard its *Aurora* satellite and continue development of advanced analytics to accomplish on-board processing for near-real-time alerts of liquid hydrocarbon pipeline leaks.

Results of these activities will be reported in the next annual report to NDIC, due in January 2021.

CONCLUSION

iPIPE has already demonstrated impressive results in advancing truly emerging technologies for pipeline leak prevention and pipeline leak detection toward commercialization. The consortium members have expressed pleasant surprise at the productive collaboration made possible by iPIPE. Where business-competitive concerns are not present, a great amount of information on issues related to pipeline integrity has been shared in an effort to advance the technologies selected for codevelopment toward commercialization.

In a short amount of time, iPIPE has garnered significant attention in the news media and among pipeline operators across the nation. Over 50 articles have been published about iPIPE in publications across the country. One new member joined iPIPE in 2019, and two new members committed to join in January 2020. Potential new consortium members have approached iPIPE about membership.

iPIPE has been a highly novel and highly successful initiative. It has served to demonstrate North Dakota leadership on the important topic of pipeline integrity. It stands as a model program for state government cooperation with industry to address the topic of responsible promotion of oil and gas resource development.

APPENDIX A

PARTIAL LISTING OF iPIPE MEDIA MENTIONS

Partial List of Articles Highlighting iPIPE

Updated December 18, 2019

Title	Date	URL
Industry responds to governor's initiative to improve pipeline technology; Program funding approved by North Dakota Industrial Commission		https://www.ndoil.org/industry-responds-to-governors-initiative-to-improve-pipeline-technology-program-funding-approved-by-north-dakota-industrial-commission/
Satelytics Selected to Participate in the Intelligent Pipeline Integrity Program (iPIPE)	5/18/2018	https://mailchi.mp/satelytics/satelytics-chosen-to-participate-in-ipipe-project?e=922473135e
ND implements intelligent pipeline project	5/22/2018	http://northamericanshalemagazine.com/articles/2380/nd-implements-intelligent-pipeline-project
North Dakota Governor Doug Burgum provides remarks this morning at the Williston Basin Petroleum Conference in Bismarck, thanks Hess and the industry for innovation through iPIPE program.	5/23/2018	https://twitter.com/HessCorporation/statuses/999315208261853185
North Dakota Pipeline Leak Detection Initiative Announced	5/25/2018	https://extension.psu.edu/north-dakota-pipeline-leak-detection-initiative-announced
New consortium sets goal of improving pipelines	5/26/2018	https://www.mrt.com/business/oil/article/New-consortium-sets-goal-of-improving-pipelines-12941971.php
Industry Responds to Governor's Initiative to Improve Pipeline Technology; Program Funding Approved By North Dakota Industrial Commission	5/26/2018	https://www.oilandgasonline.com/doc/industry-governors-initiative-pipeline-program-north-dakota-industrial-commission-0001
New consortium sets goal of improving pipelines	5/27/2018	https://www.timesunion.com/business/oil/article/New-consortium-sets-goal-of-improving-pipelines-12941971.php
Principal Engineer Jay Almlie discusses the iPipe Program on Energy Matters Radio	5/31/2018	https://www.youtube.com/watch?v=ZQuwsK0z2aM
North Dakota selects Ingu Solutions for demonstration of cutting-edge leak detection and prevention technology for oil and gas pipelines	5/31/2018	https://ingu.co/ipipe/
Leak Detection Project Kicks Off This Summer	6/1/2018	https://myemail.constantcontact.com/Here-are-the-week-s-top-North-Dakota-energy-stories-.html?soid=1102657032033&aid=NpwT2Ynl17c
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